SOME PHYSIOLOGICAL STUDIES ON INCREASING CANOLA PRODUCTION UNDER SALINITY STRESS

By

HODA SANY ZAKY HASSAN
B.Sc. Agric. Sci. (Int. Agric.), Fac. Agric., Cairo Univ., 2003
M.Sc. Agric. Sci. (Plant Physiology), Fac. Agric., Cairo Univ., 2009

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

DOCTOR OF PHILOSOPHY

In

Agricultural Sciences
Plant Physiology

Department of Agricultural Botany
Faculty of Agriculture
Cairo University
EGYPT

2017

APPROVAL SHEET

SOME PHYSIOLOGICAL STUDIES ON INCREASING CANOLA PRODUCTION UNDER SALINITY STRESS

Ph.D. Thesis
In
Agricultural Sciences (Plant Physiology)

By

HODA SANY ZAKY HASSAN

B.Sc. Agric. Sci. (Int. Agric.), Fac. Agric., Cairo Univ., 2003
M.Sc. Agric. Sci. (Plant Physiology), Fac. Agric., Cairo Univ., 2009

APPROVAL COMMITTEE

Dr. SAID AWAD MOHAMED SHEHATA …………..
Professor of Plant Physiology, Fac. Agric., Ain Shams University

Dr. AHMED HUSSEIN HANAFY AHMED …………..
Professor of Plant Physiology, Fac. Agric., Cairo University

Dr. EGLAL MOHAMED ZAKI HARB …………..
Professor of Plant Physiology, Fac. Agric., Cairo University

Dr. MOHAMED R. A. NESIEM …………..
Professor of Plant Physiology, Fac. Agric., Cairo University

Date: 12/10/2017

SUPPERVISION SHEET

SOME PHYSIOLOGICAL STUDIES ON INCREASING CANOLA PRODUCTION UNDER SALINITY STRESS

Ph.D. Thesis
In
Agricultural Sciences (Plant Physiology)

By

HODA SANY ZAKY HASSAN
B.Sc. Agric. Sci. (Int. Agric.), Fac. Agric., Cairo Univ., 2003
M.Sc. Agric. Sci. (Plant Physiology), Fac. Agric., Cairo Univ., 2009

SUPERVISION COMMITTEE

Dr. EGLAL MOHAMED ZAKI HARB
Professor of Plant Physiology, Fac. Agric., Cairo University

Dr. MOHAMED RAMADAN ABOUL-ELLA NESIEM
Professor of Plant Physiology, Fac. Agric., Cairo University

Dr. DARWISH SALEH DARWISH
Professor of Agronomy, Fac. Agric., Cairo University

Name of Candidate: Hoda Sany Zaky Hassan **Degree:**Ph.D.
Title of Thesis: Some Physiological Studies on Increasing Canola Production Under Salinity Stress
Supervisions: Dr. Eglal Mohamed Zaki Harb
Dr. Mohamed Ramadan Aboul-Ella Nesiem
Dr. Darwish Saleh Darwish.
Department: Agricultural Botany
Branch: Plant Physiology
Approval: 12/10/2017

ABSTRACT

The present investigation was conducted to study the effects of humic acid (HA), salicylic acid (SA) and ascorbic acid (AsA) on growth, yield, oil %, fatty acid composition of seed oil and chemical constituents of canola plants grown under three salinity levels (control, 4000 or 8000 ppm). This experiment was carried out in the green house of the Plant Physiology Division, Fac. of Agric., Cairo Univ., Giza, Egypt, during two successive seasons; 2014/2015 and 2015/2016.

The obtained results confirmed the significant negative effects of salinity on canola growth characters including root length and shoot height, root and shoot fresh & dry weight, total plant leaves area as well as yield components comprised of number of siliquae/plant, number of seeds/siliqua, seed yield/plant, oil % and fatty acids percentage in canola oil. Furthermore, salinity resulted in a significant decrease in chlorophyll a &b, N, P and K concentrations in roots and shoots of canola plants. However, data revealed a progressive increase in Na, free amino acids, free proline, total soluble phenols and total sugar concentrations in roots and shoots.

