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Effect of soil salinity and acidity on the germination of *Quercus emoryi* and *Robinia neo-mexicana* seeds

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EFFECT OF SOIL SALINITY AND ACIDITY ON THE GERMINATION OF QUERCUS EMORYI AND ROBINIA NEO-MEXICANA SEEDS

by

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STATEMENT BY AUTHOR

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DEDICATION

I dedicate this work to my wife, Dalal,

and to my children Ahmed, Khaled and Ziad.

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ABSTRACT

The purpose of the study was to determine the effect of four salt concentrations and four acid levels of soil solution on the germination od Quercus emoryi and Robinia neo-mexicana seeds, and to study the effects of the cation concentration changes in solution (Na, Ca, Mg, K) and exchangeable cation concentration. The solution extracts and exchange phases of both soils, salt accumulation in the soil increased by increasing the salinity and acidity of the water applied. Exchangeable sodium was related directly to the SAR of the applied solutions. The soil responded differently to the salty water and acid water. Both soil treatments released Ca, Mg and K to the soil solution from the dissolution of the primary minerals and cation exchange reaction.

CHAPTER 1

INTRODUCTION

Soil, which covers most of the land surface of the earth, ranges from a few centimeters to several meters in depth. Plants and animals play an important role in soil-formation processes. Soil formation is extremely slow in moist and warm climates; it takes thousands of years to form a few centimeters of soil. In cold and dry climates, it takes even longer, or soil may not form at all. As soil is a renewable resource, its slow rate of formation makes it practically irreplaceable.

Good soils hold the greatest populations of bacteria. Almost without exception, bacteria are involved in basic enzyme transformations that make the growth of higher plants possible including our food crops.

Chemical reactions occur in the soil as a result of exchange of cations. These chemical reactions are also essential for seed germination, plant growth and development and a good index of soil fertility. Fortunately, the soil has a considerable capacity to detoxify chemicals added to it.

Under climatic conditions favorable for a given tree specie, productivity depends solely on soil conditions. Trees grow and seeds germinate at higher rates on soils with favorable silvicultural conditions; arboreal species are more resistant to pests. The vital functions of damaged trees are more restored under favorable soil conditions. The arboreal vegetation extracts nutrients and moisture out of the soil. Successful development of vegetation is possible only on those soils which ensure full, uninterrupted provision of all the required nutritive elements as well as moisture available to the vegetation.

Sufficient soil aeration also is required to ensure the inflow of oxygen and the removal of CO_2. Direct interaction between higher plants and soil is carried out through the root system. The plants absorb both moisture and nutrients out of the soil and transfer them from the points of absorption to the aerial parts of the plant.

Using saline water for irrigation increases the soil salinity and may raise the water table. The problem is accentuated when these waters contain high concentrations of Na in relation to Ca and Mg, which will cause the deterioration of soil physio-chemical properties, and water logging and deposition of soluble salt in the soil profile that will severely restrict or eleminate the crop growth (James et al., 1982).

When soils are irrigated with saline water, the main exchange occurs between sodium in the water and calcium, magnesium and potassium on the soil complex, that ruled by ratio law which describes the equilibrium between cations of soil solution and those at exchange phases (Schofield, 1974; USSL Staff, 1954). Thus, understanding the chemistry of soil solution by knowing the quantitative relationship between major ions in solution and in soil should enable us to predict and control ion exchange in irrigated soils with low quality water and to maintain the soils productivity and monitor soil salinity and finally, improving the soil management.

The objectives of this study were to:

1. Study the cationic composition changes in the soil solution.

2. Determine the response of the soil to the addition of various types and amounts of salinity and acidity.

3. Determine the effect of four salt concentrations and four acid levels of soil solution on the germination of Quercus emoryi and Robinia neo-mexicana seeds.

4. Provide suggestions on the germination of Quercus emoryi and Robinia neo-mexicana.

CHAPTER 2

LITERATURE REVIEW

Germination of Seeds

The size and shape of seeds are variable, depending on the form of the ovary, the condition under which the parent plant is growing during the seed formation and the species. The characteristics of polymorphis seeds differ not only in shape or color, but also in their germination behavior and dormancy (Mayer, 1982).

The "normal" seed contains materials which are utilized in the process of germination. There frequently are present in the endosperm, which can contain a variety of storage material such as starch, oil, proteins or hemicelluloses.

Many seeds will not normally germinate under water, and if such seeds are kept under water for any length of time, their viability frequently becomes impaired. Other species can withstand being placed under water.

Many seeds do not germinate when placed under conditions which are normally regarded as favorable to germination, namely an adequate water supply, a suitable temperature and normal composition of the atmosphere. Such seeds can be viable, as they can be induced to germinate by various special treatments, and are said to be dormant or to be in a state of dormancy. Dormancy can be due to various causes, such as immaturity of the embryo, impermeability of the seed coat to water and gases, prevention of embryo development due to physiological causes, special requirements for temperature or light and the presence of substances inhibiting germination.

Soil Conditions

When seeds are buried in the soil, their germination behavior can be affected in various ways; for instance, cyclical change in dormancy may occur (Karssen, 1980/81). Properties of the soil, such as its structure and composition, affect germination because they determine the microhabitat of the seed.

Physical properties of the soil will determine the water holding capacity and aeration of soil as well as its hydraulic conductivity which, in turn, determines the rate of flow of water to the seed. Particle size of the soil will influence contact between the seed and its substrate, and through it the amount and the rate of water taken up by the seed (Hadas, 1977; Radas and Russo, 1974). The total soluble solids can affect germination through asmolarity and through ionic strength.

Different theories have been suggested to describe the optimal conditions for soil-water relationship in the microenvironment of germination seed. One theory assumes that there is a critical soil water potential permitting germination which is characteristic of each species (Hunter and Erickson, 1952). Another theory is based on the seed-soil contact. It was shown that when seed-soil contact was poor, the germination percentage was reduced even at high water potential of soil (Collis, George and Hector, 1966). Apparently, the soil-water matric potential is the important factor.

High salt content on the soil, especially of sodium chloride, can inhibit germination due primarily to osmotic effect. In such saline environment, the development of the seedling is extremely poor. However, a number of plants which have a special resistance to salt can develop. This type of vegetation is termed halophytic. Many of the plants so classified are distinguished by a high salt tolerance in various stages of their development, including germination rather than by a positive salt requirement. High salt tolerance. therefore, is not a proof that the plant is halophytic. But, some plants show a definite requirement for a certain salinity, and these germinate better in the presence of low concentration of salt and their subsequent development is also better.

It should be remembered that soils are quire heterogeneous. Germination and seedling establishment can be determined by microheterogenity in the soil. In germination studies, there is often a discrepancy between the germination percentage achieved under laboratory conditions and that achieved for the same stock of seeds in the field.

Soil Salinity and Acidity

The pH is the most commonly measured soil characteristic. Certainly, it is the most widely used criterion for judging whether the soil is acid, and if so, how acid (Seats and Peterson, 1964). The pH range for acid soils is from 4 to 6. The laboratory factors affecting soil pH in the arid region are thought to be the soil/water ratio and salt content of the soil/water slurry.

The main effect of salt concentration on soil pH is not through its influence on the suspension effect, but rather through cation exchange. Soil pH, lower in salt solutions than in water, decrease as salt concentration increases because of the displacement of (H) and (Al) ions from exchange sites (Peterson, 1967). Mitchell (1932) stated that ion exchange sites are found primarily on clays and soil organic matter, although all soil materials have some ion exchange capacity. In fact, soil is variable and heterogeneous because soil is formed from various chemical elements and individual molecules depending upon the nature of formation that controls its variability.

The effect of saline irrigation water on soil types is not the same. The texture of the soil tends to modify the effect to a large extent due to the influencing of texture on the moisture retention, and ion exchange release of ion by mineral dissolution. Lal and Singh (1974) reported that different soils were differently affected by the use of the same quality and quantity of irrigation water. Furthermore, they suggested that low quality waters can be used in coarse textured permeable soils.

Plant tolerance to salinity usually is appraised in one of three ways:

1. The ability of the plant to germinate and survive on saline soils.

2. The absolute plant growth or yield.

3. The relative growth or yield on saline soil as compared with that on non-saline soil (Maas, 1966).

Salinity affects plants at all stages of development, but sensitivity sometimes varies from one growth stage to the next. A comparison of salt tolerance during germination and emergence with later growth stages is difficult because different criteria must be used to evaluate plant response.

Ion adsorption is the tendency of solid surface to attract a layer of ions from the soil solution. The atomic structure of both the solid and liquid phase on either side of the plane of contact differs from the bulk soil and solution (Bolt, 1976). However, the adsorption of ions on the soil particles depends upon the total service area, especially clay, organic matter and salt fraction.

The capacity of the soil to adsorb cations is a function of particle size, temperature, soil moisture, tension, pH, oxidation potential and activity of ion present. It can be determined by utilizing the Langmuir adsorption isotherm (Olsen and Watanabe, 1967).

The solubility of minerals increases as the salt concentration of the soil solution increases. The solubility of gypsum and Ca and Mg carbonates increases as the NaCl and Na_2SO_4 concentrations increase in soil solution (Kovda, 1946). Therefore, the activity coefficient of divalent cation decreases faster with increasing salt concentration than the activity coefficient of monovalent ions.

