STUDIES ON THE SOIL-PLANT SYSTEMS IN RELATION TO NUTRIENTS AVAILABILITY

By

REFEAT GIRGIS KERLOUS

A thesis submitted in partial fulfillment
of
the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Agricultural Science

(Soil Science)

Department of Soil Science
Faculty of Agriculture
Ain Shams University

1989

APPROVAL SHEET

STUDIES ON THE SOIL-PLANT SYSTEMS IN RELATION TO NUTRIENTS AVALLABILITY

By

REFEAT GIRGIS KERLOUS

B.Sc. Agric.(Soil Science), Ain Shams Univ.,1969

M.Sc. Agric.(Soil Science), Ain Shams Univ.,1982

This thesis for Ph.D. degree has been approved by :

Prof. Dr. Fawzi M. A. H. Abed ----------

Prof. of Soil Science, Fac. of Agric., Al-Azhar Univ.

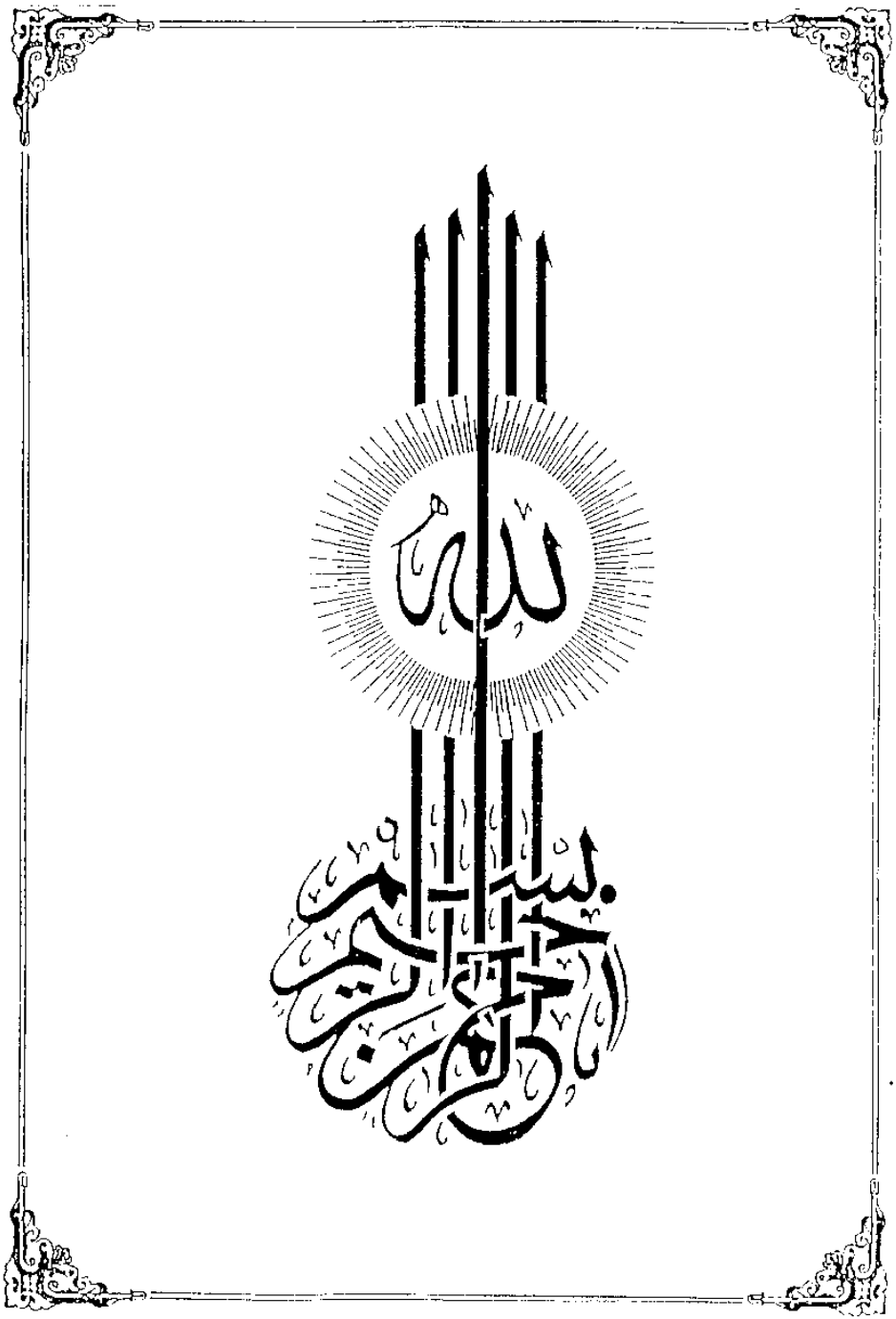
Prof. Dr. M. S. Fouda ----------

Prof. of Soil Science, Fac. of Agric.,Ain Shams Univ.

Prof. Dr. S. M. El-Sherif ----------

Prof. of Soil Science, Fac. of Agric., Ain Shams Univ.

of examination : 16 / 10 / 1989



STUDIES ON THE SOIL-PLANT SYSTEMS IN RELATION TO NUTRIENTS AVAILABILITY

By

REFEAT GIRGIS KERLOUS

B.Sc. Agr. (Soil Science), Ain Shams Univ.,1969
M.Sc. Agr. (Soil Science), Ain Shams Univ.,1982
Under the Supervision of : Prof. Dr. S.M. El-Sherif
Prof. of Soil Sci.
Prof. Dr. A.S. Ismail
Prof. of Soil Sci.

ABSTRACT

Greenhouse experiments were conducted to study the soil-plant systems in relation to nutrients availability included two kinds of crops (mono and dicotyledon) through two successive seasons grown on different soil types. The abtained results can be summarized as follows : 1. The highest values of corn shoots and ears were obtained for loamy soil. P,Fe and Zn applications increased the concentration and uptake of P by corn parts, while Zn level and uptake were reduced in shoots. On the other hand, Zn application at different rates increased proportionlly Zn content and uptake by both shoots and ears of corn .

