

**EFFECT OF BIOFERTILIZATION AND AMINO
ACIDS APPLICATION ON MINIMIZING N AND P
MINERAL FERTILIZATION LEVELS FOR
STRAWBERRY PLANTS**

By

HEBA HANAFY MOHAMED MOHAMED

B.Sc. Agric. Sc., (Horticulture), Ain Shams University, 2004

M.Sc. Agric. Sc., (Vegetable Crops), Ain Shams University, 2010

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

**DOCTOR OF PHILOSOPHY
in
Agricultural Science
(Vegetable Crops)**

**Department of Horticulture
Faculty of Agriculture
Ain Shams University**

2016

Approval Sheet

EFFECT OF BIOFERTILIZATION AND AMINO ACIDS APPLICATION ON MINIMIZING N AND P MINERAL FERTILIZATION LEVELS FOR STRAWBERRY PLANTS

By

HEBA HANAFY MOHAMED MOHAMED

B.Sc. Agric. Sc., (Horticulture), Ain Shams University, 2004

M.Sc. Agric. Sc., (Vegetable Crops), Ain Shams University, 2010

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

Dr. Mohamed Abd El-Megeed Badawi

Emeritus Professor of Vegetable Crops, Faculty of Agriculture, Cairo University

Dr. Ahmed Mahmoud El-Gizawy

Emeritus Professor of Vegetable Crops, Faculty of Agriculture, Ain Shams University

Dr. Ahmed Abou El-Yazied Abd El-Hafiz

Prof. of Vegetable Crops, Department of Horticulture, Faculty of Agriculture, Ain Shams University

Dr. Mohamed Emam Ragab

Prof. of Vegetable Crops, Faculty of Agriculture, Ain Shams University

Date of Examination: / / 2015

EFFECT OF BIOFERTILIZATION AND AMINO ACIDS APPLICATION ON MINIMIZING N AND P MINERAL FERTILIZATION LEVELS FOR STRAWBERRY PLANTS

By

HEBA HANAFY MOHAMED MOHAMED

B.Sc. Agric. Sc., (Horticulture), Ain Shams University, 2004

M.Sc. Agric. Sc., (Vegetable Crops), Ain Shams University, 2010

Under the supervision of:

Dr. Mohamed Emam Ragab

Prof. of Vegetable Crops, Department of Horticulture, Faculty of Agriculture, Ain Shams University (Principal Supervisor)

Dr. Ahmed Abou El-Yazied Abd El-Hafiz

Prof. of Vegetable Crops, Department of Horticulture, Faculty of Agriculture, Ain Shams University

Dr. Samy Abd El- Gawad Gaafar

Head Researcher of Vegetable Crops, Department of Protected Cultivation, Horticulture Research Institute, Agricultural Research Center

ABSTRACT

Heba Hanafy Mohamed Mohamed: Effect of Biofertilization and Amino Acids Application on Minimizing N and P Mineral Fertilization Levels for Strawberry Plants. Unpublished Ph.D. Thesis, Department of Horticulture, Faculty of Agriculture, Ain Shams University, 201^o.

This study was carried out during the two successive seasons of 2010/2011 and 2011/2012 at Ismailia Governorate, Egypt. The aim of the study was to investigate the effect of minimizing N and P mineral fertilization levels and using biofertilizer application and amino acids on yield and fruit quality of strawberry plants. Fresh transplants were used in a split split design with three replicates was adopted. The main plots were assigned to the mineral NP fertilization levels, i.e., 100%, 75% and 50%, while the sub - plots were for biofertilizer application i.e., with biofertilizers (*Bacillus megaterium var phosphaticum* and *Azotobacter chroococcum*) and without biofertilizer. The sub- sub – plots were for amino acids foliar spray, i.e., with or without amino acids. Results indicated that the highest values of crown diameter, chlorophyll, N, P, TSS and ascorbic acid contents were obtained from using 100% of the recommended NP level of mineral fertilizers plus biofertilizers and amino acids at 1.5 g/l in the two growing seasons. Data also concluded that using 75% of the recommended NP level of mineral fertilizers had higher significant increments in early, total yield, chlorophyll content, N, and ascorbic acid in the two tested seasons. Moreover, Festival c.v plants treated with biofertilizers and amino acids gave the highest values in early and total yield in both seasons. Data showed that fertilizing the plants with mineral fertilizers (NP) at 50% of the recommended dose gave the lowest nitrate content of fruits in the two tested seasons.

Key words: Strawberry, mineral fertilization, biofertilizer, amino acid, yield, quality.