A pH value of 7.5 or more indicates that some free carbonates of calcium of magnesium are present. Soils over 8.5 nearly always contain exchangeable sodium. Low pH values in tropical climates, on the other hand, indicate free aluminum levels which can hinder plant growth considerably (Weber, 1986). Hydrogen ions are displaced by salts contained in soils; salt also increases the hydrolysis of Al and Fe ions, increasing the H ions in solution (Chang and Thomas, 1963; Coleman et al., 1964).

Toxicity Hazards

Toxicity hazards of irrigation water occur from the presence of certain ions tend to accumulate to a concentration, that is, high enough to cause plant damage and yield reduction (Ayers and Westcot, 1985). Toxicity problems occur with a crop as a result of water uptake and the accumulation of these ions in plant tissues. The primary ions that contribute to toxicity problems are Na, NaCl, Cl and B (Bohn, McNeal and O'Connor, 1979).

Sodium toxicity also can be a problem, even at exchangeable sodium percentage levels below these which produce unfavorable soil physical conditions. Sodium tolerant crops can be affected by physical and chemical characteristics of sodic soil that reduce water movement and restrict aeration. High SAR values of irrigation water tend to raise the pH values of soil, which tends to decrease the availability of certain plant nutrients such as P, Zn, Mn and Fe (Bohn, McNeal and O'Connor, 1979). Toxicity problems will develop more rapidly as the concentration of toxic ions increase in the supplied water. Ion absorption is the tendency of solid surfaces to attract a layer of ions from the soil solution.

Cation Exchange Equation

The estimation of potential hazard of irrigation water is difficult to compute due to the insufficient knowledge of the absolute concentration value of the various cations and anions in the water, and to complexity and heterogeneity of natural soil system which involves the presence of different cations to be included into cation exchange. Many cation exchange equations have been proposed to describe the relationship between the distribution of cations in a mixture of soluble and exchangeable cations at equilibrium between the exchange complex and the solution. There are two theoretical approaches used to derive cation exchange equations to permit an estimation of the exchangeable sodium percentage of soils from their SAR value and the changes in soil ESP (exchangeable Na percent) as a result of application of the irrigation water of known composition.

1. Diffuse double-layer theory

This theory describes the molecular interaction and the columbic force that operates exchange reaction.

2. Statistical thermodynamic exchange theory

This theory is based on the law of mass action, that states that a reversible reaction will proceed towards the direction that produces equilibrium. It also suggests that both reactions will occur simultaneously in an aqueous soil suspension. However, it gives no direct information about the molecular mechanism and the forces that take place to operate the system (Shaeberg and Letey, 1987).

Several efforts have been expended to describe the exchange reaction in soil solution and exchange phase from the calculation of the equilibrium exchange constant, as follows:

$$2Nax + Ca^{++} \rightleftharpoons Cax_2 + 2Na^+$$

where x is the exchange phase.

Therefore, the exchange equilibrium constant K for the reaction is given by:

$$K = \frac{(Na)^2\ (Cax_2)}{(Nax)^2\ (Ca)}$$

where the parentheses represent the activity of chemical constituent, and x is the equivalent of exchange anions.

The sodium adsorption ratio (SAR) is defined as:

$$SAR = \frac{(Na)}{((Ca+Mg)/2)^{1/2}}$$

where the concentration of soluble cation are in milliequivalent per liter. The ESP can be calculated by the following equation:

$$ESP = \frac{(-0.0126 + 0.1475 \times SAR)}{1+(-0.0126 + 0.01475 \times SAR)} \times 100$$

CHAPTER 3

MATERIALS AND METHODS

The soil utilized in this study was collected from southern Arizona, specifically from Carr Canyon near Sierra Vista. Selected chemical properties of the top 25-cm layer of this soil is presented in Table 12.

Greenhouse Study

Plastic containers were used in conducting this study. These containers had closed bottoms. Soil samples were air-dried, well mixed and passed through a 2 mm sieve. An equal amount of soil (3.3 per container) and 3 seeds of Quercus emoryi and Robinia neo-mexicana were uniformly packed inside each container. Q. emoryi seeds were collected from Sierra Vista, Arizona and R. neo-mexicana seeds were gathered in Tucson, Arizona (Christopher City, the University of Arizona family housing). The two species, Q. emoryi and R. neo-mexicana, are used in southern Arizona extensively for fuel wood.

Four different salt concentrations (0.000 M, 0.05 M, 0.10 M and 0.20 M of NaCl) and four acid levels (0.000 M, 0.075 M, 1.10 M and 0.15 M of H_2SO_4) were studied separately for the salt and acid treatments. These experimental waters were made by adding appropriate quantities of NaCl and H_2SO_4 to deionized water. The control (deionized water) and the four saline waters were designated as WS_1, WS_2, WS_3 and WS_4, and four acid waters were designed also as WA_1, WA_2, WA_3 and WA_4. Deionized water was used to simulate rainfall for comparison.

Table 1. Selected chemical characteristics of the soil.

Soil Parameters	
pH (1:1)	3.85
EC (dS/m) (1:1)	0.55
Soluble cation (meq/L)	
Na	.13
Ca	4.40
Mg	1.25
K	.33
Exchangeable cation (meq/L)	
Na	0.16
Ca	1.14
Mg	0.231
K	0.14
SAR	0.2

Six irrigation treatments were applied to the soil container at a rate of 150 ml per irrigation. The irrigations were applied as follows:

Day	Type of Irrigation
0	treated water
1	
2	treated water
3	
4	normal water
5	
6	normal water
7	
8	treated water
9	
10	treated water
11	
12	normal water
13	
14	normal water
15	
16	treated water
17	
18	treated water
19	
20	normal water every two days until seedlings became 60 days old.

A greenhouse experiment was conducted at The University of Arizona. The design of the study was completely randomized. This design is simple and flexible. The design layout of plots was as follows: 4 treatment x 4 replications and they were randomly placed in plastic containers in the greenhouse using alpha level of 0.05. The observations of the data were collected based on the germination of seeds in each container after 60 days from planting.

Soil Analyses

The soil was air-dried and 1:1 soil:water extract obtained. Extracts were analyzed for EC, pH, Na, Ca, Mg and K. Exchangeable soil Na, Ca, Mg and K were extracted by ammonium acetate. The samples were analyzed at The University of Arizona.

Procedures used to analyze the soil followed those in USDA Handbook No. 60. Water soluble salts and exchangeable Na and K were determined by flame emission while Ca and Mg were determined by atomic absorption spectrophotometry.

CHAPTER 4

RESULTS AND DISCUSSION

The concentrations of salts in soils is a function of several factors, such as salt concentration of irrigation water,quantity of water applied, salt dissolved from soil, and salt precipitated (Levy et al., 1983). The application of low quality water to soil adds considerable amounts of ions and alters soil physical and chemical properties. However, soil texture, mineralogy, exchange reactions and the composition of soluble and exchangeable cations tend to modify the effect to a large extent (McNeal et al., 1968); Rhoades et al., 1968).

Salinity Treatment

The mean of EC, pH, germination of seed and soluble cation concentrations are presented in Table 2. Table 2 and Figure 1 show a significant difference between the treatments and among the treatments and control with the EC value increasing as the EC of the applied water increased.

EC

The indicated differences between the different EC values of different treatments is attributed to the difference in the EC values of applied waters. Therefore, all applied water resulted in higher EC values than the control. Waters with lower EC resulted in higher germination of seed.

Table 2. Means of EC, pH, soluble Na, Ca, Mg, K and germination of *Robinia neo-mexicana* seeds for different salinity treatments after water application.

Treatment	1	2	3	4	Mean
		dSm^{-1}			
EC					
WS1	0.45	0.46	2.25	0.22	0.35
WS2	2.8	2.5	2.6	2.5	2.6
WS3	5.5	5.5	5.3	4.3	5.15
WS4	10.5	7.5	8.2	8.7	8.73
pH					
WS1	4.75	3.85	4.9	4.95	4.61
WS2	4.7	4.85	4.85	4.75	4.54
WS3	4.85	4.65	4.25	3.85	4.40
WS4	4.75	4.73	3.85	3.75	4.27
		meq $liter^{-1}$			
Na					
WS1	0.70	1.17	1.17	0.91	0.99
WS2	18.17	18.61	17.83	11.57	16.55
WS3	41.13	40.43	35.87	30.52	36.99
WS4	73.04	61.39	74.17	60.43	68.89
Ca					
WS1	2.45	2.28	1.93	1.20	1.96
WS2	3.20	3.43	2.48	2.98	3.02
WS3	4.98	5.03	5.08	4.53	4.90
WS4	7.63	5.33	10.23	8.95	8.04
Mg					
WS1	0.80	0.79	0.69	0.20	0.62
WS2	1.67	1.13	0.86	1.06	1.18
WS3	1.59	0.82	1.61	1.46	1.37
WS4	1.97	1.69	2.10	2.30	2.02
K					
WS1	0.58	0.72	0.76	0.28	0.59
WS2	1.40	1.40	1.12	0.91	1.21
WS3	1.67	1.59	1.35	1.40	1.50
WS4	2.36	2.04	2.35	2.10	2.28
		%			
Germination of *Robinia neo-mexicana* seed					
WS1	100	67	67	100	83
WS2	67	33	67	67	58
WS3	33	33	33	0	25
WS4	0	0	0	0	0

Alpha level of 0.05.