2. P-application was more effective than iron for increasing sunflower shoots and plates, while application 10 ppm of Zn resulted mostly in decreasing the dry weight of sunflower shoots. In addition, P-uptake by shoots was increased when P (20 or 40 ppm), Fe (20 ppm) and Zn (10 ppm) were applied to sandy soil. Moreover, P and Fe applications reduced Zn content and uptake by sunflower parts, except few cases, the effect was depended on the rate of application and the soil type . On the other hand, Fe concentration in sunflower shoots and plates was decreased as a result of increasing P or Zn application rates while there was a positive effects on Fe level in sunflower parts when Fe-EDDHA was applied to soil .

3. P-application rates significantly rates significantly increased dry matter weight of wheat, while dry matter of spikes was significantly increased as a result of application different levels of P,Fe and Zn to all the investigated soils . The high P-application decreased Zn level and uptake by shoots and spikes of wheat

and their values still lower than those values found in the control. Also, Zn application clearly increased Zn content and uptake in both wheat parts . Also, Fe content in both wheat parts were reduced when P applied to the studied soils, Similar trend was obtained in case of Zn application . On the contrary, Fe content and uptake were increasing Fe application rates.

4. P-content and uptake by different parts of bean were increased as P-application increased while P-level in shoots and pods were decreased when Fe applied to sandy and slightly calcareous soils or when Zn applied to calcareous ones . Moreover, Zn-level and uptake by shoots and pods were reduced as different rates of P and Fe applied to soil. On the contrary, application rates appeared proportional increase in Zn-level and uptake by both bean parts as compared with the control treatment .

5. The high rate rate of P or Zn caused some decreases in Fe-availability while, Fe = application propertionally increased Fe availability in soil .

