METABOLISM OF SOME SOUND AND INFECTED BARLEY AND WHEAT PLANTS

By

KAMAL ROSHDY FOUAD HUSSEIN

B.Sc., (Agric.) 1963

M.Sc., (Agric.) 1969

Thesis Submitted in Partial Fulfilment of the Requirements for the Degree

of

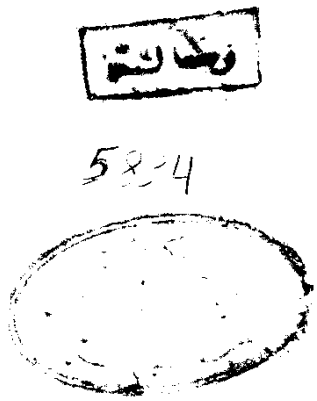
DOCTOR OF PHILOSOPHY

in

Agricultural Biochemistry

Faculty of Agriculture

Ain Shams University



1973

APPROVAL SHEET

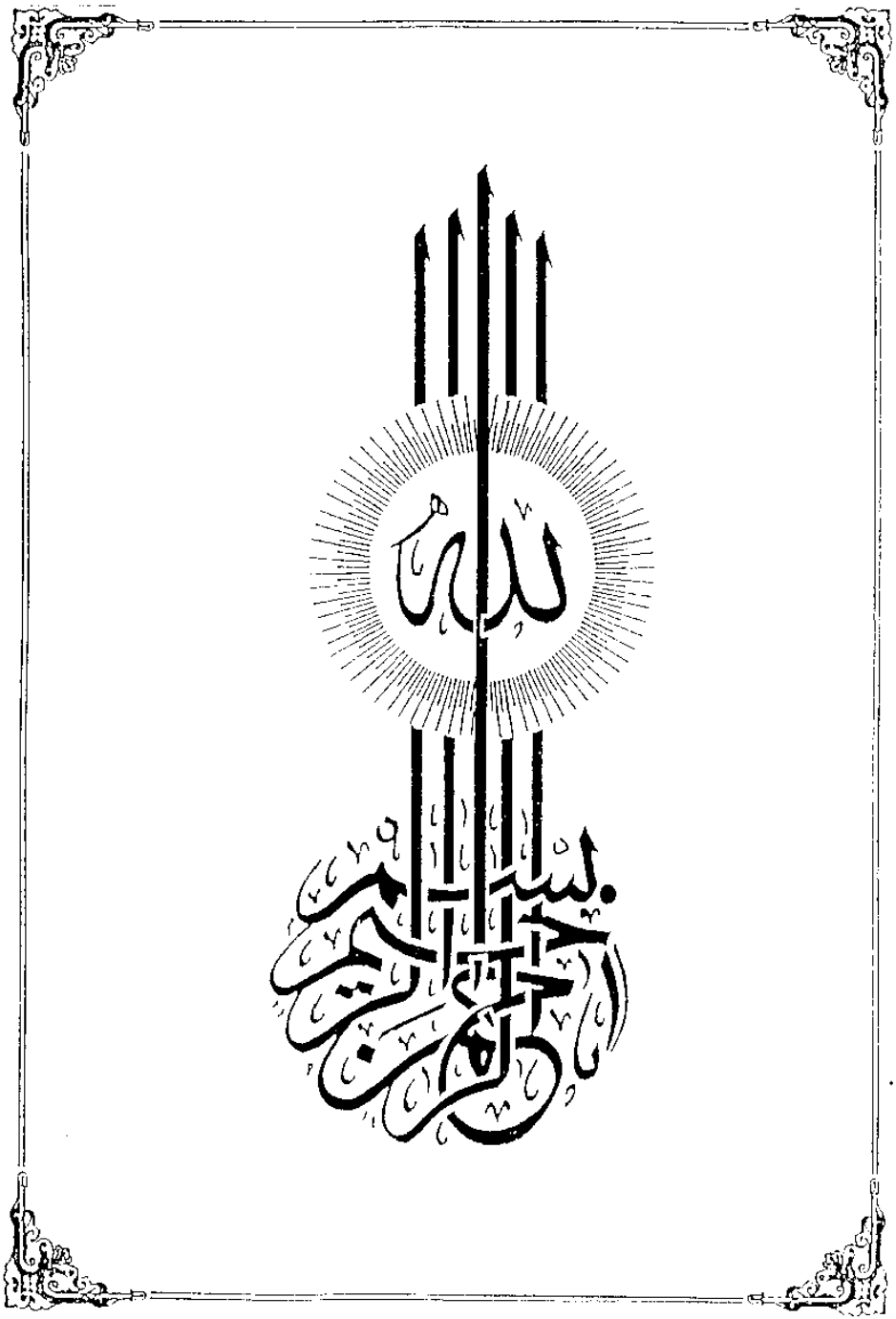
This Thesis for Ph. D Degree has been approved by:

