



Effect of Irrigation Water pH on Some Soil Properties and Growth of Some Pear Rootstocks Grown on Sand and Calcareous Soils

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Authors' contributions

This work was carried out in collaboration between all authors. Authors WEA and HMS designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors WEA and HMS managed the literature searches, analyses of the study performed the spectroscopy analysis and author WEA and author HMS managed the experimental process and authors WEA and HMS identified the species of plant. All authors read and approved the final manuscript.

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ABSTRACT

To study effect of irrigation water pH and soil type on growth of some pear rootstocks and some soil properties, two rootstocks (*Pyrus communis* and *Pyrus betulaefolia*) were grown on two soils (sand and calcareous) during successive seasons of 2010 and 2011. pH values of irrigation water were 6.0, 6.5, 7.0, 7.5 and pH 8.0. The experiment was performed in Horticultural Research Institute farm, Giza, Egypt. The tested soil properties were chemical analysis of soil water past extract, pH, soil texture and available nutrients (P, K, Fe, Zn and Mn). The following growth parameters were recorded plant height leaves number/plant, new current shoots number, vegetative growth dry weight, roots number, roots length, roots diameter. Obtained data showed significant effects for pH

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irrigation water and soil type on some of studied plant growth parameters and some of tested soil measurements. Data showed the importance nature of pH source in irrigation water i.e. chemical analysis of irrigation water. *Pyrus betulaefolia* was more tolerant to pH value variations in irrigation water than *Pyrus communis*.

Keywords: Irrigation water pH; soil type; pear rootstocks; soil properties and growth parameters.

1. INTRODUCTION

Pear (*Pyrus communis*) is one of the most important deciduous fruits that shows a great success and is widespread in the new reclaimed soils. The pear grown in Egypt decreased from 10722 (2009) to 10514 Feddans (2010) recorded from ministry of agriculture statistics. *P. communis* rootstock is widely used in Egypt than *P. betulaefolia* although the first is more susceptible to fire blight than the second. [1] Reported that *P. betulaefolia* is less susceptible rootstock to fire blight, pear decline and root aphid.

The pH scale ranges from 0 to 14 where: (1) Water with a pH lower than 7 is considered to be acidic (higher H⁺ concentration) (2) Water with a pH higher than 7 is considered to be basic (lower H⁺ concentration) (3) Water with a pH of 7.0 is considered to be neutral [2]. Dry matter accumulation in stem and roots of pear rootstocks (OH × F 51, OH × F 333, B 21, C 106 and D 50) decreased with the increasing lime percentage [3]. They added that leaf chlorotic symptoms of plants grown under increasing lime were most severe in OH × F 333, D 50 and Adams. They indicated that root Ca concentration increased linearly and root iron and manganese decreased linearly at increasing soil lime rates.

The soil pH has a direct effect on the ability of plant root cells to absorb both nutrients and water from the soil. [4] Had studied the effects of soil pH (3.9 to 7.0) on soil and plant nutrient imbalance and mortality of standard (Mazzard and Maheleb) and new (G1148-1 and G1148-8) cherry rootstocks. They found that Seedling mortality and soil Ca in all rootstocks and soil K and leaf Ca, K, Al, and Mn contents in all rootstocks but G1148-8 were higher at below optimum than at optimum soil pH. The nutrient imbalance suggests that the adaptation of these rootstocks to biotic and abiotic factors needs to be considered.

Pear trees tolerate a wide range of soil conditions. Soil fertility is not an important

criterion for growing pears because it is easily modified. Soil pH should be about 6.2 to 6.8, and can be adjusted with surface applications of limestone [5]. He added that, trees growing in fertile soils will be a little larger, and those planted on shallow or sandy soils will be a little smaller.

In addition to, in calcareous soils that have a high pH, short-term flooding can actually be beneficial to subtropical and tropical fruit crops by increasing the solubility of particle-bound nutrient elements such as Fe, Mn and Mg due to flooding-induced decreases in soil pH [6]. He reported that, flooding reduces the redox potential in the soil, resulting in Fe being reduced from Fe³⁺ to Fe²⁺, which is the cation metabolized by plants. Moreover, some authors mentioned that Water pH is important for plant management because it affects the solubility of fertilizers and the efficacy of insecticides and fungicides [7]. Availability of micronutrients such as iron, manganese, zinc, copper, and boron and future plant growth can be reduced severely by high substrate and irrigation water pH. High pH water can cause salts to precipitate out of fertilizer stock tanks. High water pH can also reduce the efficacy of pesticides. Also, some authors reported that the quality of irrigation water available to farmers and other irrigators has a considerable impact on what plants can be successfully grown, the productivity of these plants, and water infiltration and other soil physical conditions [8].

The aim of the present study is to evaluate the effect of water irrigation pH on vegetative growth and root system of one year - old pear rootstocks (*Pyrus communis* and *Pyrus betulaefolia*) grown in two different soils (Sand and calcareous).

2. MATERIALS AND METHODS

The present study was carried out during the successive seasons of 2011 and 2012. The experiment was performed in Horticultural Research Institute farm, Giza, Egypt. The effect of five irrigation water pH levels added to sand and calcareous soils on two studied pear

rootstocks (*Pyrus communis* and *pyrus betulaefolia*). Vegetative growth, chlorophyll content, root system and mineral composition of plant leaves and its content of nutrients (N, P, K, Fe, Zn, Mn) in addition some of soils analysis were conducted (EC, chemical analysis of soil water past extract, pH and available P,K, Fe, Zn, Mn) .

The selected seedling rootstocks were similar in vigor as possible and planted at mid-February in 90 polyethylene bags, 45 bags were filled with 10 Kg of sand for each rootstock and the other 45 bags were filled with 10 kg of calcareous soil for the other rootstock. The bags were equipped with holes in the bottom to allow water drainage. The plants were irrigated with tap water and add Hoagland nutrient with the recommended concentration during the first three months. Plants were arranged in 5 treatments in a complete randomized design with 3 replicates and 3 plants for each replicate. In mid May plants grown in the two soils (sand and calcareous) were irrigated weekly intervals till the end of the experiment (May till October) with the following irrigation water pH levels:

- 1-. PH 6.0 (12.5 ml HNO₃ conc. / liter water).
- 2-. PH 6.5 (5 ml HNO₃ conc. / liter water).
- 3-. PH 7.0 (Tap water).
- 4-. PH 7.5 (1.3g.KOH as powder /liter water).
- 5-. PH 8.0 (3 g. KOH as powder / liter water).

Soil Analysis

Soil chemical and physical characteristic of both sandy and calcareous soils were determined as shown in Tables 1 and 2.

2. THE FOLLOWING PARAMETERS WERE DETERMINED

2.1 Soil Analysis

At the end of the season, soil samples were taken to determine available nutrients (P, K, Fe, Zn, Mn) in soil extract of DTPA - ammonium bicarbonate solution according to [9]. Phosphorus was determined colorimetric using Spectrophotometer 20, Flame photometer was using for determine potassium. Perkin-Elmer atomic absorption used for determination of extracted micronutrients.

At the end of this study soil samples were taken from all experiment units to measure pH and EC. according to the methods described by [10,11].

2.2 Determination of Leaf Minerals Composition

Leaf minerals contents of nutrients were determined in mid-July of both seasons. Samples of 20 leaves/plant were taken at random from the previously tagged shoots of each plant. Leaf samples were oven dried at 70 °C to a constant weight and then ground. The ground samples were digested with sulphoric acid and hydrogen peroxide according to [12]. Total nitrogen and phosphorus were determined calorimetrically according to [13,14], respectively. Potassium was determined by a flame Photometer model E.E/L. [15]. Fe, Zn and Mn were measured by Perkin-Elmer atomic absorption spectrophotometer model 2380 AI, according to [16,17].

2.3 Plant Growth Parameters

The following measurements were recorded at the end of growing seasons (on October):

2.3.1 Plant height (%)

Plant height (%) was measured from the soil surface to the end of plant stem. The increment (%) in stem length was calculated as follows:

$$\text{Increment in stem height (\%)} = (\text{Final height} - \text{Initial height}) / \text{Initial height} \times 100$$

2.3.2 Stem diameter (cm)

Stem diameter (cm) was measured at 2 cm above the soil surface by using Venier caliper. The average stem diameter increment (cm) was calculated as follows:

$$\text{Stem diameter increment (cm)} = \text{final diameter} - \text{initial diameter.}$$

2.3.3 Number of leaves

Number of leaves per plant.

2.3.4 Number of new current shoots

By count the new shoots grown on the stem from May till October.