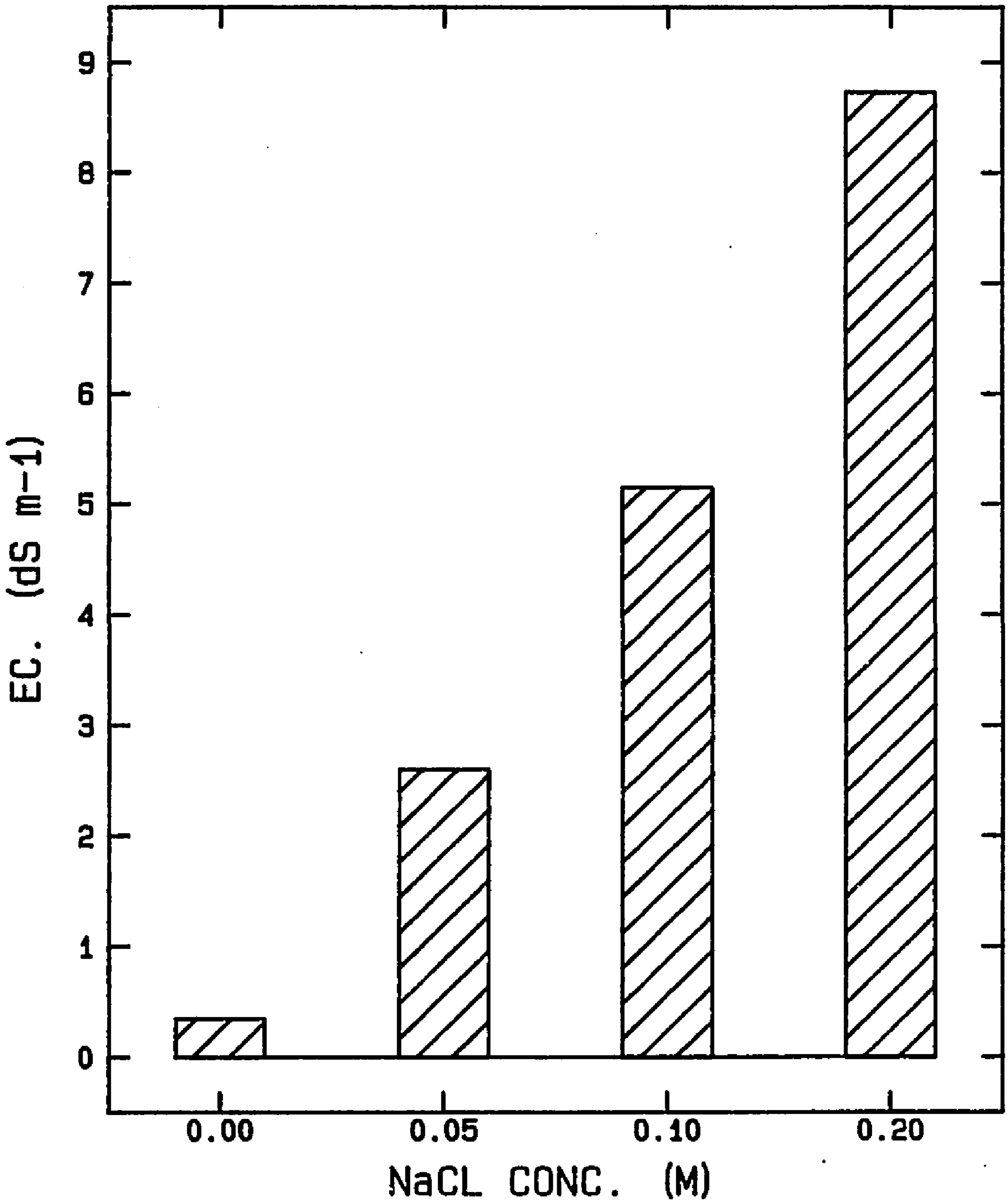

Fig. 1. Mean electric conductivity vs. NaCl concentration.

pH

The pH tends to reflect the amount of salts present. The pH results in Table 2 and Figure 2 indicate that pH decreased with increasing salt content of the water applied. The decrease of pH value with increasing salt concentration can be attributed to the depression of the thickness of diffuse double layer at higher soluble salt (Russel, 1961). Importantly, this decrease was insignificant between the treatments.

Total Soluble Salt (EC) in Soil

The results show that the chemical composition of soluble salt in the soil was closely related to the salt content of waters applied. Table 2 and Figure 3 also indicate that the water soluble salt concentrations were significantly different from each other.

Ca

Considering Ca concentrations, there is a difference among the treatments and between the treatments and control. All the treatments showed higher Ca concentration released from the soil than control with the concentration being more pronounced a the amount of salt increased in the applied water.

Na

Sodium concentration increased with increasing concentration of salt in the water applied. Table 2 and Figure 3 show a significant difference between the treatments and among the treatment and control.

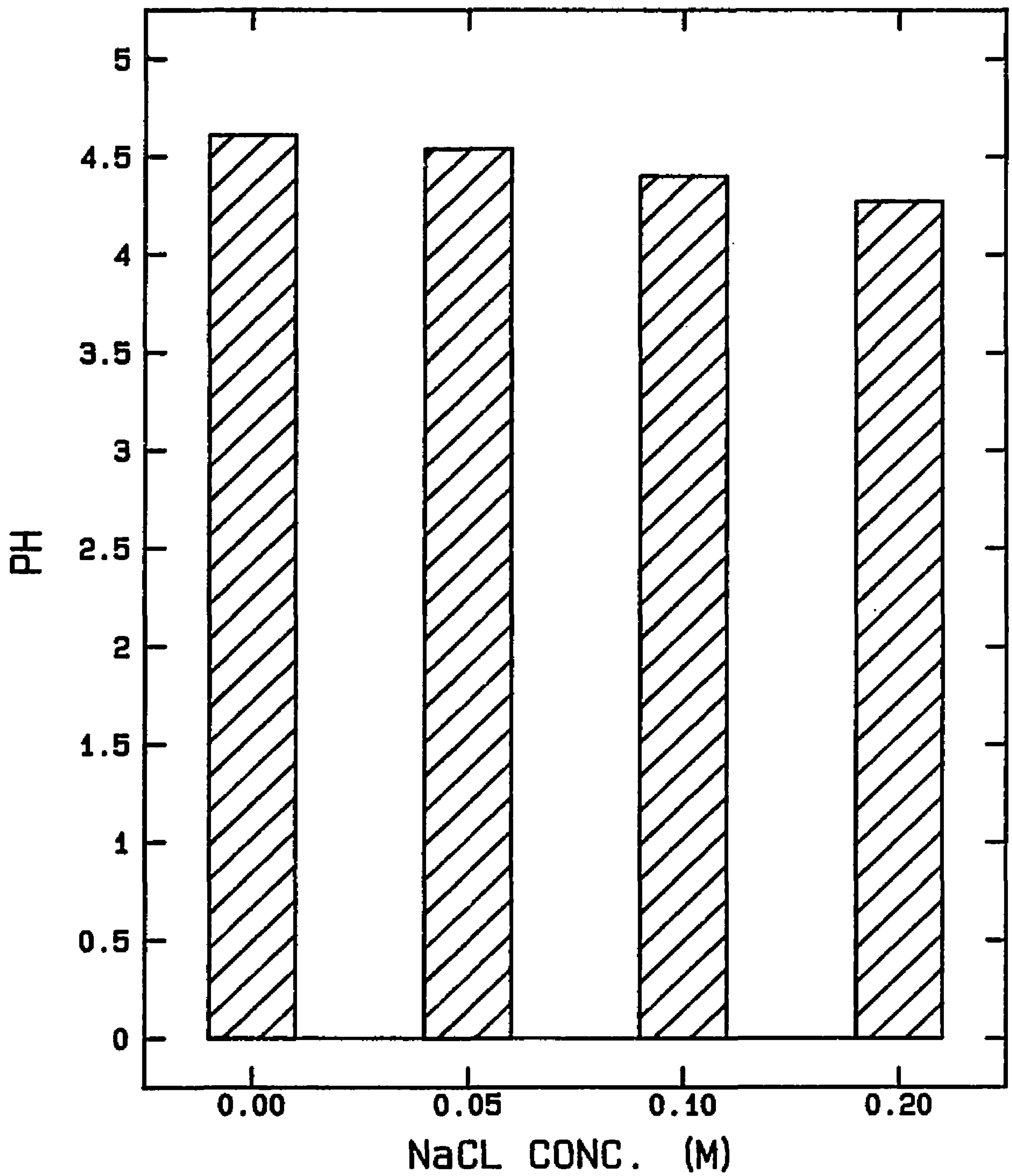

Fig. 2. Mean pH vs. NaCl concentration.