M. M. Ragab

Committee in charge

Date: 13 / 12 / 1973

-- oo 0 oo --



ACKNOWLEDGMENT

The present investigation was suggested and directly supervised by Professor Dr. Mohamed Abdel Moneim Kamal, Chairman of the Agricultural Biochemistry & Head of the Soil Department, Faculty of Agriculture, Ain Shams University (Cairo) to whom the author is greatly indebted for his inspiration, guidance and advice throughout the whole course of this work.

Thanks are also due to Professor Dr. Ahmed Said Hamed, Professor of the Agriculture Chemistry in the same Department of the Faculty for his encouragement and help.

Many thanks should be given to Professor Dr. Hussny Abdel Rahman Mohamed Professor of Plant Pathology Department, Bahtim Experiment Station for his help and criticism and revision of the thesis, besides his help and guidance.

-- oOOoo --

CONTENTS

- oo 0 oo -

INTRODUCTION

Increase of wheat and barley production in Egypt is urged in the last few years because of the rapid increase in the population. In Egypt, the production of wheat is limited to one third or less of the 6,050,000 feddans under cultivation (annon 1967).

It became necessary to import wheat from other countries to overcome such shortage for human food. For several years, it has been tried to produce wheat and barley cultivars that are resistant to prevalent races of the important rusts in Egypt to increase yield per feddan. Losses due to rust attack are very high especially in case of susceptible cultivars and decrease in yield was more than 30 % of the grain yield. Also, quality was affectected as wheat grain in such cases was shrivilled (Mohamed 1963).

Fastiduous microorganisms have specific need for differedt types of nutrients. The absence of any specific nutrients will limit or strict its growth. An organism starves when surrounding conditions departs in any appercciable manner, from the normal. Microorganisms sometimes require specific

substances for their nourishment, especially for obligate parasites, which may differentiate hosts being resistant or susceptible.

This investigations were carried out to differentiate between the constituents of wheat and barley plants resistant or susceptible to stem rust and to correlate rust reaction with the biochemical changes which take place in infected host plants. It was also attempted to seek some of the requirements for obligate parasites for their development in host plants.

-- oo 0 oo --

PART (I)

REVIEW OF LITERATURE

PART I

REVIEW OF LITERATURE

Several workers reported changes in the constituents of the wheat plants following infection. Previous work on this subject will be divided into four parts.

A. Carbohydrates metabolism:

Mains (1917), Browning (1954) and Silverman (1960), reported that sugars in general tended to increase susceptibility of detached leaves to fungal parasities by providing an extra source of energy for the invader. Since photosynthates are unnecessary when sugars are supplied, light and carbon dioxide are then not essential for infection, and darkness sometimes promotes infection.

Waters (1928), as a result of experiments on the urediospore and teliospore formation of ten species of rust, concluded that "all the rust studied are directly dependent upon the photosynthetic activity of the host".

Newton et al (1929), studied the nature of rust resistance in eight wheat varieties differing widely in resistance to stem rust.

They showed no corresponding differences in the physico-chemical properties of their expressed tissue-fluids.