Table 1. Analysis of particle size distribution % of the experiment soil samples

Soil depth (cm)	Sand %		Silt %	Clay %	O.M. %	CaCO ₃ %	Textural class
	Coarse %	Fine %					
Sand soil							
0-20 cm	73.61	15.23	0.34	10.82	0.35	0.28	Sand
Calcareous soil							
0-20 cm	11.10	22.80	24.20	41.9	0.74	27.03	Clay loam

Table 2. Chemical analysis of soil water paste extract and pH of the experiment soil samples

Soil depth	pH (1:25)	EC (dS/m)	Soluble cation (mg/L)				Soluble anion (mg/L)			
			Ca ⁺⁺	Mg ⁺⁺	Na ⁺⁺	K ⁺	CO ₃ ⁻⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻⁻
Sand soil										
0-20 cm	8.04	0.39	0.24	0.32	2.62	0.24	---	0.21	0.32	2.89
Calcareous soil										
0-20 cm	6.97	8.17	27.8	11.9	41.60	1.08	--	19.3	29.6	33.48

2.3.5 Chlorophyll content

Leaf chlorophyll content expressed as SPAD reading using a Chlorophyll meter (model SPAD 502, Minolta Corporation, N.J., USA).

2.3.6 Dry weight of vegetative growth (g.)

Vegetative organs were taken carefully from bags then washed with tap water followed by distilled water. All samples were dried at 70°C until a constant weight then average weight was calculated (g.) for each replicate.

2.3.7 Roots number

At the experiment end, all number of roots grown on the root was recorded.

2.3.8 Roots length (cm)

Roots length (cm) was measured for all roots. The average length of roots was calculated for every replicate.

2.3.9 Roots diameter (cm)

Roots diameter (cm) was observed by using a veneer caliper. Roots were divided to three groups: Less than 0.1 cm, more than 0.1 to 0.2 cm and more than 0.2 cm.

Data were statistically analyzed according to [18]. Analysis of variance (ANOVA) and least significant difference (L.S.D) values were calculated to clear the significant difference between tested factors. The used software was MINITAB statistical software release 12.

3. RESULTS AND DISCUSSION

3.1 Effect of Irrigation Water pH on Some Soil Properties

3.1.1 Soil pH and EC

Soil pH and EC values as affected with irrigation water pH values under sand and calcareous soil, and analysis of variance and LSD values for different treatments were shown in Fig. 1. pH values varied between 7.36 and 8.08 under pH 6.0 irrigation and pH 8.0 irrigation water respectively. Soil EC, dS/m values varied between 0.35 and 1.8 under irrigation water pH 6.0 and pH8.0 respectively. It was clear also that increases of irrigation water pH cause increase of soil pH and EC values on both sand and calcareous soil. Comparison with initial pH and EC values the increase of pH values was higher in calcareous soil than in sand soil. On the other hand, the increase of soil EC, dS/m in sand soil was higher than in calcareous soil. In all cases, leaching of soluble salts was happen during growth season relatively to initial soil EC, dS /m values. Although the significant differences of the pH values, all obtained pH values were in normal range. With other wards no alkalinity problems were occurred. About soil salinity, all EC values of the soil water past extract had negligible salinity effects, [19].

3.1.2 Available phosphorous (P) and potassium (K)

Available soil phosphorous and potassium mg /kg (Fig. 2) as affected with irrigation water pH values in sand and calcareous soils and analysis

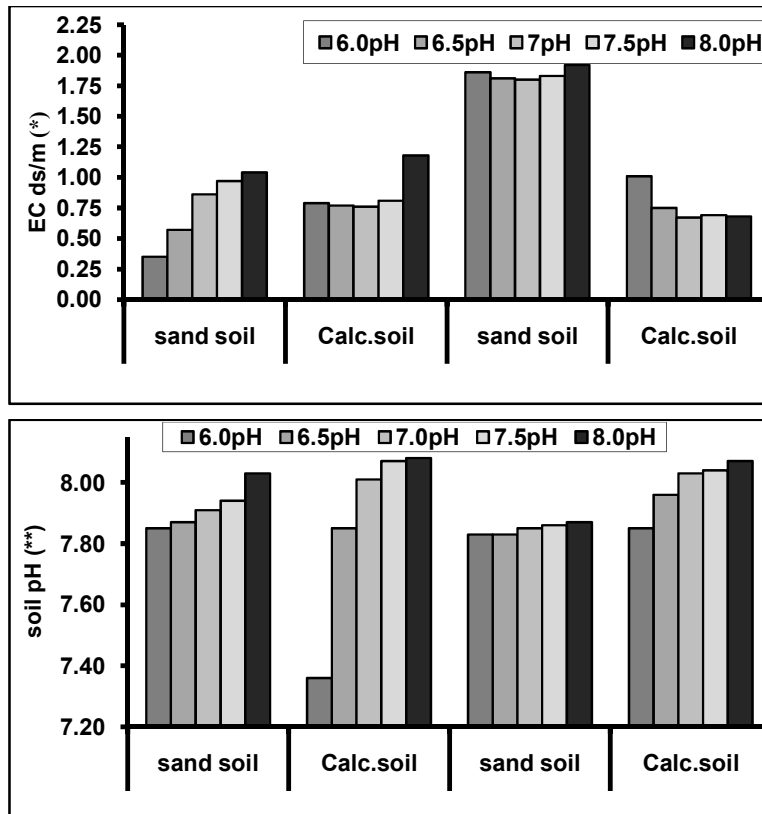
of variance and LSD values for different treatments were shown in Fig. 2.

had relatively low values when measured [20 and 21 on Grape vine].

All tested factors cleared significant effects on available phosphorous and potassium mg/kg. It is cleared also that a negative relation between pH irrigation water and both of available phosphorus and potassium. Soil type effect on available phosphorus showed that calcareous soil had low values of available P than sand soil this behavior related to the high content of calcium carbonate in calcareous soil. It was clear also that the decreases of available potassium mg/kg in sand soil were high than calcareous soil. All soil samples were occurred in very high class of available P and more than 90% of soil sample had low class of available potassium according to [9]. Leaf petiole K was noted to be high for some rootstocks while other rootstocks

3.1.3 Available zinc (Zn) and iron (Fe)

Available zinc and iron mg/kg as affected with irrigation water pH values under sand & calcareous soil and analysis of variance and LSD values for different treatments were occurred in Fig. 3. All tested factors cleared significant effects on available Zn and Fe mg/kg. It clear also that a negative relation between pH irrigation water and available Zn and Fe. Soil type effect on available zinc and iron mg/kg showed that sand soil has low values of available iron mg/kg than calcareous soil, this behavior related to the high content of mineral compounds in calcareous soil than sand.



<p>LSD 0.05 (EC dS/m) <i>S</i> = 0.031, <i>P</i> = 0.031, <i>pH</i> = 0.050, <i>P</i> x <i>pH</i> = 0.45, <i>S</i> x <i>pH</i> = 0.070, <i>S</i> x <i>P</i> = 0.070, , and <i>S</i> x <i>P</i> x <i>pH</i> = 0.100</p>	<p>LSD 0.05(pH) <i>S</i> = 0.046, <i>P</i> = 0.046, <i>pH</i> = 0.073, <i>P</i> x <i>pH</i> = 0.065, <i>S</i> x <i>pH</i> = 0.0103, <i>S</i> x <i>P</i> = 0.0103, , and <i>S</i> x <i>P</i> x <i>pH</i> = 0.146.</p>
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Fig. 1. Effect of irrigation water pH on soil pH and EC dS/m of sand and calcareous soils in the end of the season

Available Zn and Fe in all soil samples were occurred in very high class according to [9]. [22] Studied the adsorption of zinc on a calcareous soil and found that the reaction was not reversible due to some of the zinc being irreversibly fixed by soil. [23] Pointed that iron oxides readily precipitate out and form coatings on the carbonate mineral under pH 8 or above.

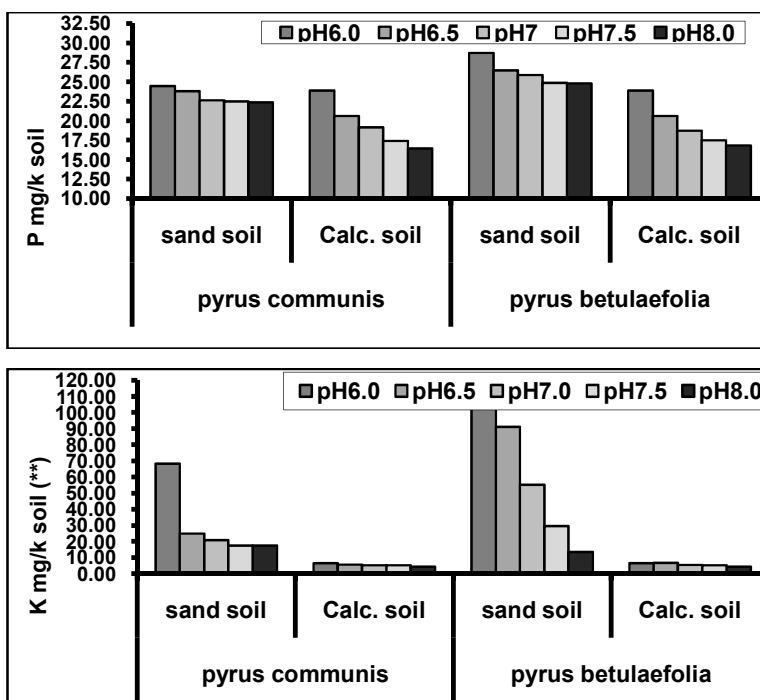
irrigation water pH, increasing of pH values caused negative effects on available Mn. Statistical analysis showed that there are highly negative significant effects for pH of irrigation water on available Mn mg/Kg soil. Available Mn in all soil samples were occurred in very high class according to [9].