The results indicated the promotive effects of HA (50 or 100 ppm), SA (36 or 72 µM) and AsA (1.5 or 3 mM) on the growth characters and yield components of canola when compared to the control. Application of HA at 100 ppm resulted in the highest root length and shoot height, root and shoot fresh & dry weight, total plant leaves area as well as yield components including number of siliquae/plant, number of seeds/siliqua, seed yield / plant and oil % as compared to the other salinity tolerance inducers or control plants. The application of 50 or 100 ppm HA or 72 µM SA to canola plants grown 4000 ppm salinity resulted in an obvious increase in oleic acid % and reduced euricic % in canola seed oil. Also, increased chlorophyll a & b, N, P, K, free amino acids, free proline, total soluble phenols and total sugar concentrations in canola roots and shoots were achieved by using salinity tolerance inducers.

It was found that canola plants grown under 4000 ppm and treated with HA at 100 ppm followed by HA at 50 ppm were able to approach their optimal productivity as compared to the control (non-salinized and untreated). Thus, these results strongly suggest that HA especially at 100 ppm application to canola plants grown under salinity stress (4000 ppm) has an effective role for potential growth regulation, improving plant resistance to salinity stress and its productivity.

Keywords: Canola, salinity, humic acid, ascorbic acid, salicylic acid, growth, yield and oil.

ACKNOWLEDGEMENT

First, I would like express my praise to great Allah for the uncountable blessings.

*I would like to express my deepest gratitude and profound thanks to **Prof. Dr. Eglal Zaki Harb,** Professor of Plant Physiology, Fac. Agric., Cairo University for her support and assistance throughout this work. I consider myself as very lucky to have **Prof. Dr. Mohamed Ramadan,** Professor of Plant Physiology, Fac. Agric., Cairo University as one of my supervisors. He always offered me continuous advice, attention and guidance. I would also like to show my gratefulness to **Prof. Dr. Abd-Alrahman Moursy Ghallab**, late Professor of Plant Physiology, Fac. Agric., Cairo University for his kind encouragement at the beginning of this work.*

*Extended gratitude also goes to **Prof. Dr. Darwish S.Darwish** Professor of Agronomy, Fac. Agric., Cairo University for his sincere and generous contribution especially in the practical part of this study.*

*Sincere appreciation to **Dr. Said A. F. Hamoda,** Head Researcher in Cotton Research Institute, Agricultural Research Centre for his keen and valuable contribution and assistance in this research.*

My gratitude also goes to all my colleagues for their continuous advice and guidance as well as members of Plant Physiology Division, Faculty of Agriculture, Cairo University for being so helpful and cooperative.

My best regards and thanks to my parents, husband and sisters for their sincere support, compassion, patience and motivation, whom without this work wouldn't have been accomplished in its present form.

LIST OF ABBREVIATIONS

ABA	Abscisic Acid
ACC	Aminocyclopropane Carboxilic Acid
ACS	Aminocyclopropane Carboxylic Acid Synthase
AKT1	serine/threonine protein kinase enzyme
APX	Ascorbate Peroxidase
ASA	Ascorbic Acid
ATP	Adenosine Triphosphate
ATPase	Adenosine Triphosphatase
CAT	Catalase
Chl	Chlorophyll
Cu/ZnSOD	Copper and Zinc-containing Superoxide Dismutase
Cys	Cysteine
DAS	Days After Sowing
DHAR	Dehydroascorbate Reductase
DNase I	Deoxyribonuclease I
dS m^{-1}	deci-Siemens / m = 1 m moh.cm^{-1} ≅ 640 ppm
Fe-SOD	Iron Superoxide Dismutase
Fv/Fm	variable/ maximum chlorophyll fluorescence
GA	Gibberellic Acid
GDH	Glutamate Dehydrogenase
GK	Glutamyl Kinase
GLC	Gas –Liquid Chromatography
Gly I	Glyoxalase I