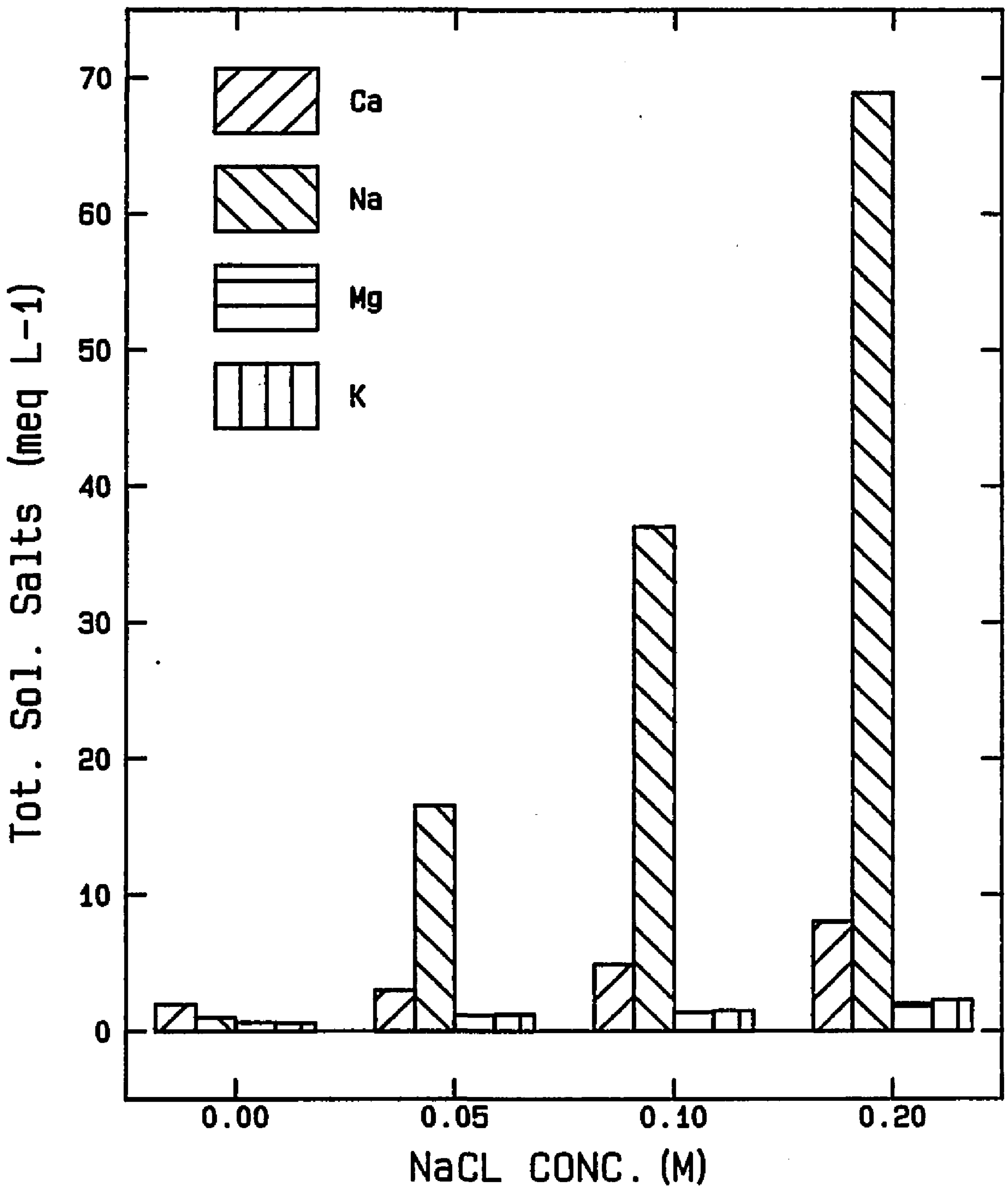

Fig. 3. Mean total soluble salts vs. NaCl concentration.

It is clear from the experimental data that Na concentration is related to Na concentration of the applied water.

Mg

The applied water released some Mg from the soil. There was a significant difference between the treatment and among the treatment and control and between WS1 and WS4.

K

There was a significant difference between the treatment and control and a significant difference between the treatment WS2 and WS4 and a significant difference between the treatment WS3 and WS4.

SAR

The change in SAR value (Table 3 and Fig. 4) show that SAR increased with increasing amount of salts in the added water; this was due to SAR increasing (by the square root) of the salt concentration (James et al., 1982). It can be seen from Figure 4 that the SAR was initially modified by the soluble salts of soil produced from dissolution of calcium carbonate and exchange reaction, which tends to decrease Na concentration at the soil solution by replacing Na for Ca. Therefore, it was followed by an increase in SAR due to the further addition of Na by applied waters.

Exchangeable Cation Concentration

The salt water effectively increased the exchangeable Na, while Ca, and Mg decreased similarly (Table 4 and Fig. 5) as reflected by increasing the SAR of the soil extract. The amount of exchangeable Ca,

Table 3. Means of SAR and ESP of soil for different salt treatments after water application.

	Treatment			
	WS1	WS2	WS3	WS4
SAR (S)	0.87	11.4	20.89	30.70
ESP (S)	2.57	13.48	22.81	20.57
SAR (E)	0.26	0.55	0.88	1.46
ESP (E)	0.88	0.44	0.36	0.88

(E) Exchangeable cation.

(S) Total soluble salts.

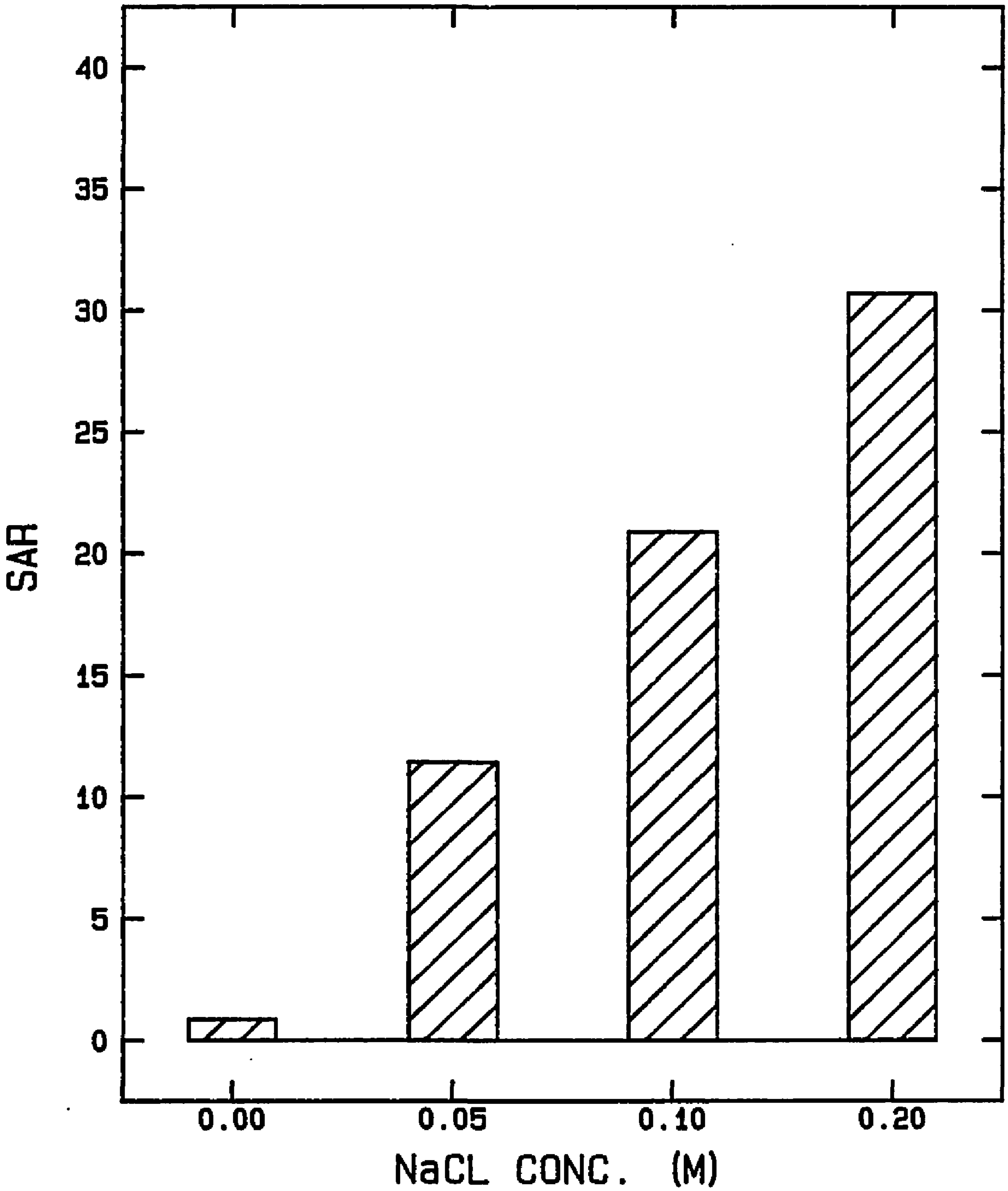

Fig. 4. Mean of sodium absorption ratio vs. NaCl concentration.

Table 4. Mean of exchangeable Na, Ca, Mg and K in the soil for different salt treatments after water application.