3.1.4 Available manganese (Mn)

As shown in Fig. 4 Irrigation water pH and its effect on available Mn in sand and calcareous soil, and the highest and lowest values were 8.58 and 2.45 under pH6.0, calcareous soil, *Pyrus betulaefolia* rootstock and pH 8.0, *Pyrus betulaefolia* rootstock, sand soil respectively. Individual effects for different tested factors revealed that available Mn in calcareous soil is high than in sand soil. About effect of

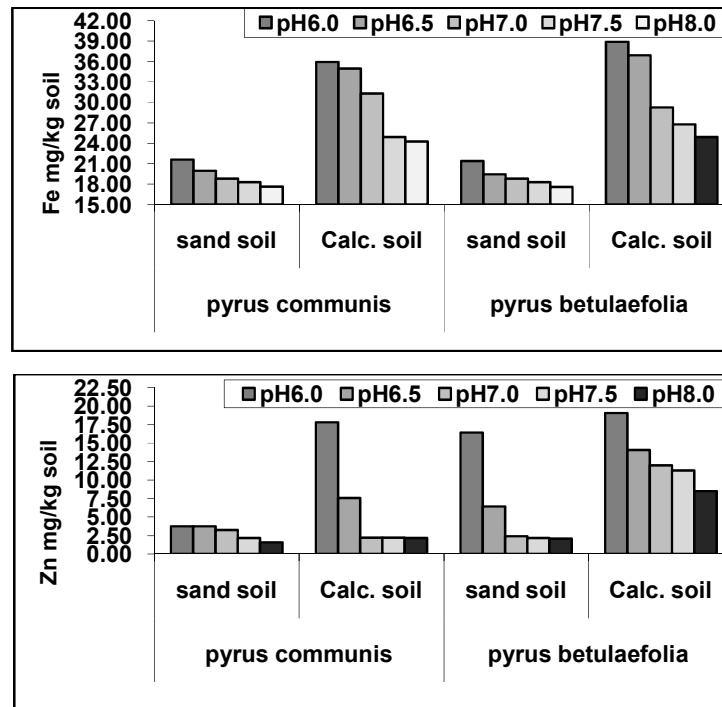
3.2 Leaf Mineral Composition

Mineral composition of plant leaves for macro nutrients N, P and K (%) occurred in Figs. 5, 6, 7. Whereas, Fig. 8 illustrated micro nutrients Fe, Zn and Mn (mg/kg) in plant leaves. Following simple description for mentioned nutrients classes or levels used in the discussion, [24]: Efficient, this is the range of concentrations in the specified plant part which associated with severely reduced growth and production.



<p>LSD 0.05 (P) $S = 0.296, P = 0.296, pH = 0.468, P \times pH = 419, S \times pH = 0.662, S \times P = 0.662, \text{ and } S \times P \times pH = 0.936$</p>	<p>LSD 0.05 (K) $S = 0.254, P = 0.254, pH = 0.40, P \times pH = 0.359, S \times pH = 0.567, S \times P = 0.567, \text{ and } S \times P \times pH = 0.800$</p>
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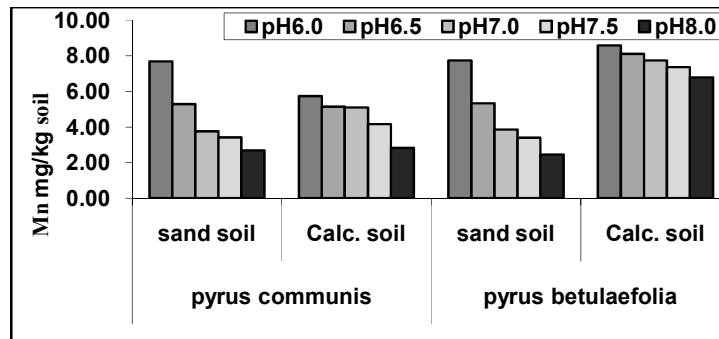
Fig. 2. Effect of irrigation water pH on available K and P mg/kg of sand and calcareous soils



LSD 0.05 (Zn) S = 40.39, P = 40.39, pH = 63.85, P x pH = 57.11, S x pH = 90.30, S x P = 90.30, and S x P x pH = 127.71

LSD 0.05 (Mn) S = 2.623, P = 2.623, pH = 4.147, P x pH = 3.709, S x pH = 5.864, S x P = 5.864, and S x P x pH = 293

Fig. 3. Effect of two soil types and different pH levels on Iron and Zinc content on soil of *Pyrus communis* and *Pyrus betulaefolia* pear rootstocks as average of 2011 and 2012 seasons



LSD 0.05 S = 5.014, P = 5.014, pH = 7.429, P x pH = 7.092, S x pH = 11.213, S x P = 11.213, and S x P x pH = 15.857

Fig. 4. Effect of two soil types and different pH Levels on Manganese content on soil of *Pyrus communis* and *Pyrus betulaefolia* pear rootstocks as average of 2011 / 2012 seasons

Marginal, this is the range of concentrations in the specified plant part which associated with a reduction in growth or production, plant do not show visible symptoms of deficiency. Critical value, Plant nutrient status should normally be kept above the critical value. Adequate, This classification known as "intermediate",

satisfactory ", " normal " of "sufficient". High, this classification usually represents the range of concentrations in the specified plant part between the adequate range and excessive range. Excessive, The concentrations in the specified plant part associated with severely reduced quality.

3.2.1 Nitrogen (N) %

Nitrogen (N) % in plant leaves varied between the lowest value, 0.95 at pH 8.0 *Pyrus betulaefolia* rootstock, sand soil and the highest value, 2.54 at pH 6.0, *Pyrus betulaefolia* rootstock, calcareous soil. Soil effect showed that N% for calcareous soil was more than sand soil, and N% for *Pyrus communis* rootstock was higher than *Pyrus betulaefolia* rootstock. It was clear also pH effect on leaves nitrogen, N% that increase the values with decreasing of pH values. The mean values of pear leaves N% cleared that about pH treatments, only N% at pH6.0 was the marginal level but N% at all the other pH points were deficient class <1.8. As soil pH is strongly correlated to the availability of these elements for plant uptake [25].

About soil type and rootstocks, all its values of pear leaves N% were deficient, [24]. Statistical analysis cleared that there were significant effects on leaves nitrogen, N % for all treatments (Fig. 5).

3.2.2 Phosphorus (P) %

Phosphorus (P) in plant leaves varied between the lowest value, 0.40 at pH8.0, *Pyrus betulaefolia* rootstock, calcareous soil and the highest value, 1.69 at pH 6.0, *Pyrus betulaefolia* rootstock, calcareous soil. Soil effect showed that P % for calcareous soil was higher than sand soil, and P % for *Pyrus communis* rootstock was highest than *Pyrus betulaefolia* rootstock. It was clear negative pH effect on leaves phosphorous, P % that increased the values with decreasing of pH values (Fig. 6).

The mean values of pear leaves P% cleared that all values were at excessive level >0.30, [24]. Statistical analysis cleared that there were significant effects on leaves phosphorous, P% for pH, (pH and Soil), (pH and rootstock) and (pH, Soil and rootstock).

3.2.3 Potassium (K) %

Potassium, K, % in plant leaves varied between the lowest value, 0.65 at pH 8.0, *Pyrus betulaefolia* rootstock, sand soil and the highest value, 3.14 at pH 6.0, *Pyrus communis* rootstock, sand soil. Soil effect showed that potassium, K % for sand soil was more than calcareous soil, and P % for *Pyrus communis* rootstock was highest than *Pyrus betulaefolia* rootstock. It was clear slightly negative pH effect on leaves potassium,

K % that increased the values with decreasing of pH values (Fig. 7).

About pear leaves K% showed that its mean values were in adequate level for pH points 6.0 and 6.5, the other pH points occurred in marginal class.

Mean pear leaves K% of sand soil was adequate class and calcareous was marginal. About The rootstocks, mean K% of leaves for *Pyrus communis* was adequate level and marginal for *Pyrus Betulaefolia*, [24]. Statistical analysis cleared that there were significant effects on leaves potassium (K) % for all treatments. K was significantly higher in some rootstocks than in others, but varied from, site to site as well [26].