6. Zn-availability in soil was cnot clearly affected by P or Fe application, although the values of Zn availability after dicotes plants were somewhat higher than those values obtained after monocotes plants either in summer season or in winter one. On the other hand, Zn application rates (5 or 10 ppm) proportionally increased available Zn in soil after different crops cultivation.

ACKNOWLEDGEMENT

The author wishes to express his deep gratitude and thanks to Prof. Dr. Saad M. El-Sherif and Prof. Dr. Abdel-Samad S. Ismail,Soils Department, Faculty of Agriculture, Ain Shams University, for their supervision, valuable suggestions, deep interest, continuous help and constructive criticism throughout the coarse or research and writing the thesis .

The author is also indebted to Dr. M. A. Mostafa, Associate Prof. of Soils Department, Faculty of Agriculture , Ain Shams University and Dr. Sh. M. Gawish, Lecturer in Soils Department, Faculty of Agriculture, Ain Shams University, for their kind help and fruitful efforts through the whole stages of the investigation and deep interest in this study .

Special thanks are also due to Dr. M. A. Negm, Researcher in Sandy and Calcareous Soils Research Department, Soils and Water Res. Inst. Agric. Res. Center for suggesting the problem and sincere help throughout the entire work .

CONTENTS

	Page
1. INTRODUCTION.	1
2. REVIEW OF LITERATURE	3
2.1. Phosphorus in soil.	3
2.2. The effect of phosphorus fertilization on yield and mineral composition of different plants.	6
2.3. Iron in soil.	19
2.4. The effect of iron fertilization on yield and mineral composition of different plants.	23
2.5. Zinc in soil.	30
2.6. The effect of zinc fertilization on yield and mineral composition of different plants.	33
3. MATERIALS AND METHODS.	50
4. RESULTS AND DISCUSSION.	55
4.1. First experiment.	55
4.1.1. The effect of P , Fe and Zn applications on yield and mineral compostion of corn plants.	55
4.1.1.1. Dry matter yield.	55
4.1.1.2. Mineral composition.	58
4.1.1.2.1. P-content.	58
4.1.1.2.2. Fe-content.	63
4.1.1.2.3. Zn-content.	68
4.1.2. The effect of P , Fe and Zn applications on yield and mineral composition of sunflower plants. . . .	74
4.1.2.1. Dry matter yield.	74
4.1.2.2. Mineral composition.	77
4.1.2.2.1. P-content.	77
4.1.2.2.2. Fe-content.	81
4.1.2.2.3. Zn-content.	86
4.2. Second experiment.	90
4.2.1. The effect of P , Fe and Zn applications on yield and mineral composition of wheat plants.	90
4.2.1.1. Dry matter yield.	90
4.2.1.2. Mineral composition.	93

Page

4.2.1.2.1. P-content. 93
4.2.1.2.2. Fe-content. 97
4.2.1.2.3. Zn-content. 101

4.2.2. The effect of P , Fe and Zn applications on yield and mineral composition of bean plants. 107
4.2.2.1. Dry matter yield. 107
4.2.2.2. Mineral composition. 110
4.2.2.2.1. P-content. 110
4.2.2.2.2. Fe-content. 114
4.2.2.2.3. Zn-content. 119

4.3. Effect of P , Fe and Zn applications on some nutrients availability after grown different plant species. . . . 140
4.3.1. P-availability. 140
4.3.2. Fe-availability. 150
4.3.3. Zn-availability. 159

5. SUMMARY AND CONCULUSIONS. 168

6. REFERENCES. 175

7. ARABIC SUMMARY. . . . . .

LIST OF TABLES

Tables — Page

1- Some physical and chemical properties of the studied soils 51

2- Effect of P , Fe and Zn applications on dry matter yield (g/pot) of shoots and ears of corn plants grown on different soils 56

3- Effect of P , Fe and Zn applications on P-content (%) of the shoots and ears of corn plants grown on different soils. 59