Treatment	1	2	3	4	Mean
	--------------------	meq/liter	----------------		
Na					
WS1	0.17	0.33	0.14	0.18	0.21
WS2	0.49	0.41	0.49	0.38	0.44
WS3	1.38	0.54	0.55	0.72	0.70
WS4	1.33	1.48	0.73	1.07	1.15
Ca					
WS1	1.12	1.21	1.00	1.04	1.09
WS2	1.15	1.06	0.97	1.12	1.07
WS3	1.31	0.98	0.93	1.07	1.07
WS4	0.97	1.27	0.95	1.06	1.06
Mg					
WS1	0.21	0.24	0.22	0.25	0.23
WS2	0.19	0.19	0.19	0.19	0.19
WS3	0.21	0.17	0.17	0.24	0.20
WS4	0.15	0.19	0.18	0.19	0.18
K					
WS1	0.19	0.24	0.26	0.17	0.22
WS2	0.13	0.12	0.14	0.16	0.14
WS3	0.24	0.14	0.16	0.20	0.19
WS4	0.13	0.22	0.18	0.20	0.18

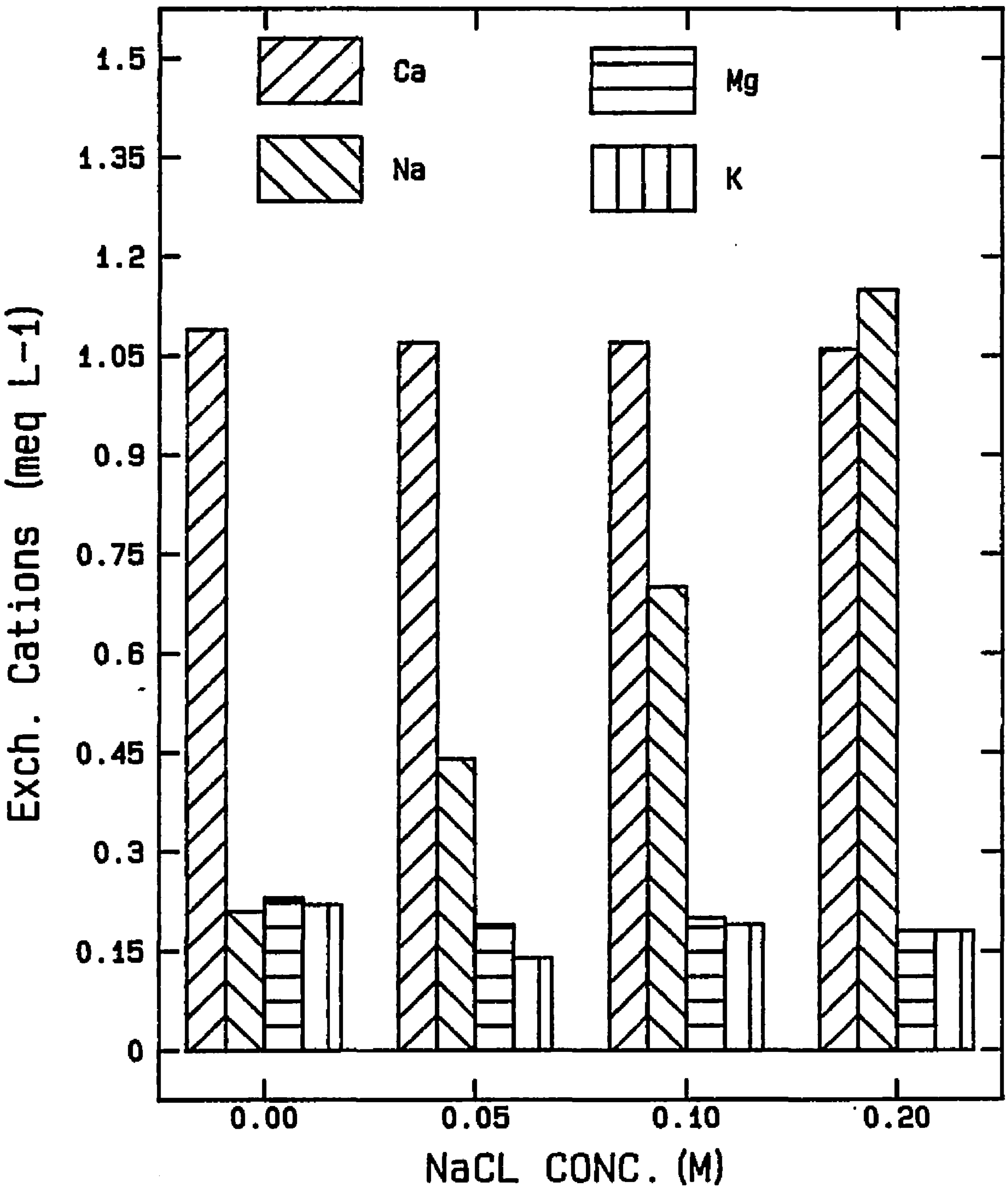

Fig. 5. Mean major exchangeable cations vs. NaCl concentration.

Na and Mg between the treatment was noticeably different due to the difference in the concentration of salt in applied water used.

Germination of Seeds

Salinity reduces or slows germination. It is often difficult to obtain a satisfactory stand of furrow irrigated plants on saline soil or when using moderately saline water. In some cases, growers plant two or three times as much seed as normal, hoping to offset the reduced germination (Ayers and Westcot, 1985).

Quercus emoryi did not germinate under any conditions, *Robinia neo-mexicana* did germinate under all conditions except for the high salt treatment. So as Table 2 and Figure 6 show, no significant difference between treatments WS2 and control, but there were significant differences between the treatment WS3 and WS4 and between the control. Treatment WS1 shows no significant difference between the WS3 and WS4.

Acidity Treatments

EC

The EC values for soluble water ions generally increase in the EC value of different treatments (Table 5). There was a significant difference among the acid treatments and between the acid treatments and control. Table 5 and Figure 7 shows the EC value was higher as the amount of cation released from the soil, and the salt concentration increase with decreasing the pH values.

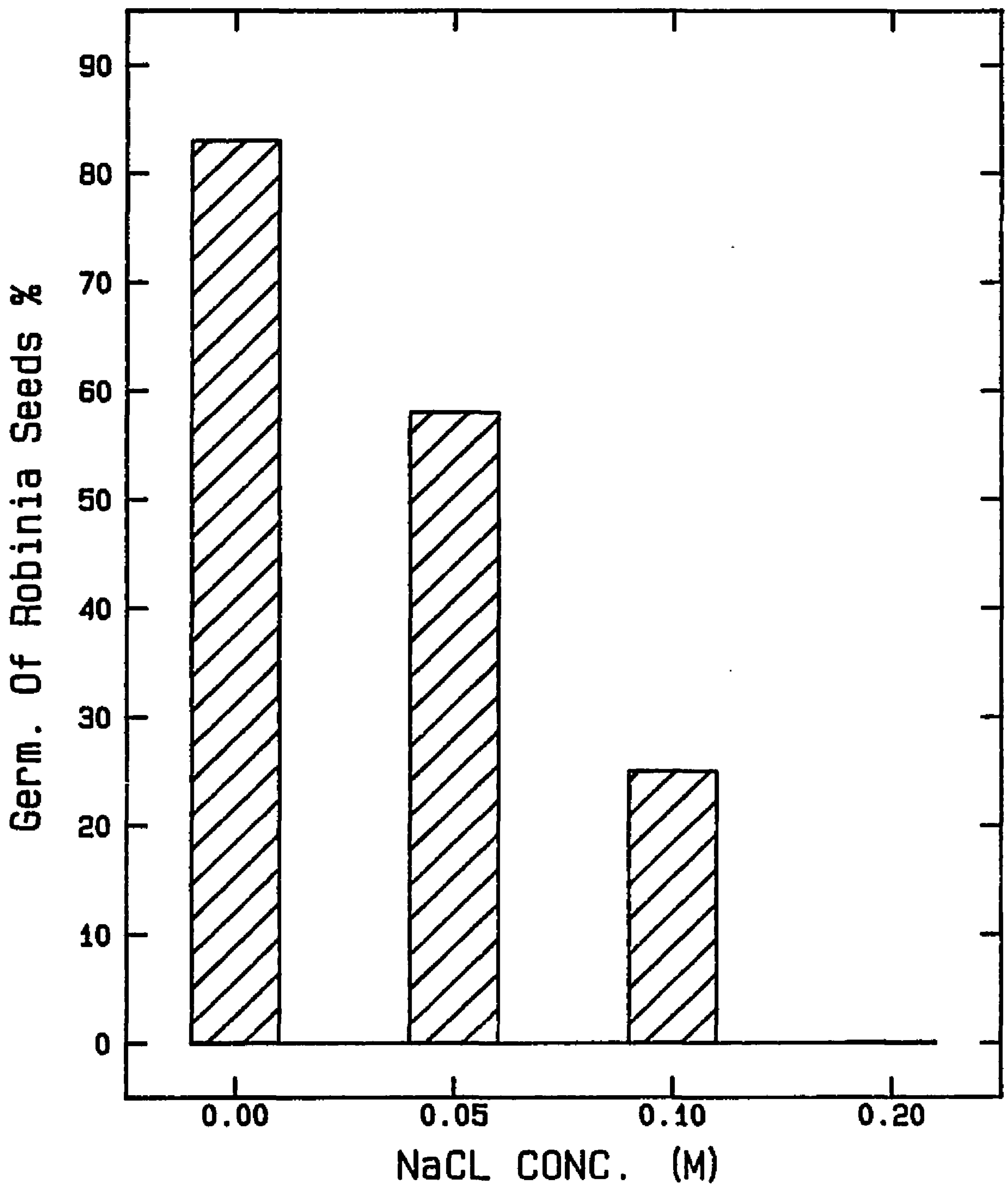

Fig. 6. Mean percentage of germination of <u>Robinia</u> <u>neo-mexicana</u> seeds vs. NaCl concentration.