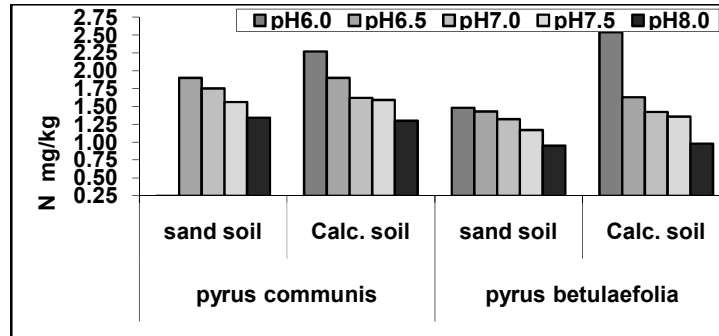
3.2.4 Iron (Fe), Zinc (Zn) and Manganese (Mn) mg/kg

Iron (Fe) mg/kg in plant leaves varied between the lowest value, 109.67 at pH 8.0 *Pyrus betulaefolia* rootstock, calcareous soil and the highest value, 982.85 at pH 6.0 *Pyrus betulaefolia* rootstock, sand soil. Zinc (Zn) mg/kg in plant leaves varied between the lowest value, 24.0 at pH 8.0, *Pyrus betulaefolia* rootstock, sand soil and the highest value, 155.0 at pH 6.0, *Pyrus betulaefolia* rootstock, calcareous.

Manganese (Mn) mg/kg in plant leaves varied between the lowest value, 36.06 at pH8.0, *Pyrus betulaefolia* rootstocks, calcareous soil and the highest value, 252.46 at pH 6.0, *Pyrus betulaefolia* rootstocks, sand soil. Statistical analysis cleared that there were significant effects on leaves Zn and Mn mg/kg for all factors but Fe mg/kg was significant for all treatments except soil factor.

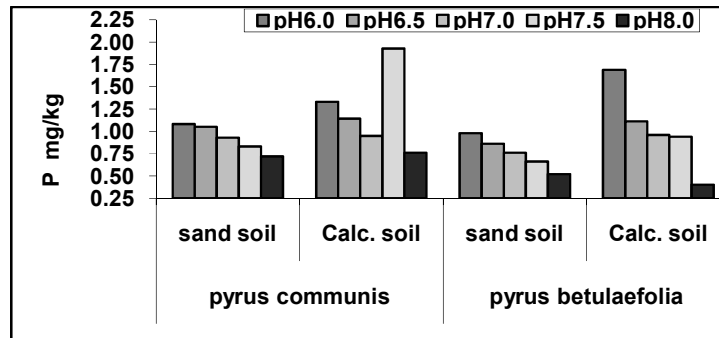
Soil type's effect showed that zinc, Zn mg/kg for calcareous soil was markedly higher than sand soil but Mn mg/kg in plant leaves was higher in the plants grown on sand than on calcareous soil. Fe mg/kg and Mn for *Pyrus betulaefolia* rootstock were highest than *Pyrus communis* rootstock but Mn mg/kg for *Pyrus communis* rootstock was less than *Pyrus betulaefolia* rootstock. It was clear high negative pH effect on leaves Fe, Zn and Mn mg/kg that increased the values with decreasing of pH irrigation water values (Fig. 8) The mean values of pear leaves Fe mg/kg cleared that all values were occurred at marginal level <60 mg/kg, [24].

About pear leaves Zn mg/kg showed that its mean values were in marginal level for pH 6.0, all the other pH points occurred in deficient class, <10 mg/kg, [24]. In this respect, [27] mentioned that availability of zinc decreases with increasing soil pH due to increased adsorptive capacity.



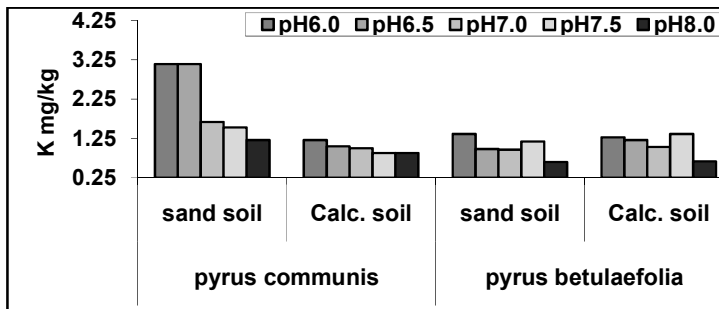
LSD 0.05
 $S = 0.035, P = 0.035, pH = 0.055, P \times pH = 0.049, S \times pH = 0.077, S \times P = 0.077, \text{ and } S \times P \times pH = 0.109$

Fig. 5. Effect of two soil types and different pH levels on Nitrogen content on leaves of *Pyrus communis* and *Pyrus betulaefolia* pear rootstocks as average of 2011 and 2012 seasons



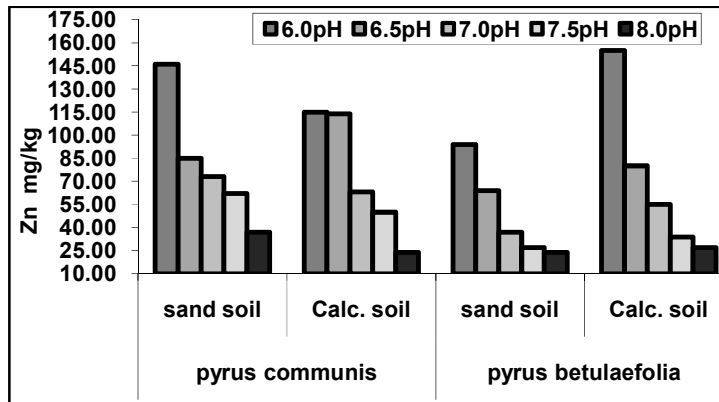
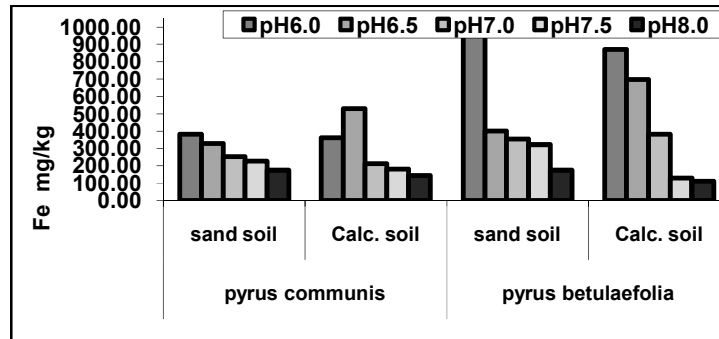
LSD 0.05 (P)
 $S = 0.209, P = 0.209, pH = 0.330, P \times pH = 0.245, S \times pH = 0.467, S \times P = 0.467 \text{ and } S \times P \times pH = 0.660$

Fig. 6. Effect of two soil types and different pH levels on leaf P content of *Pyrus communis* and *Pyrus betulaefolia* pear rootstocks as average of 2011 and 2012 seasons

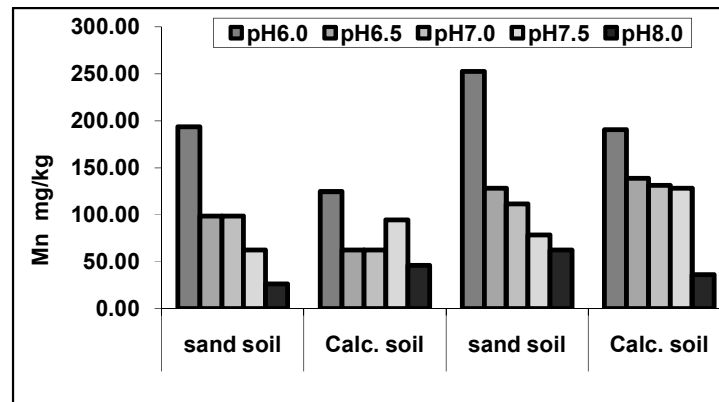


LSD 0.05 (K)
 $S = 0.011, P = 0.011, pH = 0.018, P \times pH = 0.016, S \times pH = 0.025, S \times P = 0.016 \text{ and } S \times P \times pH = 0.036$

Fig. 7. Effect of two soil types and different pH levels on leaf K content of *Pyrus communis* and *Pyrus betulaefolia* pear rootstocks as average of 2011 and 2012 seasons



<p>LSD 0.05(Fe) $S = 0.111, P = 0.111, pH = 0.175, P \times pH = 0.157, S \times pH = 0.248, S \times P = 0.248, \text{ and } S \times P \times pH = 0.350$</p>	<p>LSD 0.05(Zn) $S = 1.349, P = 1.340, pH = 2.133, P \times pH = 1.908, S \times pH = 3.160, S \times P = 3.160, \text{ and } S \times P \times pH = 4.265$</p>
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<p>LSD 0.05 $S = 0.001, P = 0.001, T = 0.001, P \times T = 0.001, S \times T = 0.001, S \times P = 0.001, \text{ and } S \times P \times T = 0.002$</p>

Fig. 8. Effect of two soil types and different pH levels on Iron, Zinc and manganese mg/kg content on leaves of *Pyrus communis* and *Pyrus betulaefolia* pear rootstocks as average of 2011 and 2012 seasons

The mean values of pear leaves Mn mg/kg cleared that all pH points were occurred at marginal level 20-59 mg/kg. About the rootstocks, the mean of Mn mg/kg in leaves for both pear rootstocks were occurred at marginal class. Calcareous soil had adequate level of Mn

in analyzed pear leaves but in sand soil was in deficient class, [24].

