

**EFFECT OF COMPOST AND BIO-FERTILIZERS
APPLICATION ON PHOSPHORUS
AVAILABILITY OF PHOSPHATE ROCK**

By

RASHA RAMZY MOHAMED AFIFY

B.Sc. (Soil Reclamation), Fac. Agric., Alex Univ., Egypt, 2002.

M.Sc. (Soil Science), Fac. Agric., Cairo Univ., Egypt, 2008.

THESIS

**Submitted in Partial Fulfillment of the
Requirements for the Degree of**

DOCTOR OF PHILOSOPHY

In

**Agricultural Sciences
(Soil Science)**

**Department of soils
Faculty of Agriculture
Cairo University
EGYPT**

2014

SUPERVISION SHEET

**EFFECT OF COMPOST AND BIO-FERTILIZERS
APPLICATION ON PHOSPHORUS
AVAILABILITY OF PHOSPHATE ROCK**

**Ph.D. Thesis
By**

RASHA RAMZY MOHAMED AFIFY

**B.Sc. (Soil Reclamation), Fac. Agric., Alexandria Univ., Egypt, (2002).
M.Sc. (Soil Science), Fac. Agric., Cairo Univ., Egypt, (2008).**

SUPERVISION COMMITTEE

Dr. MOHAMEDY IBRAHIM EL-KHERBAWY
Professor of Soils, Fac. Agric., Cairo University.

Dr. SAYED TAHA ABOU-ZEID
Professor of Soils, Fac. Agric., Cairo University.

Dr. HESHAM IBRAHIM EL-AILA
**Professor of Plant Nutrition- Plant Nutrition Department,
National Research Centre, Dokki, Cairo.**

Name of Candidate: Rasha Ramzy Mohamed Afify **Degree:** Ph.D.
Title of Thesis: EFFECT OF COMPOST AND BIO-FERTILIZERS APPLICATION ON PHOSPHORUS AVAILABILITY OF PHOSPHATE ROCK
Supervisors: Prof. Dr. Mohamedy Ibrahim El-Kherbawy, Prof. Dr. Sayed Taha Abou-Zeid and Prof. Dr. Hesham Ibrahim El-Aila ,
Department: Soil Science
Branch: Plant Nutrition **Approval:** / /

ABSTRACT

Low bioavailability of P in soil from the applied phosphatic fertilizers due to fixation/precipitation is considered the most critical factor in limiting optimum crop yields. Thus availability of alternate and cheap P resources is imperative for sustainable crop production and is a dire need of the hour. Phosphate Rock (PR) is a cheap source of P, but cannot be used directly as a soil amendment because of its very poor water solubility (0.1%). However, the bioavailability of PR-P can be enhanced by complexing it with compost and/or through the use of specific bioinoculants. A series of experiments were conducted to assess and evaluate the different Egyptian Phosphate Rock sources and select the best phosphate rock to produce phosphocompost to study the effectiveness of various approaches to solubilize PR-P and the impact of bioavailable PR-P on growth and yield of Banana and Soybean plants under green house and field conditions. According to the wide applications of phosphate rock types in Egyptian agricultural lands, phosphate rocks (PRs) were divided into three groups, the 1st (GI) is El-Sebaiya (east and west Nile Valley) group, the 2nd (GII) is Safaga (Red Sea, Hamraween) group and the 3rd (GIII) contains other types such as Abu-tartur (Western Desert) and Al-Oroba (Nile Valley) type. Different chemical and physical characterizations of these groups and phosphate desorption from the raw materials of these types were analyzed. The obtained results showed that Egyptian types of PRs have a significant variation in their potential toxic elements PTEs contents, total and available P and other chemical characterizations studied such as EC – pH and CaCO₃. According to kinetic study used, the variations in kinetic parameters in different types concluded that phosphate retained in raw materials with different forces represent variation in P bioavailability. El-sebaiya west and Al-Oroba type have been the best phosphate rock to use.

Results for pot and field trials on banana and soybean plants, phosphocompost 20% El-Sebaiya with bacteria followed by phosphocompost 20% Al-Oroba with bacteria inoculate with Mycorrhizae the best in promoting growth and yield of banana and soybean plants in both pot and field trials. Other treatments also produced higher yield contributing traits than uninoculated with available Mycorrhizae, but with relatively less proficiency. The results of these studies may imply that PR inoculated with bacteria and Mycorrhizae proved to be aviable approach to use PR and organic waste for persistent crop production as well as for supporting healthier environment.