Table 5. Means of EC, pH, Na, Ca, Mg, K and germination of *Robinia neo-mexicana* seeds after acid water treatments were applied.

Measurement	1	2	3	4	Mean
		dSm^{-1}			
EC					
WA1	0.20	0.41	0.19	0.18	0.26
WA2	2.80	2.25	2.25	2.90	2.55
WA3	3.50	3.70	2.80	3.30	3.28
WA4	4.50	3.60	4.20	4.50	4.20
pH					
WA1	4.85	3.90	5.02	5.01	4.70
WA2	3.40	3.15	3.45	3.35	3.34
WA3	2.98	2.98	3.25	3.45	3.17
WA4	2.95	3.00	2.95	2.75	2.91
		meq/liter			
Na					
WA1	0.11	0.13	0.30	0.26	0.2
WA2	0.39	0.26	0.33	0.39	0.34
WA3	0.46	0.52	0.33	0.33	0.41
WA4	0.50	0.37	0.33	0.39	0.40
Ca					
WA1	0.85	2.79	5.75	0.33	2.43
WA2	22.20	20.10	19.20	21.30	20.70
WA3	22.00	22.90	23.00	22.30	22.70
WA4	14.75	19.60	13.30	17.50	22.55
Mg					
WA1	2.91	0.80	0.31	0.20	1.08
WA2	5.44	4.95	4.98	6.67	5.51
WA3	7.48	7.39	6.30	6.61	6.95
WA4	8.43	7.43	8.00	4.43	7.07
K					
WA1	0.32	0.71	0.32	0.27	0.41
WA2	2.27	1.69	1.97	2.44	2.09
WA3	2.81	2.76	2.38	2.28	2.56
WA4	3.94	2.56	2.78	3.13	3.10
		%			
Germination of Robinia neo-mexicana seed					
WA1	100	67	100	100	91.75
WA2	67	33	67	67	58.50
WA3	33	0	33	33	24.75
WA4	0	33	0	0	8.25

Alpha equals 0.05

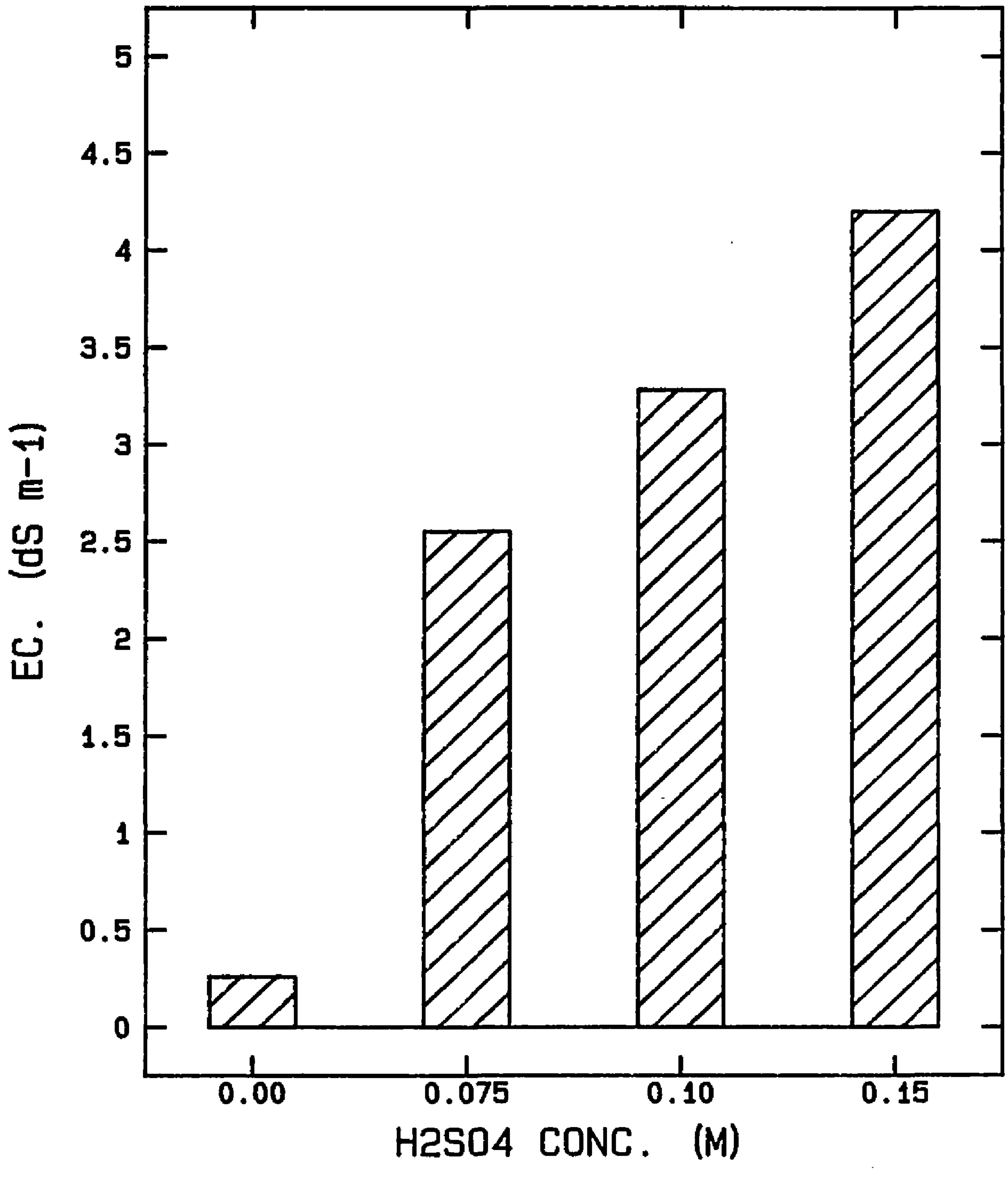

Fig. 7. Electric conductivity vs. H_2SO_4 concentration.

pH

The pH value decreased with increasing the concentration of acid water applied, as Table 5 and Figure 8 shows. The pH value was lower as the concentration of water acid applied increased. Table 5 shows a significant difference between the treatment and the control. The indicated difference between the different EC values of different treatments is attributed to the difference in pH values of applied water.

Total Soluble Salts in the Soil

The chemical composition of the soluble water is shown in Table 5 and Figure 9. There was a significant difference between the treatments and control, as well as among the acidity treatments themselves.

Ca

Considering Ca concentrations, there is a difference among acidity treatments and between acidity treatments and the control. All the treatments showed higher Ca concentration than the other pH levels.

Na

In contrast, Na concentrations, increased with increasing the level of acidity in the water applied. Table 5 and Figure 9 show the significant difference between the acidity treatment and control. The difference among Na was due to the Ca concentration in solution, the Ca replacing the Na on the soil phase in the exchange reaction.

Mg

Ca replaced Mg in the soil phase. The soil released some Mg, and it was significantly different between the treatments and the control.