Analysis of available micro nutrients in the types of soil and the two pear rootstocks leaves composition of micro nutrients showed that

although most of available micro nutrients in the soil were high, the composition of pear leaves from micro nutrient were low. This mean that the importance of spray micro nutrients fertilization.

3.3 Effect of Irrigation Water pH on Vegetative Growth

3.3.1 Stem length increment %

The increment of stem length is shown in Fig. 9 pH irrigation water effect was significant in both seasons (2010 & 2011) for the two rootstocks (*Pyrus communis* and *pyrus betulaefolia*) and two soils (sand & calcareous) under study. *Pyrus betulaefolia* rootstock, the best value was obtained from pH 7.5 (34.82 %) in sand soil in the two seasons under study but in calc. soil, it was in pH 7.0 (35.08%) in both seasons under study. while the lowest values were recorded with pH 7.0 (9.59%) in sand soil compared with lime (Calc.) soil was (21.93 %) in pH 6.0 as mean to the two seasons.

Also, *Pyrus communis* rootstock, it noticed that the best value obtained in pH 6.5 ranging 50.00% in sand soil and pH 7.0 (50.00%) in calc. soil. However, the lowest value obtained in sand soil was pH 7.5 (36.06%) but in calc. soil was (39.87%) in pH 8.0 in both seasons 2010 & 2011. Statistical analysis cleared that there were significant effects on stem length increment % for all treatments except pH, soil and the interaction between Soil and rootstocks. Concern to [28] plant height were not decreased as the soil pH was increased (pH8.2) compared with those grown at pH5.5.

3.3.2 Stem diameter increment

Data presented in Fig. 9 showed significant differences in diameter of stem in response to pH water and type of soil. *Pyrus betulaefolia* rootstock, pH 8.0 gave the highest value in diameter of stem in sand soil (0.55 cm) as mean value but in calc. soil the best result was obtained in pH 7.0 (0.65cm) in both seasons. Whereas, it was found that lowest stem diameter increment in *Pyrus betulaefolia* rootstock stem were recorded in pH 6.0 & 6.5 as means in two seasons in sand soil (0.35cm). For calcareous soil, it found that pH 6.0 in two seasons as mean gave the least stem diameter (0.42 cm), respectively.

Pyrus communis rootstock, accordingly, data in Fig. 9 obviously that the highest value was

recorded in pH 6.5 (0.70 cm) in sand soil and pH 6.0 (0.43 cm) in calcareous soil in the two seasons under study. Also, the lowest data was obtained in pH 7.5(0.38cm) in two seasons in sand soil but in calcareous soil in pH 7.0 gave the lowest stem diameter (0.30cm), respectively.

Statistical analysis cleared that there were significant effects for irrigation water pH, the interaction between rootstocks & pH and the interaction between soils & pH on stem diameter cm. Regard to [28] reported that shoot diameter was affected by pH soil as well as the shoot height and dry weight.

3.3.3 Current shoots number

Fig. 10 shows the effect of pH water irrigation on the No. of current shoots. The results showed significant and differences in pH degrees in both experimental seasons. *Pyrus betulaefolia* rootstock, the highest number of current shoots was obtained in the pH 6.5(11.59 shoot) in seasons 2010 & 2011 in sand soil and pH 6.0 (19.83 shoot) in Calc. soil in both seasons under study. The least result was in pH 6.0(5.67 shoots) in sand soil and pH 8.0(6.83 shoots) for calcareous soil.

Whereas, *Pyrus communis* rootstock, in sand soil pH 6.5 gave the highest number of current shoots (6.83 shoots) in both seasons under study and pH 6.0 (8.33 shoots) in calcareous soil. However, the least number of current shoots were recorded in sand soil with pH 7.5 (3.33shoots) in both season but in calcareous soil was in pH 7.0 & 6.5 (5.33 & 5.33 shoots) in season 2010 and 2011. Statistical analysis cleared that there were significant effects on current shoots number/plant for all tested factors except rootstocks with pH.

3.3.4 Leaves number per plant

From Fig. 10 *Pyrus betulaefolia* rootstock, pH 6.5 gave the highest average number of leaves under either sand (206.50 leaves) and calcareous soil (208.15 leaf) in the both seasons under study. But pH 8.0 decreased the average number of leaves in both soils and seasons under study (108.30) in sand soil and (134.15 leaf) leaf in Calc. soil.

On the other hand, *Pyrus communis* rootstock, it is noticed that pH 7.5 (109.65 leaf) increased the average of leaves under sand soil condition in both seasons 2010 & 2011 while pH 6.0 gave

(89.33 leaf) under calcareous soil. Whereas, the lowest average of leaves recorded by pH 6.0 (80.50 leaf) in sand soil and pH 6.5 (80.81 leaf) in calcareous soil. Generally the average number of leaves increased as pH decreased in both rootstocks under study.

Statistical analysis cleared that there were significant effects on leaves number/plant and current shoots number/plant for all tested factors except soils. [28] mentioned that soil pH affects nutrient availability to plants; it is enough to see changes in vegetative vigor with varying soil pH.

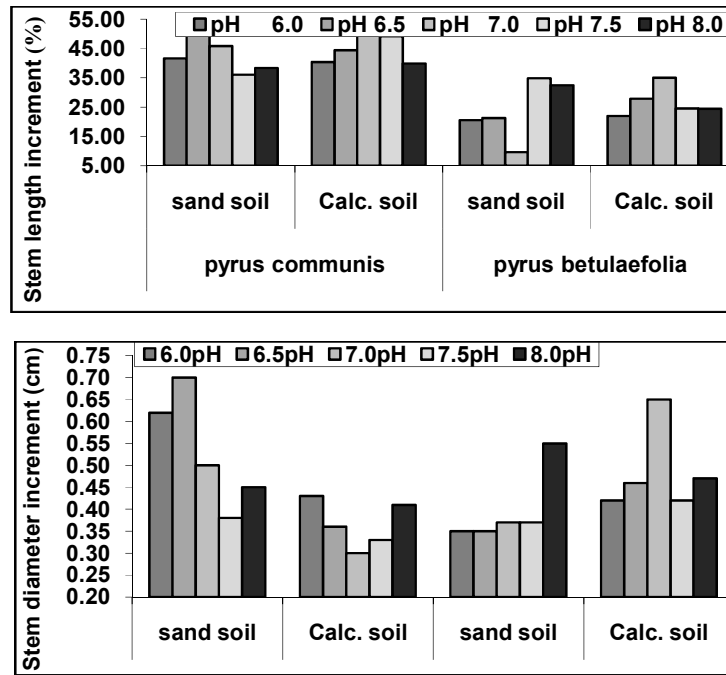
3.3.5 Chlorophyll content

Fig. 11 clarifies that total chlorophyll content reading affected by pH degree either increasing or decreasing for the two rootstocks fewer than two types of soil in seasons 2010 & 2011.

Concerning to *Pyrus betulaefolia* rootstock, pH 7.0 increases the chlorophyll content reading in

sand soil (40.29) while in calcareous soil pH 6.0 gave the highest chlorophyll content reading (38.92) in two 2010 & 2011 seasons. Herein, the least chlorophyll content recorded in pH 6.0 in sand soil (32.59) and pH 7.5 in calcareous soil (22.43) by fewer 2010 & 2011 seasons.

As regard to pH irrigation, data indicated that *Pyrus communis* rootstock affected by pH 6.0 which gave the best chlorophyll content reading in either sand (50.70) or calcareous soil (35.88). Also, the lowest value was recorded in pH7.0 for either sand soil (41.40) or calc. soil (24.03) in both seasons under study. Statistical analysis cleared that there were significant effects on chlorophyll reading for all tested factors and its double interactions. Significant response to either treatment was not observed with respect to chlorophyll content in the current study, though trends at pH 6 show similarities to the findings of [26,29] ,despite differences in scion variety.



LSD 0.05 (stem length) S= NS, P=3.33, pH=NS, P x pH=7.44, S x pH=1.26, and S x P =NS	LSD 0.05 (stem diameter) S=NS, P=NS, pH=1.16, P x pH=0.73 S x pH=0.73, ,and S x P=NS
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Fig. 9. Effect of irrigation water pH on average stem length increment (%), and stem diameter (cm) of *Pyrus communis* and *Pyrus betulaefolia* pear rootstocks as average of 2011 and 2012 seasons

3.3.6 Vegetative growth dry weight

Dry Vegetative growth as affected with irrigation water pH values on two rootstocks (*Pyrus communis* & *Pyrus betulaefolia* rootstocks) and two types of soil (sand and calcareous soil).