ACKNOWLEDGEMENT

First of all, Praise be to who guided us to this felicity, never could we have guidance, have not it been for the guidance of Allah.

I'm grateful to Professor **Dr. Mohamed Emam Ragab**, Prof. of Vegetable Crops and Vice Dean of Faculty of Agriculture, Ain Shams University who kindly devoted a great deal of his valuable time for the planning and the entire development of this work. Due to his sincere initiating power, expert guidance stimulating suggestion and constructive criticism, this work has been brought to light.

I'm grateful to Professor **Dr. Ahmed Abou El-Yazied Abd El-Hafiz**, Prof. of Vegetable Crops, Faculty of Agriculture, Ain Shams University for his supervision, great support during the preparation of this work. Deepest and sincere gratitude are extended to him.

I would like to thank **Dr. Ahmed Abdelwahab Abdelhafez**, Prof. of Agriculture Microbiology, Faculty of Agriculture, Ain Shams University, for his great valuable help, continuous encouragement and supervision during the preparation of this work.

I would like to thank **Dr. Samy Abdelgawad Gafaar**, former Head of Research, Protected Cultivation Department, Horticulture Research Institute, Agriculture Research Center, for his great valuable help and advice of this thesis deepest gratitude for him.

My sincere thanks to all staff members of Horticulture Department, and Strawberry and Non-Traditional Crop Center, Ain Shams University, for their useful cooperation. Also, special thanks to staff members of Protected Cultivation Department, Horticulture Research Institute, Ministry of Agriculture, for their help.

Great thanks and deep gratitude are extended to **my family** and **my husband** for their help and support during the study.

CONTENTS

	Page
I. INTRODUCTION	1
II. REVIEW OF LITERATURE	3
2.1. Vegetative growth characteristics	3
2.1.1. Effect of NP fertilization	3
2.1.2. Effect of biofertilization	4
2.1.3. Effect of the combination of NP and biofertilization	5
2.1.4. Effect of amino acids	6
2.2. Chemical constituents of plant foliage	9
2.2.1. Photosynthetic pigments	9
2.2.1.1. Effect of NP fertilization	9
2.2.1.2. Effect of biofertilization	10
2.2.1.3. Effect of the combination of NP and biofertilization	10
2.2.1.4. Effect of amino acids	11
2.2.2. Mineral constituents	11
2.2.2.1. Effect of NP fertilization	11
2.2.2.2. Effect of biofertilization	12
2.2.2.3. Effect of the combination of NP and biofertilization	12
2.2.2.4. Effect of amino acids	13
2.3. Total fruit yield and its components	14
2.3.1. Effect of NP fertilization	14
2.3.2. Effect of biofertilization	15
2.3.3. Effect of the combination of NP and biofertilization	16
2.3.4. Effect of amino acids	17
2.4. Fruit components	18
2.4.1. Effect of NP fertilization	18
2.4.2. Effect of biofertilization	19
2.4.3. Effect of the combination of NP and biofertilization	19
2.4.4. Effect of amino acids	20

	Page
III. MATERIALS AND METHODS	22
3.1. Vegetative growth characteristics.....	25
3.1.1. Number of leaves / plant.....	25
3.1.2. Average leaf area	25
3.1.3. Crown diameter/ plant	25
3.1.4. Number of secondary crowns/plant.....	25
3.1.5. Plant height / plant	25
3.1.6. Number of inflorescences / plant.....	25
3.1.7. Fresh weight / plant.....	25
3.1.8. Dry weight / plant.....	25
3.2. Chemical composition of plant foliage.....	25
3.2.1. Chlorophyll content.....	25
3.2.2. Nitrogen content.....	26
3.2.3. Phosphorus content.....	26
3.3. Yield and its components.....	26
3.3.1. Early yield/ plant	26
3.3.2. Total yield/ plant	26
3.4. Fruit components	26
3.4.1. Physical quality.	26
3.4.1.1. Fruit weight.....	26
3.4.1.2. Fruit firmness.....	26
3.4.2. Chemical quality	27
3.4.2.1. Total soluble solids contents (TSS).....	27
3.4.2.2. Titrable acidity (TA)	27
3.4.2.3. Total soluble solids / titrable acidity (TSS / acid).....	27
3.4.2.4. Ascorbic acid content.....	27
3.4.2.5. Total and reducing sugars.	27
3.4.2.6. The pH of juice	27
3.4.2.7. Nitrate content	28
3.5. Statistical analysis.....	28