Gly II	Glyoxalase II
GPX	Glutathione Peroxidase
GR	Glutathione Reductase
GS	Glutamine Synthetase
GSH	Reduced Glutathione
GSSG	Glutathione Disulphide
GST	Glutathione S- Transferase
HA	Humic Acid
HA7	Biostimulant Extracted from Humic Acid
HS	Humic Substances
IAA	Indole Acetic Acid
IUPAC	International Union of Pure and Applied Chemistry
LDL	Low Density Lipoprotein
MDA	Malondialdehyde
MDHAR	Monodehydroascorbate Reductase
MW	Molecular Weight
NADP	Nicotinamide Adenine Dinucleotide Phosphate
NR	Nitrate Reductase
NUE	Nitrogen Use Efficiency
P5CS	1-Pyrroline-5-Carboxylate Synthase
PAL	Phenylalanine Ammonia-Lyase
PDH	Proline Dehydrogenase
PEG	Polyethylene Glycol
PEP	Phophoenolpyruvate
PGR	Plant Growth Regulators

POX	Peroxidase
PPO	Polyphenol Oxidase
PROX	Proline Oxidase
PS I	Photosystem I
PS II	Photosystem II
ROS	Reactive Oxygen Species
SA	Salicylic Acid
SOD	Superoxide Dismutase
SPAD	Soil Plant Analysis Development
WUE	Water Use Efficiency

CONTENTS

LIST OF TABLES

INTRODUCTION

Canola was developed in the 1970s by Canadian plant scientists. It refers to the "double-low" variety of the rapeseed plant *(Brassica napus*) from which the oil should contain less than 2% erucic acid in its fatty acids profile and the solid component shall contain less than 30 µmole/g of glucosinolates. Globally, canola is now the third most important source for vegeTable oil for human consumption after palm and soybean oils, ranked first and second, respectively. Canola oilseed production is second only to soybean oilseed production.

Canola oil is known for its outstanding nutritional content and is considered one of the healthiest vegeTable oils available to consumers. Compared to all other vegeTable oils in the market, canola oil has the lowest levels of saturated fatty acids reaching about 7 % (the lowest among common cooking and salad vegeTable oils), 18.6% linoleic acid, 9.1% linolenic acid and 63.2% mono-unsaturated fatty acids. Interestingly, canola oil is high in monounsaturated fat which may reduce the risk of coronary heart disease by lowering bad LDL cholesterol in the blood and helping control blood glucose. Canola oil is a beneficial source of tocopherols (vitamin E, an antioxidant) and vitamin k as well as phytosterols that help reduce cholesterol. Lastly, like all vegeTable oils canola is cholesterol free. The health benefits of canola oil have enhanced the adoption of canola as a healthy dietary source across the globe. Thus more demand for canola production over the world.

The high smoking point of canola oil along with the previously mentioned benefits makes it suiTable for culinary purposes such as frying, baking, marinating and salad oil. It also showed success in other industries such as cosmetics (shampoo and soap), printing ink and lubricants. Biofuel feedstock is one of the newer uses for canola. It's the feedstock of choice for Canadian-produced biodiesel because of its exceptional cold weather performance. In addition, canola meal, the part left over after the seeds are crushed and the oil extracted, is high–protein meal that is an excellent animal feed for cattle, poultry, swine and fish.

The productivity of crops is not increasing in parallel with the food demand. The lower productivity in most of the cases is attributed to various abiotic stresses. Curtailing crop losses due to various environmental stresses is a major area of concern to cope with the increasing food requirements (Shanker and Venkateswarlu, 2011).

Rising soil salinity has been a major problem in the soils of Egypt in recent decades. Plant growth and development is hampered due to salinity stress through lowering osmotic potential of soil solution (water stress), nutritional imbalance, specific ion effect (salt stress) or a combination of these factors. During the development of salt stress within a plant, all the major processes such as photosynthesis, protein synthesis, as well as metabolic processes, in particular nitrate uptake, translocation, and assimilation is impaired. Salt stress induces severe metabolic disfunctions by boosting reactive oxygen species formation and accumulation, lipid peroxidation, oxidative stress, damage in DNA, inactivation of enzymes and senescence, with the loss of chlorophylls