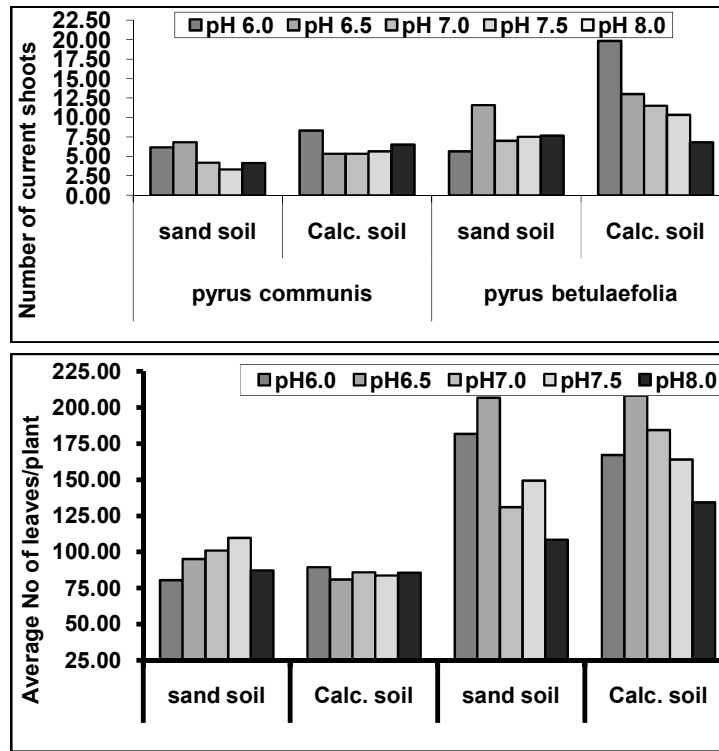
Fig. 12 show that *Pyrus betulaefolia* rootstock affected significantly by pH 6.5 (39.18 g) under sand soil condition but in calcareous soil the best value was pH7.5 (38.76 g).Whereas, the least values were in pH 7.5(23.50 g) in sand soil and pH 8.0 (29.54 g) in calcareous soil under the studied seasons 2010 & 2011. On the other hand, *Pyrus communis* rootstocks, it found that the highest dry weight was recorded by pH 8.0 (12.69 g) in sand soil and in calc. soil was pH6.0 (13.68 g). Also, the lowest values recorded were pH 6.5 (10.36 g) in sand soil and Calc. soil was pH7.5 (10.53g). Statistical analysis cleared that there were significant effects on vegetative dry weight g / plant for all tested factors except

interaction between soils and rootstocks. In this respect, [30] recorded that there was a large differences between rootstocks with respect to vegetative growth dry weight, when grown under "neutral"(6.9) and calcareous (8.2) soil conditions.

It is noticed that present data show that there was a significant affect occurred in vegetative growth to respond to pH water irrigation on two rootstocks under study. Also, *Pyrus betulaefolia* show positive effect when pH irrigation water was decreased compared by *Pyrus communis*.

3.4 Roots System

It is clear that the various pH water irrigation degrees and types of soils caused a significant influence on rooting behavior of pear rootstocks (*Pyrus betulaefolia* & *Pyrus communis* rootstocks).



LSD 0.05(No. of current shoots) S=NS, P=6.32, pH=10.08, P x pH=14.26, S x pH=14.26 and S x P=9.02	LSD 0.05 (No. of leaves) S=1.05, P=1.05, pH=1.67, P x pH = NS, S x pH = 2.36 and S x P=1.49
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Fig. 10. Effect of irrigation water pH on current shoots number / plant and leaves number/plant of *Pyrus communis* and *Pyrus betulaefolia* grown on sand and calcareous soil

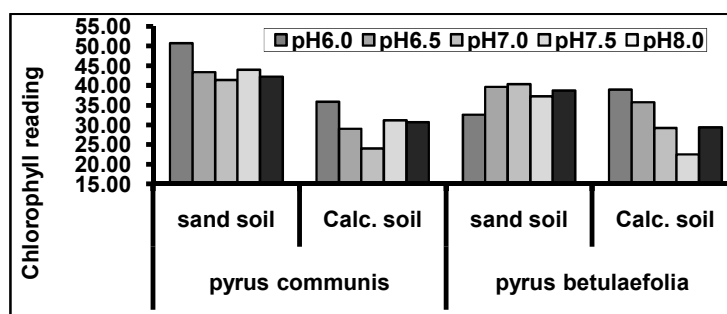
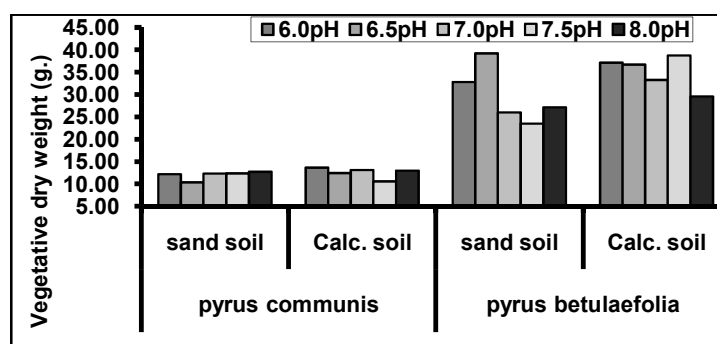


Fig. 11. Effect of irrigation water pH on chlorophyll reading of *Pyrus communis* and *Pyrus betulaefolia* grown on sand and calcareous soil



LSD 0.05 (chlorophyll reading)
 S=1.67, P=1.67, pH=2.64, P x pH=3.74, S x pH=3.74 and S x P=2.36

Fig. 12. Effect of irrigation water pH on vegetative dry weight g./plant of *Pyrus communis* and *Pyrus betulaefolia* grown on sand and calcareous soil

3.4.1 Root dry weight

Data illustrated by Fig. 13, clearly demonstrate that pH water irrigation degrees and types of soil affected on roots dry weight (g). It noticed that *Pyrus betulaefolia* rootstocks, gave the highest dry weight with pH 8.0 (44.61 g) in sand soil. Whereas, in Calc. soil pH 7.5 gave the highest result (51.63 g) in the two seasons. Also, the lowest dry weight recorded in pH 7.5 (29.82 g) under sand soil condition and pH 8.0(32.56 g) under calcareous soil in seasons 2011&2012.

In addition, data show that, *Pyrus communis* rootstocks, the highest dry weight (g) resulted from pH 6.0 in two types of soil (26.59 & 37.79 g). While, the least values of dry weight were shown in pH 7.0(20.99 g) in sand soil and In Calc. soil pH 6.5 (26.03 g) in both seasons under study. Statistical analysis cleared that there were significant effects on roots dry weight g./ plant for soils, rootstocks and interaction between soils & pH only.

3.4.2 Root length (cm)

All root length (cm) observations were occurred in Figs. 14, 15 and 16. These measures were length less than 0.1 cm, length ranging 0.1 to 0.2 cm and length greater than 0.2 cm.

3.4.2.1 Length less than 0.1cm

In this respect, *Pyrus betulaefolia* rootstock under sand soil condition recorded that the tallest mean value 16.61 cm followed by 16.12cm in pH 6.5 and pH 7.0 (Fig. 14). Whereas, in Calc. soil the best value was in pH 6.0 (14.19 cm) followed by pH 7.5 (13.91 cm). Moreover, the least value was with pH 8.0 (13.37cm) under sand soil condition but in calcareous soil, pH 6.5 gave the lowest length (9.12cm) in 2010 & 2011 seasons.

Pyrus communis rootstocks, data resulted that the tallest root were with pH 7.0 (11.66cm) under sand soil and (10.70 cm) in Calc. soil. As, the least length was recorded in pH 7.5& 8.0(8.65 & 8.35cm) under sand soil and in Calc. soil pH 6.5 recorded (8.97cm) in two seasons under study.

Statistical analysis cleared that there were significant effects on roots length less than 0.1cm. for all factors and its interactions except rootstocks & pH.

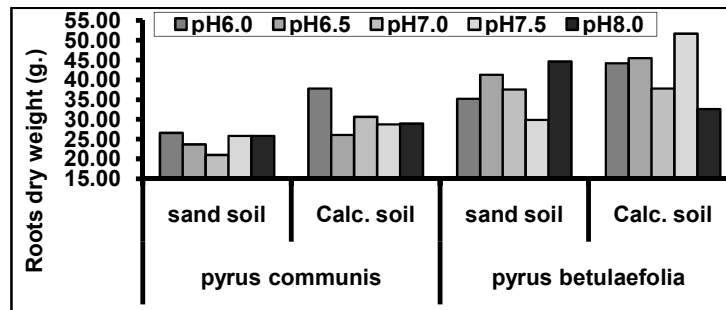
3.4.2.2 Length ranging 0.2 cm

It is quite evident from Fig. 15 that pH water significant affected on root length ranging from 0.1 to 0.2 cm of *Pyrus betulaefolia* rootstock under the two types of soil in seasons 2010-2011. pH 8.0 cased the tallest root (11.78 cm) ranging 0.2 cm in both seasons under sand soil while, in calc. soil it noticed that pH 7.5 gave the best length (15.91cm) followed by pH 7.0 (14.73 cm). In this respect, the lowest length was recorded in pH 7.0 (10.63 cm) in sand soil and pH 6.5 in Calc. soil (10.47 cm). *Pyrus communis* rootstock, responded positively, as well as, pH 6.5 gave the highest value (20.14 cm) in sand soil and pH 8.0 (18.44 cm) in calcareous soil. Whatever, the least value of the root length was

16.51 cm in pH 8.0 under sand soil and 10.03cm in calcareous soil, respectively in both seasons under study. ANOVA predicted significant effects for all studied factors on roots length from 0.1 to 0.2 cm.