4- Effect of P , Fe and Zn applications on P-uptake (mg/pot) of shoots and ears of corn plants grown on different soils. 62

5- Effect of P , Fe and Zn applications on Fe-content (ppm) of shoots and ears of corn plants grown on different soils. 64

6- Effect of P , Fe and Zn applications on Fe-uptake (ug/pot) of shoots and ears of corn plants grown on different soils. 67

7- Effect of P , Fe and Zn applications on Zn-content (ppm) of the shoots and ears of corn plants grown on different soils. 69

8- Effect of P , Fe and Zn applications on Zn-uptake (ug/pot) of the shoots and ears of corn plants grown on different soils. 72

9- Effect of P , Fe and Zn applications on dry matter yield (g/pot) of shoots and plates of sunflower plants grown on different soils 75

10-Effect of P , Fe and Zn applications on P-content (%) of the shoots and plates of sunflower plants grown on different soils. 78

11 - Effect of P, Fe and Zn applications on P-uptake (mg/pot)of shoots and plates of sunflower plants grown on different soils. 80
12 - Effect of P , Fe ,and Zn applications on Fe-content (ppm) of shoots and plates of sunflower pants grown on different soils 82
13 - Effect of P , Fe and Zn applications on Fe-uptake (ug/pot) of shoots and plates of sunflower plants grown on different soils. 84
14 - Effect of P , Fe and Zn applications on Zn-content (ppm) of the shoots and plates of sunflower plants grown on different soils. 87
15 - Effect of P , Fe ,and Zn applications on Zn-uptake (ug/pot) of the shoots and plates of sunflower plants grown on different soils. 89
16 - Effect of P , Fe and Zn applications on dry matter yield (g/pot) of shoots and spikes of wheat plants grown on different soils 91
17 - Effect of P , Fe , and Zn applications on P-content (%) of the shoots and spikes of wheat plants grown on different soils. 94
18 - Effect of P, Fe , and Zn applications on P-uptake (mg/pot) of shoots and spikes of wheat plants grown on different soils 96
19 - Effect of P , Fe , and Zn applications on Fe-content (ppm) of shoots and spikes of wheat plants grown on different soils. 98
20 - Effect of P, Fe ,and Zn applications on Fe-uptake (ug/pot) of shoots and spikes of wheat plants grown on different soils 100
21 - Effect of P , Fe ,and Zn applications on Zn-content (ppm) of the shoots and spikes of wheat plants grown on different soils 102
22 - Effect of P , Fe ,and Zn applications on Zn-uptake (ug/pot) of the shoots and spikes of wheat plants grown on different soils 105

Page

23 - Effect of P , Fe and Zn applications on dry matter yield (g/pot) of shoots and pods bean plants grown on different soils 108
24 - Effect of P , Fe ,and Zn applications on P-content (%) of the shoots and pods bean plants grown on different soils 111
25 - Effect of P , Fe ,and Zn applications on P-uptake (mg/pot) of shoots and pods of bean plants grown on different soils. 113
26 - Effect of P, Fe, and Zn applications on Fe-content (ppm) of shoots and pods of bean plants grown on different soils 115
27 - Effect of P , Fe and Zn applications on Fe-uptake (ug/pot) of shoots and pods of bean plants grown on different soils 117
28 - Effect of P , Fe and Zn applications on Zn-content (ppm) of the shoots and pods of bean plants grown on different soils 120
29 - Effect off P, Fe ,and Zn applications on Zn-uptake (ug/pot) of the shoots and pods of bean plant grown on different soils 122
30 - Effect of P-application rates on P-residual (ppm) in the studied soils after growing different plant species. 141
31 - Effect of Fe-application on P-residual (ppm) in the studied soils after growing different plant species. 145
32 - Effect of Zn-application on P-residual (ppm) in the studied soils after growing different plant species.. 147
33 - Effect of P-application rates on Fe-residual (ppm) in the studied soils after growing different plant species. 151
34 - Effect of Fe-application rates on Fe-residual (ppm) in the studied soils after growing different plant species. 154
35 - Effect of Zn application rates on Fe-residual (ppm) in the studied soils after growing different plant species. 157