	Page
4. RESULTS AND DISCUSSION	29
4.1. Vegetative growth characteristics.....	29
4.1.1. The main effect of mineral fertilization, biofertilizer and amino acids on vegetative growth characteristics	29
4.1.1.1. Number of leaves / plant	29
4.1.1.2. Average leaf area	30
4.1.2 Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on number of leaves and average leaf area.....	31
4.1.2.1. Number of leaves / plant	31
4.1.2.2. Average leaf area	32
4.1.3 Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on number of leaves and average leaf area	32
4.1.3.1. Number of leaves / plant	32
4.1.3.2. Average leaf area	33
4.1.1. The main effect of mineral fertilization, biofertilizer and amino acids on crown diameter and plant height.....	34
4.1.1.3. Crown diameter	34
4.1.1.4. Plant height	35
4.1.2. Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on crown diameter and plant height.....	35
4.1.2.3. Crown diameter	35
4.1.2.4. Plant height	36
4.1.3. Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on crown diameter and plant height	37
4.1.3.3. Crown diameter	37
4.1.3.4. Plant height	38
4.1.1. The main effect of mineral fertilization, biofertilizer and	38

	Page
amino acids on number of secondary crowns and inflorescences.....	
4.1.1.5. Number of secondary crowns / plant	38
4.1.1.6. Number of inflorescences	39
4.1.2. Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on number of secondary crowns and inflorescences.	39
4.1.2.5. Number of secondary crowns/plant	39
4.1.2.6. Number of inflorescences per plant	40
4.1.3. Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on number of secondary crowns and inflorescences.	41
4.1.3.5. Number of secondary crowns/plant	41
4.1.3.6. Number of inflorescences per plant	41
4.1.1. Main effect of mineral fertilization, biofertilizer and amino acids on fresh and dry weight.....	42
4.1.1.7. Fresh weight/plant.....	42
4.1.1.8. Dry weight/plant.....	43
4.1.2. Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on fresh and dry weight.....	45
4.1.2.7. Fresh weight/plant.....	45
4.1.2.8. Dry weight/plant.....	46
4.1.3. Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on fresh and dry weight	46
4.1.3.7. Fresh weight/plant	46
4.1.3.8. Dry weight/plant.....	47
4.2.1. The main effect of mineral fertilization, biofertilizer and amino acids on Chemical composition of plant foliage	47
4.2.1.1. Chlorophyll content.....	47

	Page
4.2.1.2. Nitrogen content.....	49
4.2.1.3. Phosphorus content.....	49
4.2.2. Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on chlorophyll content, nitrogenous and phosphorus.....	51
4.2.2.1. Chlorophyll content	51
4.2.2.2. Nitrogen content.....	52
4.2.2.3. Phosphorus content.....	52
4.2.3. Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on chlorophyll content, nitrogenous and phosphorus.....	53
4.2.3.1. Chlorophyll content	53
4.2.3.2. Nitrogen content.....	54
4.2.3.3. Phosphorus content	54
4.3. Yield and its components	54
4.3.1. Main effect of mineral fertilization, biofertilizer and amino acids on early and total yield.....	54
4.3.1.1. Early yield/plant	54
4.3.1.2. Total yield/plant	55
4.3.2. Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on early and total yield.....	56
4.3.2.1. Early yield/plant.....	56
4.3.2.2. Total yield/plant	58
4.3.3. Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on early and total yield.....	58
4.3.3.1. Early yield/plant	58
4.3.3.2. Total yield/plant.....	59
4.4. Fruit components	
4.4.1. Physical quality.....	59

	Page
4.4.1.1. Main effect of mineral fertilization, biofertilizer and amino acids on fruit weight and fruit firmness	59
4.4.1.1.1. Fruit weight	59
4.4.1.1.2. Fruit firmness	61
4.4.1.2. Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on fruit weight and fruit firmness	62
4.4.1.2.1. Fruit weight	62
4.4.1.2.2. Fruit firmness	63
4.4.1.3. Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on fruit weight and fruit firmness.....	64
4.4.1.3.1. Fruit weight	64
4.4.1.3.2. Fruit firmness	64
4.4.2. Chemical quality.....	65
4.4.2.1. Main effect of mineral fertilization, biofertilizer and amino acids on chemical quality	65
4.4.2.1.1. Total soluble solids (T.S.S.).....	65
4.4.2.1.2. Total titratable acidity (T.T.A).....	66
4.4.2.1.3. Total soluble solids / titratable acidity ratio (TSS/acid)	66
4.4.2.1.4. Ascorbic acid content.....	67
4.4.2.1.5. The pH of juice	68
4.4.2.1.6. Nitrate content	68
4.4.2.1.7. Total and reducing sugars.....	68
4.4.2.2. Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on chemical quality	69
4.4.2.2.1. Total soluble solids (T.S.S.)	69
4.4.2.2.2. Total titratable acidity (T.T.A)	70