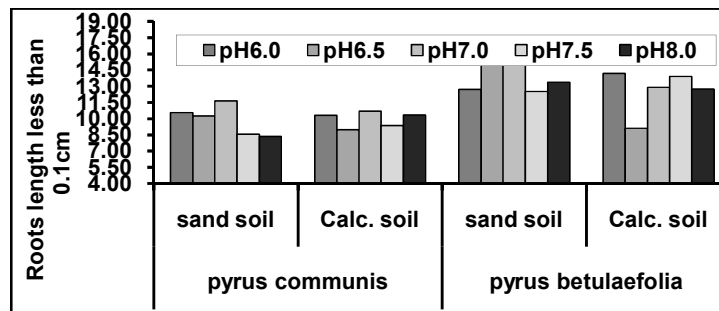
3.4.2.3 Length greater than 0.2cm

Root length more than 0.2 cm was clearly affected by pH irrigation water (Fig. 16). *Pyrus betulaefolia* rootstock, pH 6.0 recorded the highest roots length (14.03 cm) and pH 7.5 the lowest roots length (8.08 cm) in sand soil. As for, Calc. soil pointed that pH 7.0 increased the roots length (16.26 cm) whereas, pH gave the least root (11.24cm) in both seasons under study. Results revealed that *Pyrus communis* rootstocks, it was affected by using pH irrigation water, pH 6.5 gave the highest length greater than 0.2 mm 14.60 cm and the lowest value was 10.86 by pH 7.0 under sand soil.



LSD 0.05 S=2.45, P=2.45, pH=NS, P x pH= NS, S x pH = 5.48 and S x P= NS

Fig. 13. Effect of irrigation water pH on roots dry weight g. /plant of *Pyrus communis* and *Pyrus betulaefolia* grown on sand and calcareous soil



LSD,0.05 S=0.056, P=0.056, pH=0.089, PX pH=NS, SX pH=1.26, SXP= 0.80

Fig. 14. Effect of irrigation water pH on average roots length less 0.1 cm of *Pyrus communis* and *Pyrus betulaefolia* grown on sand and calcareous soils

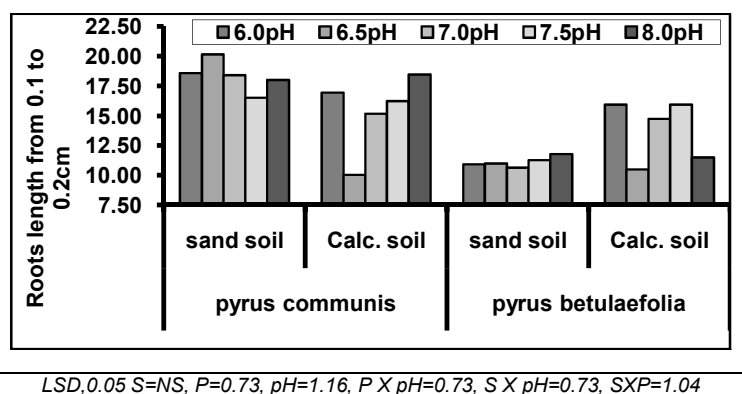


Fig. 15. Effect of irrigation water pH on average roots length ranging 0.1 to 0.2 cm of *Pyrus communis* and *Pyrus betulaefolia* grown on sand and calcareous soils

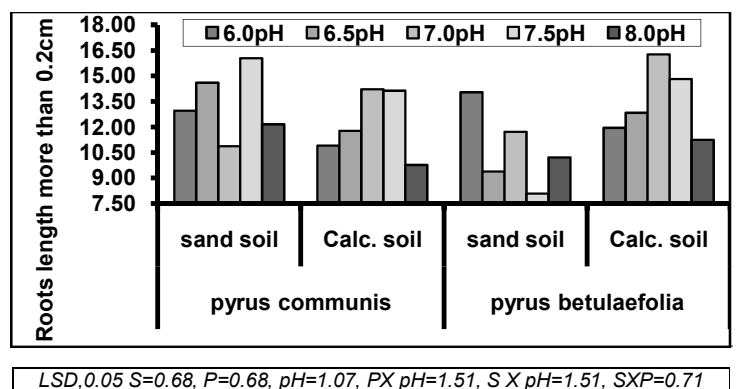


Fig. 16. Effect of irrigation water pH on average roots length greater than 0.2 cm of *Pyrus communis* and *Pyrus betulaefolia* grown on sand and calcareous soils

However, in Calc. soil pH 7.0 recorded a higher value (14.21 cm) and the least was 9.77 cm with pH 8.0. Statistical analysis showed that there were significant effects on roots length more than 0.2cm. for all mentions experiment factors and its interactions.

3.4.3 Roots number

3.4.3.1 Length less than 0.1cm

It can be noticed from (Fig. 17) that *Pyrus betulaefolia* rootstock affected by pH 6.0 in sand soil which gave the best number of roots less than 0.1cm (416.00 root/rootstock) compared with the other applied of pH degrees. Also, in Calc. Soil was pH 8.0 gave the highest number of roots (510.50 root /rootstock) less than 0.1 cm. *Pyrus communis* rootstock, Data revealed that pH 6.0 increased the number of roots less than 0.1cm (552.30root/rootstock) compared with the other pH degrees. Statistical analysis showed that there were significant

effects on roots number less than 0.1 cm for all mentions experiment factors and its interactions.

3.4.3.2 Lengths from 0.1to 0.2 cm

Regarding to (Fig. 18) roots number less than 0.2 cm, *Pyrus betulaefolia*, pH 6.0 was recorded the highest roots number (24.24root/rootstock) in sand soil and in Calc. soil pH 6.0 (29.90 root / rootstock) .

Pyrus communis rootstock, data clearly indicated that pH 6.0 affected positively in increasing roots number less than 0.2 cm (16.50 root/rootstock) in sand soil and(25.67 root/rootstock) in Calc. soil. But, pH 7.5 in sand soil (10.67 root/ rootstock) and pH 6.5 in Calc. soil (17.67 root /rootstock) affected negatively in roots number respectively. Statistical analysis showed that there were significant effects on roots number from 0.1cm. o 2.cm. for all mentions experiment factors and its interactions.

3.4.3.3 Length greater than 0.2cm

Data in Fig. 19 showed that, different pH degrees affected in roots number more than 0.2 cm in both rootstocks and two types of soils under studying in seasons (2011&2012).

Pyrus betulaefolia rootstocks, it noticed that pH 6.0 increased the roots number in sand soil (18.80 root/rootstock) and calcareous (16.21 root/ rootstock).The lowest roots number value was with pH 7.5 (12.46 root/rootstock) in sand soil and (13.86 root/rootstock) in Calc. soil. As for, *Pyrus communis* rootstock, data recorded that pH 7.0 gave the best roots number (11.00 root /rootstock) and the lowest number was by pH 6.5 (4.84 root/rootstock) in sand soil. Whereas, in calcareous soil pH 6.0 resulted the best number (10.84 root / rootstock) and the least was (4.84 root /rootstock) in pH 6.5.

Statistical analysis showed that there were significant effects on roots number more than 0.2cm for all mentions experiment factors and its interactions.

Generally, the best result (roots number) were obtained with the PH 6.0 for the *Pyrus betulaefolia* rootstocks grown in sand soil and pH in Calc. soil. Whereas, *Pyrus communis* were pH 7.0 in sand soil and pH 6.0 in Calc. soil. From all data of vegetative growth predicted that *Pyrus betulaefolia* was more tolerant than *Pyrus communis* to pH values variations in irrigation water under both sand and calcareous soils. *Pyrus betulaefolia* was higher than *Pyrus communis* in all vegetative growth values with %72 and %91 in sand and calcareous soil respectively. Also, it noticed that root system goes in a parallel with vegetative growth due to the significance of treatments interaction.