DEDICATION

I dedicate this work to whom my heartfelt thanks; to my parents, brothers and my sisters for all the support, patience and help they lovely offered along the period of my post graduation.

ACKNOWLEDGMENT

*Praise be to **ALLAH**, the Lord of the World, by whose grace this work has been completed.*

*The author wishes to express her deep gratitude and appreciation to **Dr. M. I. El-Kherbawy** Professor of Soils, Faculty of Agriculture, Cairo University who gave me an opportunity to work under his supervision and gave me this topic to work on it and guidance of this work, giving facilities of research and preparation of the manuscript. I am proud and honored to be her student.*

*The deepest gratitude and sincere appreciation to **Dr. S.T. Abou-zeid** Professor of Soils, Faculty of Agriculture, Cairo University, for supervision, encourage during the course of this work,*

*Sincere appreciations are due to **Dr. H. I. El-Aila**, Professor of Plant Nutrition, Plant Nutrition Department, National Research Centre, Dokki, Cairo, Egypt, his valuable supervision, advice, continuous and encourage during the course of this work.*

*I wish to express thanks to **Dr. kh. Morse** Prof. of Plant Nutrition, Plant Nutrition Department, National Research Centre, Dokki, Cairo, Egypt, for his valuable scientific supervision, and sincere help.*

*Thanks also, to **Dr. A. Zaghlool**, Professor of Soil and Water use Department, National Research Centre, Dokki, Cairo, Egypt, for his help, encouragement, guidance of this work and writing the thesis.*

*Thanks also, to **Dr F. Hellsal**, Assistant Professor of Plant Nutrition, Plant Nutrition Department, National Research Centre, Dokki, Cairo, Egypt, for his supervision.*

I would like to acknowledge Plant Nutrition Department, National Research Centre (NRC) for providing funding to conduct this study.

CONTENTS

	Page
INTRODUCTION	1
REVIEW OF LITERATURE	4
1. Phosphate rock origin	4
2. World phosphate rock production	5
3. Phosphate resources in Egypt	6
4. Alternative options for PR utilization	8
a) Partial acidulation.....	9
b) Elemental sulphur addition.....	10
c) Thermal treatment.....	12
d) Organic solubilization.....	12
e) Phospho-composting.....	13
f) Green manure and PR.....	16
5. Biological fertilizer	17
a) Bacterial.....	19
b) Fungi.....	22
6. Factors influencing the phosphate rock solubilization and availability to plant	25
7. Phosphate rock for direct application in agriculture	29
8. Availability of phosphorus in agriculture	31
9. The need for sustainable development	33
10. Trace elements in the phosphate rock	35
11. Seedlings of fruit plants (Banana, Grand Naine)	36
a) Effect of inorganic fertilizer on banana growth.....	38
b) Effect of mycorrhizal fungi on banana growth.....	40
c) Effect of interaction between inorganic and biofertilizer on banana growth.....	40
12. Legume plant (Soybean, Glycine max L.)	41
MATERIALS AND METHODS	46

RESULTS AND DISCUSSION.....	55
I. Survey, quantities and qualitative evaluation of phosphate rocks applied in Egyptian agricultural lands..	55
1. Chemical characterization of commercial phosphate rock used in Egypt.....	55
2. Total potential toxic elements in phosphate rocks used in Egyptian agricultural lands.....	64
3. Kinetics of long-term phosphate dissolution from phosphate rocks used in Egyptian agricultural lands.....	68
4. Kinetic parameters of best fitted models describe phosphate release from PR applied in Egyptian agricultural farms.....	73
5. Correlation analysis between different kinetic parameters and some properties of PR applied in Egyptian soils.....	79
II. Effect of phospho-compost applied in agricultural farms of new reclaimed areas.....	82
1.Kinetics of phosphate desorbtion from the compost enriched with Al-Oroba and El-Sebaiya phosphate rock types at different rates and technique of application.....	83
2.Kinetic parameters for the best fitted models describe phosphate release from compost enriched with Al-Oroba and El-Sebaiya PRs.....	88
a) Modified Freundlich kinetic model.....	88
b) Hoerl equation.....	99
3. Effect of composting process and incubation time on the forms of phosphate inside the compost enriched with Al-Oroba PR.	108
a) Exchangeable P.....	109
b) Organic Pool.....	112
4. Effect of reseidence time through composting process on variations of some parameters related with phosphate desorption from phospho-compost system.....	115
a)Change of pH of the system.....	115