Gassner and Hassebrauk (1933), have shown that available nitrogen had an effect on the ability of the rust fungus to survive. Low levels of nitrogen led to higher content of soluble carbohydrates and the development of rust is retarded.

Johnson and Johnson (1934), studied the relationship between sugar content and reactions to stem rust of mature and immature tissues of the wheat plant and concluded that as all the varieties, irrespective of resistance or susceptibility to rust in the adult stage, showed much the same difference in the sugar content (reducing sugar and disaccride) content expressed as (invert sugars) of their young and older tissues, it does not seem likely that there is any direct relation between sugar content and reaction to rust.

Yarwood (1934), using detached floating clover leaflets, found that 10 percent sucrose (as compared to 2 percent) in water increased susceptibility to obligate parasites, but decreased susceptibility to facultative parasites. Apparently this effect is a matter of vigour, since vigorous plants seem generally more susceptible to obligate parasites and less susceptible to facultative ones. Thus, leaflets removed in the late afternoon, or young leaflets, were more vigorous and more susceptible to rust and mildew and less susceptible to leaf spot and anthracnose than those removed in the early morning or older leaflets.

Caldwell et al (1934), and Murphy (1936), analyzed the rusted material and indicated that rust infection reduced the concentration of soluble sugars, but such analyses were often made on portions of adult plants inoculated earlier with the fungus.

Daly (1949), analyzed wheat leaves for several constituents, including sugars and concluded that none of the fractions could be linked with resistance or susceptibility.

According to Sempio (1950), however, the increased metabolism did not necessarily confer resistance, metabolic defence mechanism involoing rather an increase in rates of photosynthesis and glycolysis over respiration. Aprevalence of synthetic processes tends towards resistance, where as high respiration rates causing increased degradative processes tend toward susceptibilty. High initial photosynthesis may provide more sugars which are converted to insoluble products not assimible by the parasite, or may to a substitutions of isomers which can be better utilized by the host than by the parasite. Sempio suggested that products of fermentation may be toxic to the invader, glycolysis thus increasing resistance.

Cutter (1951), hypothesized that an itermediate in metabolism, possibly the phosphorylated sugars, may be required by the rust as an obligate parasite.

Shu and Ledingham (1956), studied the nutrition of uredospores of wheat stem rust (Puccinia graminis) at the Prairie Regional Laboratory, Sasktoon by supplying various compounds labelled with C^{14} .

They indicated that D. mannose, D-glucose, sucrose and D-fructose were utilized better than other carbohydrates.

They further (1956), found that the glucose -6-phosphate oxidation pathway was actively involved in the carbohydrate metabolism of rust fungi.

Samborski and shaw (1956), indicated that the rust infection of susceptible host greatly decreased sugar content (Hexose, sucrose), mostly the sucrose fraction.

The reduction may be due to increased respiration of the infected leaves.

Kamal and Naguib (1957), found that the decrease in grain weight of wheat due to Puccinia graminis was from 4.16 to 1.36 g/100 grains in variety Tosson and the corresponding figures for reduction of total carbohydrates in the grain were 2171.89 to 462.94 mg. glucose per 100 grains. The main reduction is revealed in the poly-saccharide fraction, yet a considerable reduction was also observed in the small amount of sugars present in healthy grains. The reduction

was more from sucrose and fructose than from glucose.

Daly et al (1957), and shaw & samborski (1957), described the fundamental changes in the rates and nature of respiratory pathway during infection of higher plant tissues by obligate parasites, particularly rust fungi. Although disease can cause increase of 400 % in rates with a marked lowering of C_6/C_1 ratio, there is considerable uncertainty about the carbohydrate changes which accompany the respiratory alteration.

Jain and Pelletier (1958), detected several other sugars in rusted and nonrusted wheat leaves by the use of radioactive carbon dioxide and reported increased labelling in sedoheptulose when plants with low level of infection metabolized $C^{14}O_2$ in the light.

Wang (1960), reported similar results and found that this change occurred in uninfected host cells of diseased leaves. Inview of the association of respiratory changes with invaded tissue and complicating role of light in these experiment, the