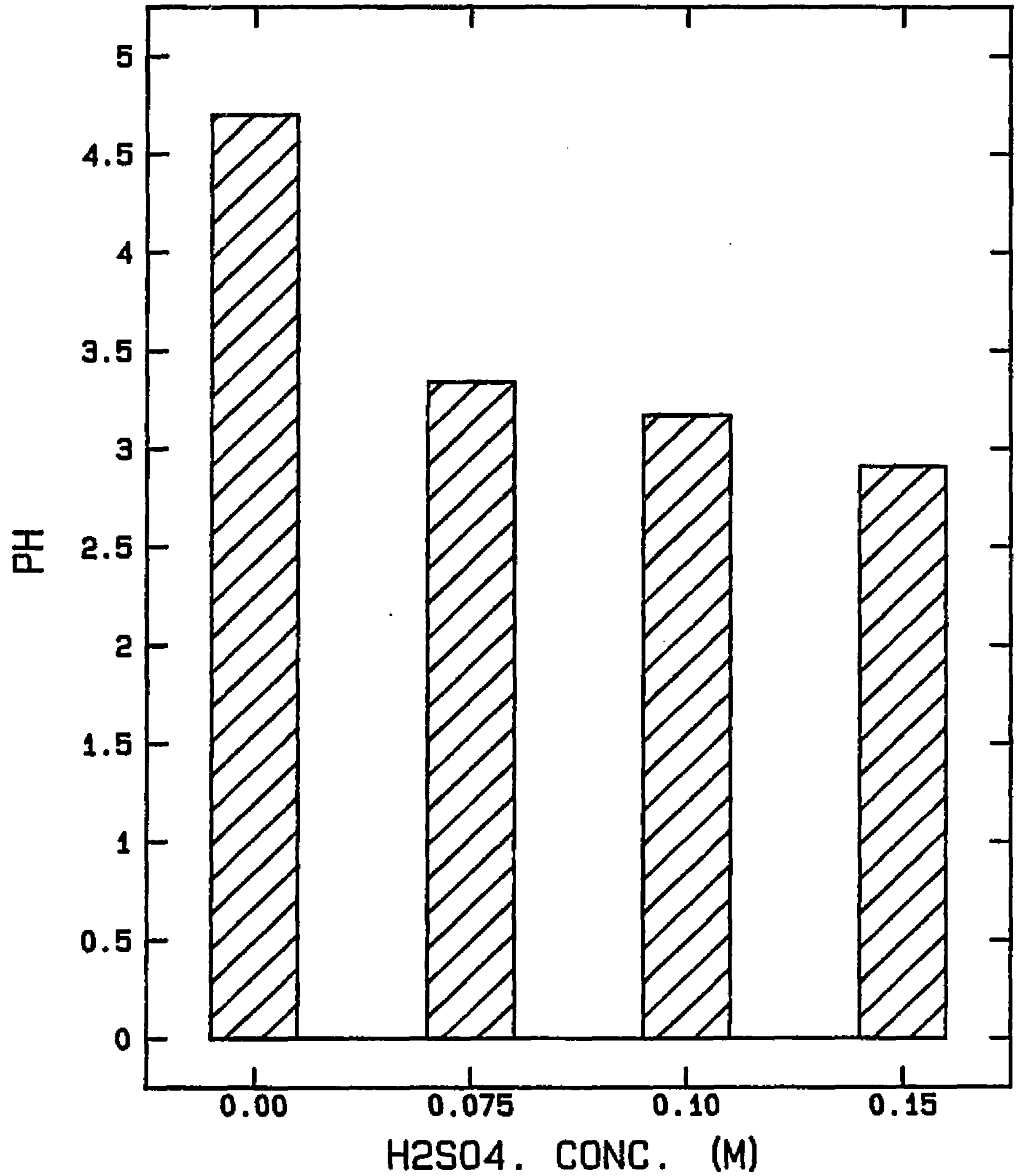

Fig. 8. Mean pH vs. H_2SO_4 concentration.

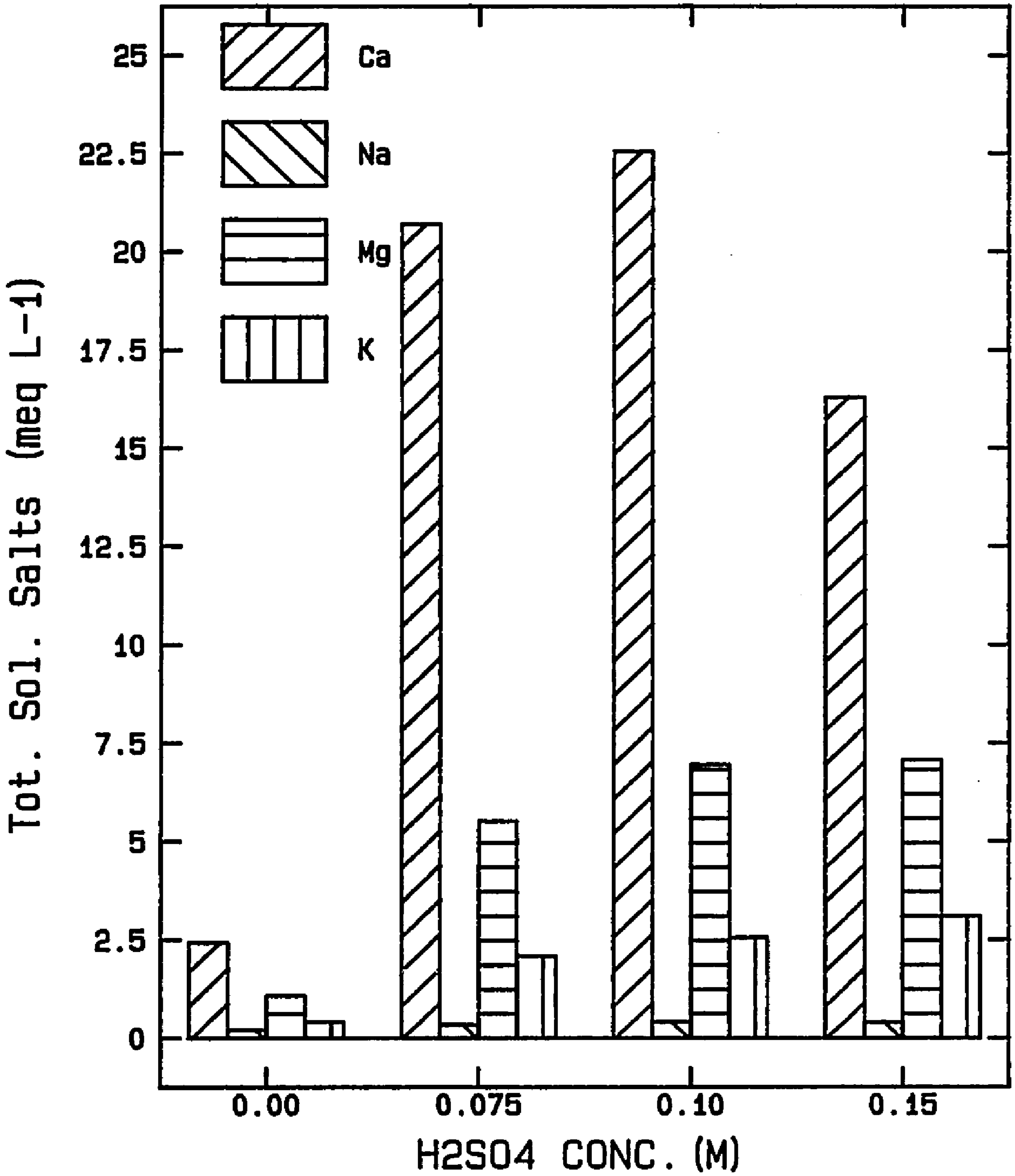

Fig. 9. Mean total soluble salts vs. H_2SO_4 concentration.

K

Applied Ca also released K from the soil. There was a significant difference between the treatment and control and significant difference between treatment WA2 and WA4.

Exchangeable Cation Concentration

The exchangeable Ca, Na, Mg and K showed no significant difference between the treatment and in the amount of treatment and control, as shown in Table 6 and Figure 10.

Germination of Seeds

The effects of low pH on plant growth are generally caused by toxic levels of soluble ions in the soil solution. Such effects on germination can also arise from nutritional imbalance, however, since the concentrations of nutrient ions may either increase or decrease under acidic condition (Bohn, McNeal and O'Connor, 1985). Under the conditions of this study none of the _Quercus emoryi_ seeds germinated. _Robinia neo-mexicana_ seeds did germinate as Table 5 and Figure 11 shows, there was significant difference between the treatment and control. Treatment WA2 was significantly different from treatment WA3 and WA4 but there was no significant difference between the treatment WA3 and treatment WA4

Table 6. Means of exchangeable Na, Ca, Mg and K in the soil for different acid treatments after water application.

Measurement	1	2	3	4	Mean
		meq/liter			
Na					
WA1	0.19	0.25	0.18	0.17	0.20
WA2	0.10	0.29	0.12	0.10	0.15
WA3	0.20	0.29	0.07	0.17	0.18
WA4	0.27	0.17	0.18	0.11	0.18
Ca					
WA1	1.04	1.12	1.16	1.19	1.13
WA2	1.31	1.25	1.27	1.38	1.30
WA3	1.52	1.72	1.59	1.49	1.58
WA4	1.43	1.36	1.40	1.64	1.46
Mg					
WA1	0.23	0.25	0.27	0.25	0.25
WA2	0.27	0.29	0.31	0.31	0.30
WA3	0.27	0.32	0.28	0.24	0.28
WA4	0.23	0.22	0.20	0.24	0.22
K					
WA1	0.16	0.18	0.17	0.17	0.17
WA2	0.16	0.23	0.18	0.18	0.19
WA3	0.33	0.30	0.17	0.18	0.25
WA4	0.27	0.18	0.21	0.21	0.22