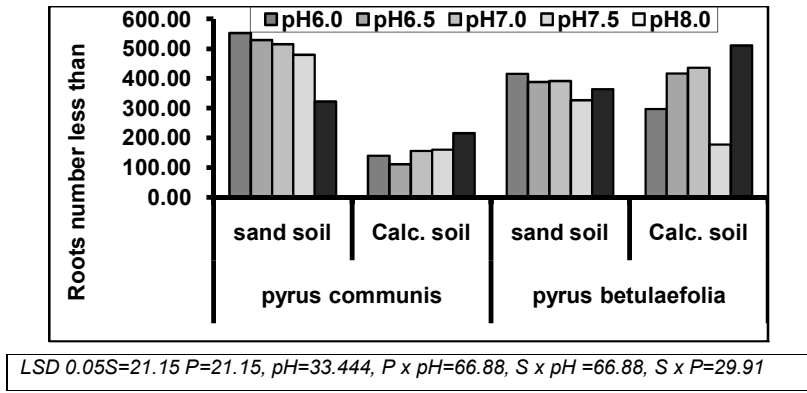


Fig. 17. Effect of irrigation water pH on average roots number less 0.1 cm of *Pyrus communis* and *Pyrus betulaefolia* grown on sand and calcareous soils

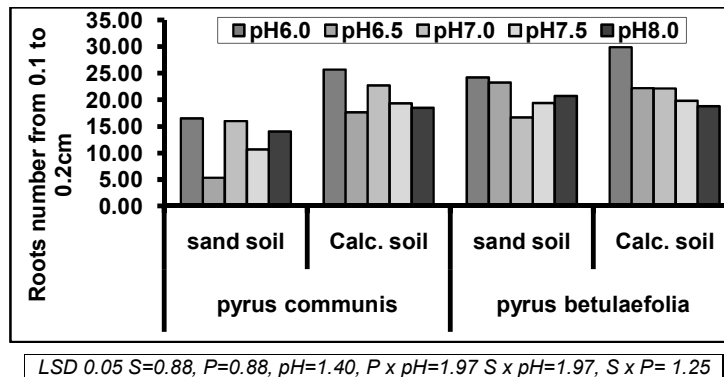


Fig. 18. Effect of irrigation water pH on average roots number ranging 0.1 to 0.2 cm of *Pyrus communis* and *Pyrus betulaefolia* grown on sand and calcareous soils

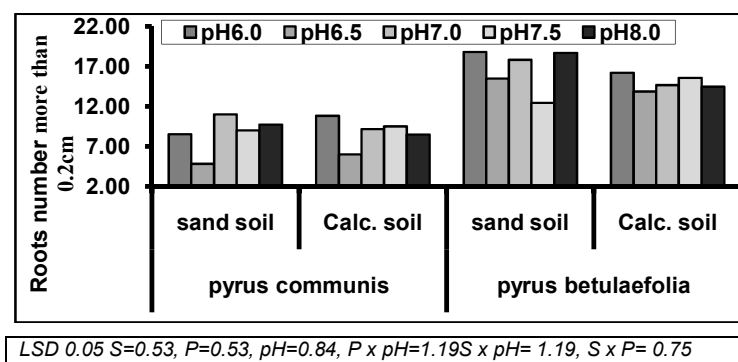


Fig. 19. Effect of irrigation water pH on average roots number greater than 0.2 cm of *Pyrus communis* and *Pyrus betulaefolia* grown on sand and calcareous soils

4. CONCLUSION AND RECOMMENDATIONS

The results of this study can be summarized that irrigation water pH and soil type showed significant effects on the studied vegetative growth parameters and some of tested soil measurements. Data cleared the importance nature of pH source of irrigation water or chemical analysis of irrigation water; sodium salts well different in comparison with potassium salt source. Amount of N and K addition through irrigation water, to get different pH values, was negligible amount in comparison with its quantities of fertilizer addition.

From all data of vegetative growth predicted that *Pyrus betulaefolia* was more tolerant than *Pyrus communis* to pH values variations in irrigation water under both sand and calcareous soils. Analysis of available micro nutrients in the soil and pear leaf composition of micro nutrients showed that although most of available micro nutrients in the soil were high, the composition of pear leaves from micro nutrient were low. This mean that the importance of spray micro nutrients fertilization.

The quality of irrigation water available to farmers and other irrigators has a considerable impact on what plants can be successfully grown, the productivity of these plants, and water infiltration and other soil physical conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Jones AL, Aldwincjkle HS. Compendium of apple and pear diseases. APS Press The American Phytopathological Society, 2nd Ed. 1990;2-4.
- Douglas Cox. Water Quality: pH and Alkalinity. Plant and Soil Sciences University Massachusetts Amherst August 1995. United States Department of Agriculture National Institute of Food and Agriculture©2013 University of Massachusetts Amherst • Site Policies Civil Rights and Non-Discrimination Information .This site is maintained by Center for Agriculture in the College of Natural Sciences.
- Tagliavini M, Bassi D, Marangoni B. Growth and mineral nutrition of pear rootstocks in lime soils. Horticulturae. 1993;54(1):13-22.
- Melake berhan H, Bird GW, Jones AL. Soil pH affects nutrient balance in Cherry Rootstock Leaves. HortScience. 2001;36:837-998.
- Marini RP. Growing Pears in Virginia. Virginia Cooperative Extension. 2002;Publication Number 422-017.
- Schaffer B, Davies FS, Crane JH. Responses of subtropical and tropical fruit trees to flooding in calcareous soil. HortScience. 2006;41:549-555.
- Dean Wiegers. pH measurements in Irrigation Water. Agriculture and Greenhouse Specialist Hanna Instruments dwiegers@hannainst.com; 2013.
- Bauder TA, Waskom RM, Sutherland PL, Davis JG. pH and Alkalinity. Colorado State University factsheets, Managing Saline Soils 0.503 and Managing Sodic Soils 0. 504. Updated Friday, April 19,

- 2013 .USDA/NRCS area resource conservationist; 2013.
9. Lindsay WL, Norvell WA. Development of DTPA Soil test for Zn, Fe, Mn and Cu . Soil Sci. Soc. Amer. J. 1978;42:421.
 10. Black CA, Evans DD, Ensming LE, White JL. Methods of soil analysis. Agron. Sever No. 9. Amer. Soc. Agron. Inc. Madison, Wisconsin, USA; 1965.
 11. Page AI, Miller RH, Keeney DR. Methods of Soil Analysis. Part 2: Chemical and Microbiological properties. 2nd Ed. Amer. Soc. of Agron. Madison, Wisconsin, USA; 1982.
 12. Evenhuis B, Dewaard PW. Principles and practices in plant analysis inst., Amsterdam Paper. 1980;15:152-163.
 13. Evenhuis B. Simplified methods for foliar Analysis Koninklijk Instituut voor de tropen, Amsterdam. 1978;1-17.
 14. Murphy S, Riley JP. A modified single solution method for the determination of phosphate in natural water. Anal. Chim. Acta. 1962;27:31-36.
 15. Jackson NL. Soil chemical analysis. Prentice-Hall Inc. Englewood Cliffs, NS. 1967;15.
 16. Jackson NL, Ulrich A. Analytical methods for use plant analysis. Coll. of Agric., Exp. State Bull. 1959;766:35.
 17. Yoshida S, Forno DA, Cock JH, Gomez KA. Laboratory manual for synthesis. J. Plant Physiol. 1972;59:569-57.
 18. Snedecor GW, Cochran GW. Statistical Method. 7th Ed. The Iowa State Univ. Iowa, USA. 1990;85-86.
 19. USDA Salinity Laboratory Staff Diagnosis and improvement of saline and alkali soils. USDA, Handbook. 1953;60:160.
 20. Wolf TK, Pool RM. Effects of rootstock and nitrogen fertilization on the growth and yield of Chardonnay grapevines in New York. Am. J. Enol. Vitic. 1988a;39:29-37.
 21. Ruhl EH. Uptake and distribution of potassium by grapevine rootstocks and its implication for grape juice pH of scion varieties. Aust. J. Exp. Agric. 1989;29:707 - 712.
 22. Kiekens L. Zinc, in Alloway B.J. (ed) Heavy Metals in soils (2nd edn) Blackie Academic and professional, London. 1995;284-305.
 23. Uygur V, Rimmer DL. Reactions of zinc with iron coated calcite surfaces at alkaline pH. European Journal of Soil Science. 2000;51:511-516.
 24. Reuter DJ, Robinson JB. Plant analysis, an Interpretation Manual. In kata Press Melbourne. Sydney; 1986.
 25. Marschner H. Mineral nutrition of higher plants, 2nd ed., P889. Academic Press, London; 1997.
 26. Candolfi -Vasconcelos MC, Castagnoli S, Baham J. Grape rootstocks and nutrient uptake and efficiency. In proceedings of the Oregon Horticultural Society, Portland, Or. 1997;279.
 27. Degryse F, Smolders E, Parker DR. Metals complexes increase uptake of Zn and Cu by plants: Implications for uptake add deficiency studied in chelator-buffered solutions. Plant and Soil. 2006;289:171-185.
 28. Chunhi Ma, Kenji Tanabe, Akihiro Itai, Fumio Tamura, Jong - Pil Chun and Yuan wen Teng. Tolerance to Lime - induced Iron chlorosis of Asian pear rootstocks (Pyrus SPP). J. Japan. Soc. Hor. Sci. 2005;74(6):419-423.
 29. Keller M, Kummer M, Vasconcelos MC. Soil nitrogen utilisation for growth and gas exchange by grapevines in response to nitrogen supply and rootstock. Australian Journal of Grape and Wine Research. 2001;7:2-11.
 30. Bavaresco L, Frascini P, Perino A. Effect of rootstock on the occurrence of lime-induced chlorosis of potted *Vitis vinifera* L. cv. 'Pinot blanc'. Plant Soil. 1993;157:305-311.

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