b)Temperature.....	118
c)Effect of residence time on the variation of total nitrogen, organic carbon and C/N ratio in the compost enriched with PR and SSP.....	119
1.Total N.....	119
2. C/N ratio.....	120
3. Organic carbon.....	121
III. Utilization of phospho-compost applied on sandy soil cultivated with banana seedlings, (Grand Naine)....	124
1)Shoot and root fresh and dry weight.....	124
2) Number of leaves.....	134
3) Plant height.....	135
4) Stem diameter.....	139
5. Nutrient uptake.....	140
a) Nitrogen.....	140
b) Phosphorus.....	145
c) Potassium.....	148
3. Residual amounts of nutrients in soil system.....	151
IV. Utilization of phosphocompost applied on sandy soil cultivated with soybean plants.....	156
1) Shoot and root fresh and dry weight.....	156
2) Plant height (cm).....	162
3) 100 Seed weight (gm).....	164
4) Seed yield (Kg/Fed).....	166
5. Nutrient uptake.....	167
a) Nitrogen.....	167
b) Phosphorus.....	170
c) Potassium.....	174
3. Residual amounts of nutrients in different soil systems after soybean harvesting.....	177
SUMMARY.....	183

REFERENCES.....	205
ARABIC SUMMARY	

LIST OF TABLES

No	Title	Page
1.	1. Some chemical characteristics of the organic media.....	47
2.	Particle size distribution of the used soil sample.....	50
3.	Some chemical properties of the used soil sample.....	50
4.	Major oxides and trace elements contents of phosphate rock samples used in soils.	58
5.	Chemical formula of groups found in PR used in soils.	60
6.	Particle distribution (%) of phosphate rocks samples used in Egypt.....	62
7.	Some Chemical characterization of the phosphate rock used in Egypt.....	63
8.	Total contents of heavy metals (mg kg ⁻¹) found in commercial phosphate rock samples applied in Egyptian soils.....	66
9.	The rate of Constants, coefficient of determination R ² and stander error SE of different models of phosphate desorption from different phosphate rocks types.....	75
10.	Correlation analysis between different kinetic parameters and some properties of PR applied in Egyptian soils.....	81
11.	Rate constants, coefficient of determination R ² and standard error SE of power function equation of phosphate desorption from Al-Oroba PR and SSP-enriched compost treatments applied at different times of incubation.....	90
12.	Rate constants, coefficient of determination R ² and standard error SE of power function equation of phosphate desorption from El-Sebaiya PR and SSP-enriched compost treatments applied at different times of incubation.....	96
13.	Rate constants, coefficient of determination R ² and standard error SE of power function equation of phosphate desorption from Al-Oroba PR and SSP-enriched compost treatments applied at different times	

	of incubation.....	101
14.	Rate constants, coefficient of determination R^2 and standard error SE of power function equation of phosphate desorption from El-Sebaiya PR and SSP-enriched compost treatments applied at different times of incubation.....	103
15.	Effect of different phosphocompost treatments on shoot and root fresh weight (g/plant) of Banana seedlings treated with or without mycorrhizae.....	125
16.	Effect of different phosphocompst treatments on shoot and root dry weight (g/plant) of Banana seedlings treated with or without mycorrhizae.	130
17.	Effect of different phosphocompst treatments on plant height and stem diameter (cm) of Banana seedlings treated with or without mycorrhizae.	138
18.	Effect of different phosphocompost treatments on N uptake (mg/plant) of banana shoot and root treated with or without mycorrhizae.....	142
19.	Effect of different phosphocompost treatments on the P uptake (mg/plant) of banana shoot and root treated with or without mycorrhizae.....	147
20.	Effect of different phosphocompost treatments on the K uptake (mg/plant) of banana shoot and root treated with or without mycorrhizae.....	150
21.	Effect of different phosphocompst treatments on N content (ppm) of soil treated with or without mycorrhizae.	152
22.	Effect of different phosphocompst treatments on P content (ppm) of soil treated with or without mycorrhizae.....	153
23.	Effect of different phosphocompst treatments on K content (ppm) of soil treated with or without mycorrhizae.....	155
24.	Effect of different phosphocompst treatments applied on soybean plants (shoot fresh and dry weight) at 70 and 120 days (g/plant) in soil treated with or without mycorrhizae.	157