Alpha equals 0.05

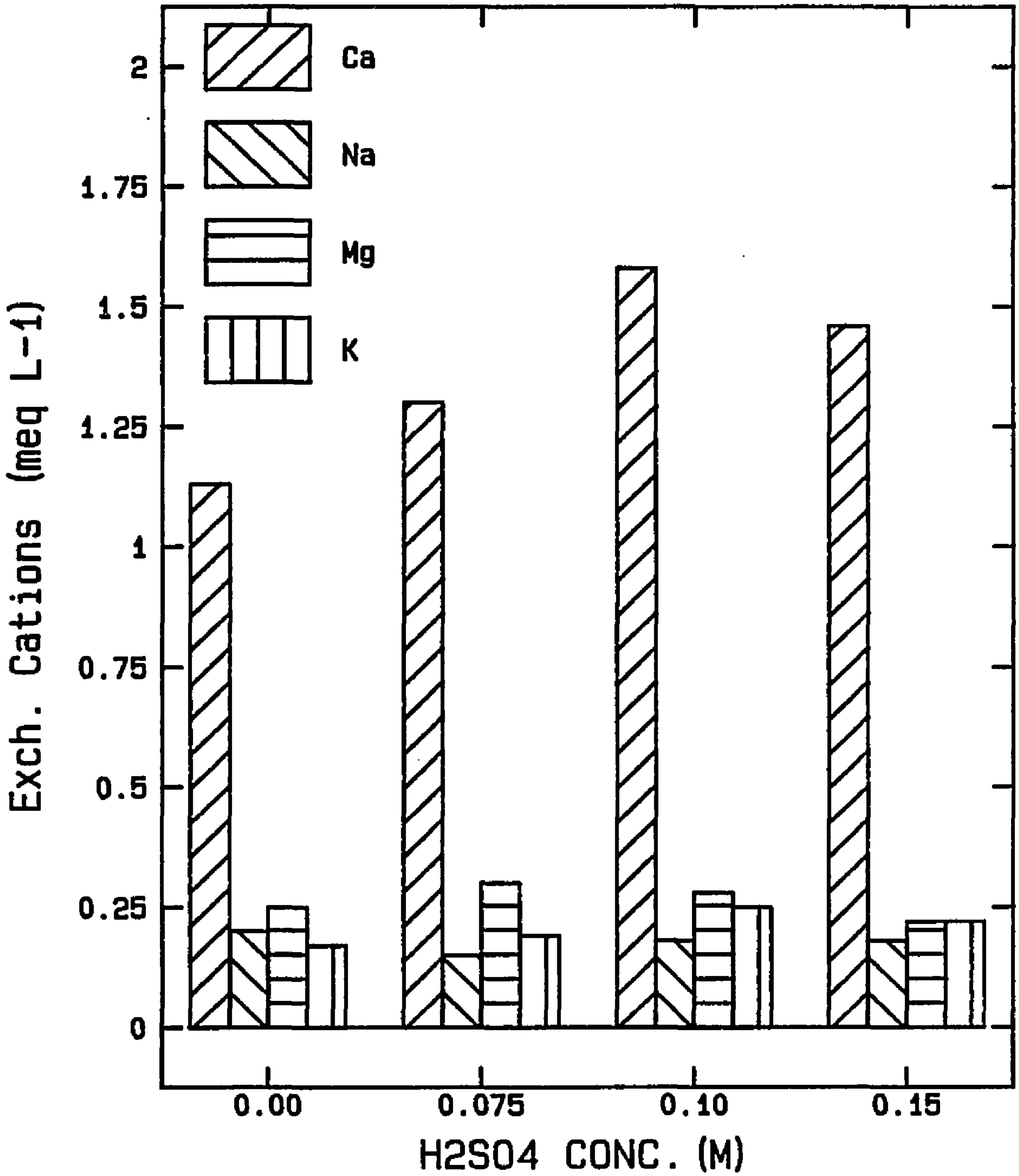

Fig. 10. Mean of major exchange cations (meq/L) vs. H_2SO_4 concentration (M).

Table 7. Means of SAR and ESP of soil for different acid treatments after water application.

	Treatment			
	WA1	WA2	WA3	WA4
SAR (S)	0.15	0.094	0.11	0.12
ESP (S)	1.05	1.13	1.11	1.10
SAR (E)	0.18	0.20	0.19	0.20
ESP (E)	1.00	0.97	0.99	0.98

(E) Exchangeable cation.

(S) Total soluble salts.

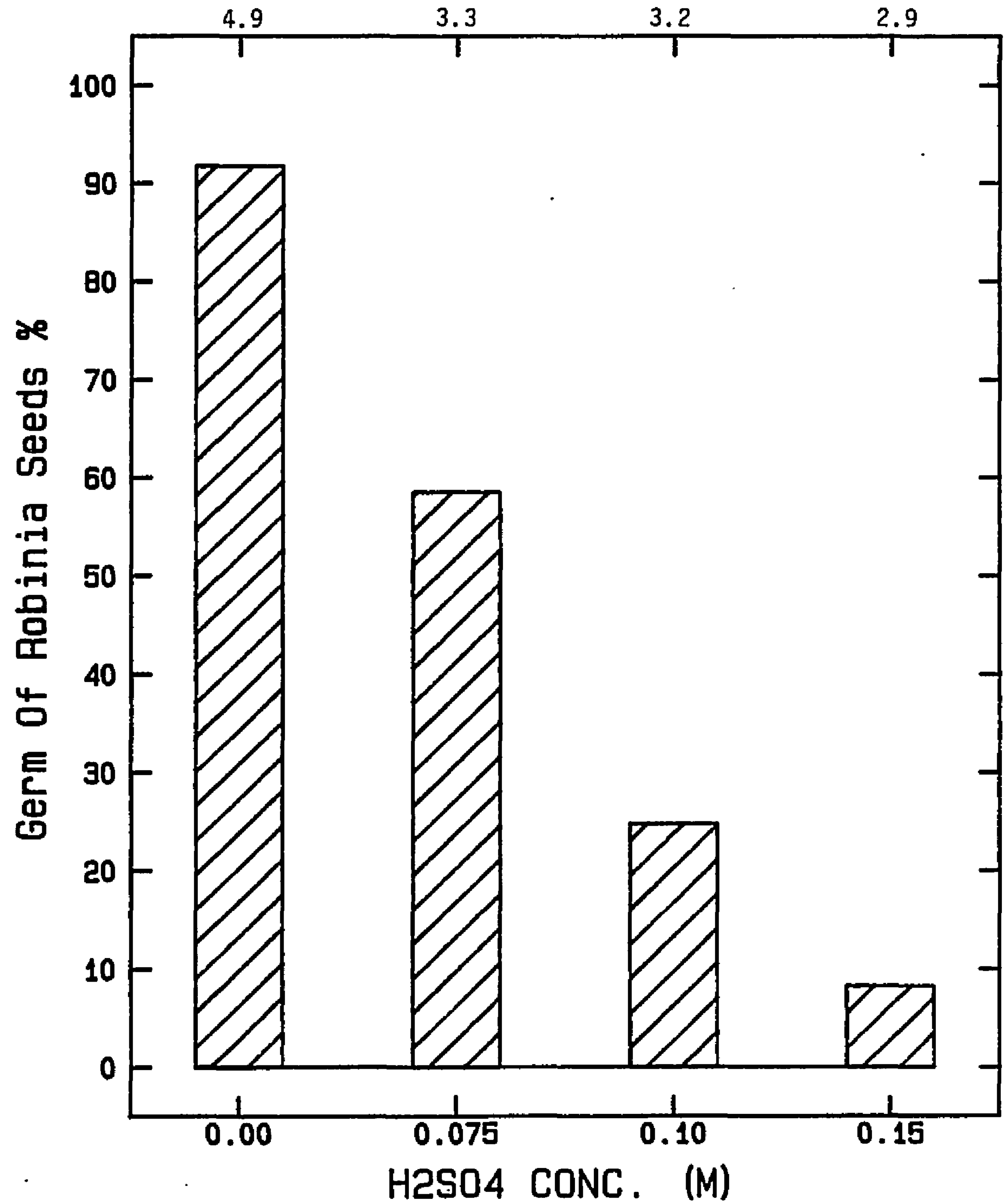

Fig. 11. Mean of percentage of germination of Robinia neo-mexicana seeds vs. H_2SO_4 concentration.

CHAPTER 5

CONCLUSIONS

The objectives of this study was to determine the response of different treatments of soil to germination of Quercus emoryi and Robinia neo-mexicana seeds and amount of saline and acid irrigation waters and to study the change in soil properties such as soluble and exchangeable cation concentrations (Ca, Na, Mg and K) EC, pH and SAR of both soil solution extracts at different concentration of NaCl and H_2SO_4 from application of these waters.

The soils under study were saline soil and acid soil. The irrigation waters had different salinities and different acidities. The saline irrigation water showed a significant difference in EC and pH from the acidic irrigation water. The EC values means showed increasing in both salinity and acidity treatments. Some cations appeared to be released is a result of EC means indicated increase in its values. The means of pH values decreased in saline water with the increase of NaCl in the water applied, but in acid soil the pH values were significantly different with H_2SO_4 concentration in the water applied.

Soluble cation concentrations in soil were closely related to the concentration of the applied waters. Means of pH values in saline soil decreased with increased NaCl in the water applied, but in acid soils, the pH value was significantly different with concentration of H_2SO_4 in water applied.

Soluble cation concentrations in soil related to the concentrations of the applied waters; however, both soils released Ca, Exchangeable Ca increased with increasing concentration of H_2SO_4 in applied water and increased Na concentration with increasing NaCl concentration in applied water.

The SAR of soil increased as the amount of the salt and application rates of the solution increased with both treatments. Germination of seeds decreased with an increase in salinity and acidity of irrigation waters, the water with higher salinity resulted in lower percentages of seed germination and also the water with lower pH resulted in lower percentages of germination of seeds.

The acid soil contained nutrient released than the saline soil and, therefore, the percentage of germination of seeds in the acid soil was higher than the percent of germination of seed in saline soil.

The EC, pH and cation concentration increased as the total NaCl and H_2SO_4 concentration increased in the applied solution. Therefore, using saline waters or acid water will result in a major change in the cations concentration (nutrients) of soils. In conclusion, the study recommends the planting of Robinia neo-mexicana seeds in acid soils rather than in saline soil. Quercus emoryi seeds did not germinate in either type of soils.

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