	Page
4.4.2.2.3. Total soluble solids /titratable acidity ratio (TSS/acid)	71
4.4.2.2.4. Ascorbic acid content.....	71
4.4.2.2.5. The pH of juice	72
4.4.2.2.6. Nitrate content	73
4.4.2.2.7. Total and reducing sugars	73
4.4.2.3. Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on chemical quality.....	75
4.4.2.2.1. Total soluble solids (T.S.S.)... ..	75
4.4.2.2.2. Total titratable acidity (T.T.A)	75
4.4.2.2.3.Total soluble solids /titratable acidity ratio (TSS/acid)	76
4.4.2.2.4. Ascorbic acid content.....	76
4.4.2.2.5. The pH of juice	76
4.4.2.2.6. Nitrate content	77
4.4.2.2.7. Total and reducing sugars	77
V. SUMMARY AND CONCLUSION.....	79
VI. REFERENCES.....	84
VII. ARABIC SUMMARY	

LIST OF TABLES

	Page
Table (A): Chemical analyses of the used amino acids (Amino Zeid).....	23
Table (B): Physical and chemical analysis of the soil of experimental site	24
Table (C): Average temperatures during the growing periods under Ismailia Governorate conditions.....	28
Table (1): Main effect of mineral fertilization, biofertilizers and amino acids on number of leaves and average leaf area during 2010/2011 and 2011/2012	30
Table (2): Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on number of leaves and average leaf area during 2010/2011 and 2011/2012.....	31
Table (3): Effect of the interaction among mineral fertilization, biofertilizer and amino acids on number of leaves and average leaf area during 2010/2011 and 2011/2012....	33
Table (4): Main effect of mineral fertilization, biofertilizers and amino acids on crown diameter and plant height during 2010/2011 and 2011/2012.....	34
Table (5): Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on crown diameter and plant height during 2010/2011 and 2011/2012.....	36
Table (6): Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on crown diameter and plant height during 2010/2011 and 2011/2012.....	37

	Page
Table (7): Main effect of mineral fertilization, biofertilizers and amino acids on Number of secondary crowns and inflorescences during 2010/2011 and 2011/2012.....	38
Table (8): Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on number of secondary crowns and inflorescences during 2010/2011 and 2011/2012.....	40
Table(9): Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on number of secondary crowns and inflorescences during 2010/2011 and 2011/2012.....	42
Table(10) : Main effect of mineral fertilization, biofertilizer and amino acids on fresh and dry weight during 2010/2011 and 2011/2012	43
Table(11): Effect of the first degree of interaction among of mineral fertilization, biofertilizers and amino acids on fresh and dry weight during 2010/2011 and 2011/2012..	45
Table(12): Effect of the second degree of interaction among mineral fertilization, biofertilizers and amino acids on fresh and dry weight during 2010/2011 and 2011/2012 ..	47
Table(13): Main effect of mineral fertilization, biofertilizer and amino acids on chlorophyll content, nitrogen and phosphorus / plant during 2010/2011 and 2011/2012...	48
Table(14): Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on chlorophyll content, nitrogen and phosphorus / plant during 2010/2011 and 2011/2012.....	51

	Page
Table(15): Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on chlorophyll content, nitrogen and phosphorus/ plant during 2010/2011 and 2011/2012.....	53
Table(16): Main effect of mineral fertilization, biofertilizer and amino acids on early and total yield during 2010/2011 and 2011/2012.....	55
Table(17): Effect of the first degree of interaction among mineral fertilization, biofertilizer and amino acids on early and total yield during 2010/2011 and 2011/2012.....	57
Table(18): Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on early and total yield during 2010/2011 and 2011/2012.....	59
Table(19): Main effect of mineral fertilization, biofertilizer and amino acids on fruit weight and fruit firmness during 2010/2011 and 2011/2012	60
Table(20): Effect of the first order interactions among mineral fertilization, biofertilizer and amino acids on fruit weight and fruit firmness during 2010/2011 and 2011/2012	62
Table(21): Effect of the second degree of interaction among mineral fertilization, biofertilizer and amino acids on fruit weight and fruit firmness during 2010/2011 and 2011/2012	64
Table(22): Main effect of mineral fertilization, biofertilizer and amino acids on total soluble solid, total titratable acidity and Total soluble solids / titratable acidity ratio during 2010/2011 and 2011/2012.....	65