25.	Effect of different phosphocompost treatments on soybean plants (root fresh and dry weight) at 70 and 120 days (g/plant) in soil treated with or without mycorrhizae	161
26.	Effect of different phosphocompost treatments on plant height (cm), 100 seed weight (gm) and seed yield Kg/Fed in soybean plants treated with or without mycorrhizae.. . . .	165
27.	Effect of different phosphocompst treatments on N shoot and root uptake mg/plant in soybean plant 70 and 120 days treated with or without mycorrhizae.....	169
28.	Effect of different phosphocompost treatments on P shoot and root uptake mg/plant in soybean plant after 70 and 120 days treated with or without mycorrhizae....	172
29.	Effect of different phosphocompost treatments on K shoot and root uptake mg/plant in soybean plant after 70 and 120 days treated with or without mycorrhizae....	176
30.	Effect of different phosphocompost treatments on N, P and K soil concentration ppm in soybean plant at 70 days soil treated with or without mycorrhizae.....	178
31.	Effect of different phosphocompost treatments on N, P, and K soil concentration ppm in soybean Plant at 120 days soil treated with or without mycorrhizae.....	179

LIST OF FIGURES

No	Title	Page
1.	World phosphate rock production.....	6
2.	Distribution of phosphate deposits in Egypt	7
3.	Kinetics of phosphate release from the different types of PR applied in agricultural land at different stages.....	70
4.	Kinetics of phosphate desorption from different groups of PR tested.....	71
5.	Kinetics of phosphate desorption from the compost enriched with varied rates of Al-Oroba PR at different incubation times.....	85
6.	Kinetics of phosphate desorption from the compost enriched with varied rates of El-Sebaiya PR at different incubation times.	87
7.	Change in exchangeable P through the entire reaction time of compost enriched with Al-Oroba PR in comparing with compost enriched with SSP.....	110
8.	Change in exchangeable P through the entire reaction time of compost enriched with El-Sebaiya PR in comparing with compost enriched with SSP.....	112
9.	Change in organic P through the entire reaction time of compost enriched with Al-Oroba PR in comparing with compost enriched with SSP.....	113
10.	Change in organic P through the entire reaction time of compost enriched with El-Sebaiya PR in comparing with compost enriched with SSP.....	113
11.	Change in pH values through the entire reaction time of compost enriched with Al-Oroba PR in comparing with compost enriched with SSP.....	116
12.	Available phosphorus concentration in compost enriched with 10% Al-Oroba	116
13.	Change in pH values through the entire reaction time in compost enriched with El-Sebaiya PR in comparing with SSP enriched compost.....	118

14.	Change in temperature degree (C0) through the entire reaction time of compost enriched with Al-Oroba PR in comparing with compost enriched with single superphosphate	119
15.	Change in C/N ratio through the entire reaction time of compost enriched with Al-Oroba PR in comparing with compost enriched with SSP.....	121
16.	Change in C/N ratio through the entire reaction time of compost enriched with El-sebaiya PR in comparing with compost enriched with SSP.....	121
17.	Change in OC through the entire reaction time of compost enriched with Al-Oroba PR in comparing with compost enriched with SSP.....	122
18.	Change in OC through the entire reaction time of compost enriched with El-Sebaiya PR in comparing with compost enriched with SSP.....	123
19.	Effect of different phosphocompost treatments on shoot and root fresh weight (g/plant) of Banana seedlings	126
20.	Effect of different phosphocompost treatments on shoot and root dry weight (g/plant) of Banana seedlings	131
21.	Effect of different phosphocompst treatments on leaves number, plant height and stem diamter of banana seedlings	137
22.	Effect of different phosphocompost treatments on N, P and K uptake (mg/plant) of banana shoot	143
23.	Effect of different phosphocompost treatments on N, P and K uptake (mg/plant) of banana root.....	144