Page

36 - Effect of P application rates on Zn-residual (ppm) in the studied soils after growing different plant species. 160
37 - Effect of Fe application rates on Zn residual (ppm) in the studied soils after growing different plant species. 163
38 - Effect of Zn application rates on Zn residual (ppm) in the studied soils after growing different plant species. 166

LIST OF FIGURES

FIGURES

Page

1.. Effect of P-application rates on dry matter yield of shoots and fruit parts of different plant species grown on the studied soils 125

2.. Effect of Fe-application rates on dry matter yield of shoots and fruits parts of different plant species grown on the studied soils 126

3.. Effect of Zn-application rates on dry matter yield of shoots and fruit parts of different plant species grown on the studied soils 127

4.. Effect of P-application rates on P-uptake by shoots and fruits parts of different plant species grown on the studied soils 130

5.. Effect of Fe-application rates on P-uptake by shoots and fruits parts of different plant species grown on the studied soils 131

6.. Effect of Zn-application rates on P-uptake by shoots and fruits parts of different plant species grown on studied soils 132

7.. Effect of P-application rates on Fe-uptake by shoots and fruits parts of different plant species grown on the studied soils 134

8.. Effect of Fe-application rates on Fe-uptake by shoots and fruits parts of different plant species grown on the studied soils 135

9.. Effect of Zn application rates on Fe-uptake by shoots and fruits parts of different plant species grown on the studied soils 136

10. Effect of P-application rates on Zn-uptake by shoots and fruits parts of different plant species grown on the studied soils 137

FIGURES

Page

11. Effect of Fe-application rates on Zn-uptake by shoots and fruits parts of different plant species grown on the studied soils 138

12. Effect of Zn application rates on Zn-uptake by shoots and fruit parts of different plant species grown on the dstudied soils 139

13. Effect of P application rates on P-availability in the studied soils after harvesting different plant species 142

14. Effect of Fe-application rates on P-availability in the studied soils after harvesting different plant species. 146

15. Effect of Zn-application rates on P-availability in the studied soils after harvesting different plant species 148

16. Effect of P-application rates on Fe-availability in the studied soils after harvesting different plant species. 152

17. Effect of Fe-application rates on Fe-availability in the studied soils after harvesting different plant species 155

18. Effect of Zn-application rates on Fe-availability in the studied soils after harvesting different plant species. 158

19. Effect of P-application rates on Zn-availability in the studied soils after harvesting different plant species. 161

20. Effect of Fe-application rates on Zn-availability in the studied soils after harvesting different plant species. 164

21. Effect of Zn-application rates on Zn-availability in the studied soils after harvesting different plant species. 167

1. INTRODUCTION

In many countries, such in Egypt , one of the obvious needs for expanding food production, to meet the needs of growing population, is to find ways for utilizing land which has hitherto been unproductive . Under such conditions, there are two obvious requirements to identify the restraints to plant growth which soil conditions can impose and to develop the most efficient methods for circumventing them, taking into account the local circumstances .

Concerning plant species , in dicotyledons the diameter of roots may increase with time due to cambial activity, and this should reduce any gap between the root and the solid phase . This progressive thickening does not occur in monocotyledons as they lack vascular cambium, and the diameter of their roots can decrease as they age because of the degeneration of the cortex . Therofore, the trirelations between soil properties , nutrient availability and plant species were focused under this study . In other words, the main objective of the present work is to study one of the trirelations includes :

a) mono- and dicotyledon plants, i.e., cron , wheat, sunflower and beans .

b) representative soil samples for sandy, calcareous and alluvial soils .

c) different levels of phosphorous , iron and zinc .