GENETICS STUDIES ON MATURE PLANT REACTIONS TO WHEAT RUSTS AND GRAINS QUALITY IN TETRAPLOID

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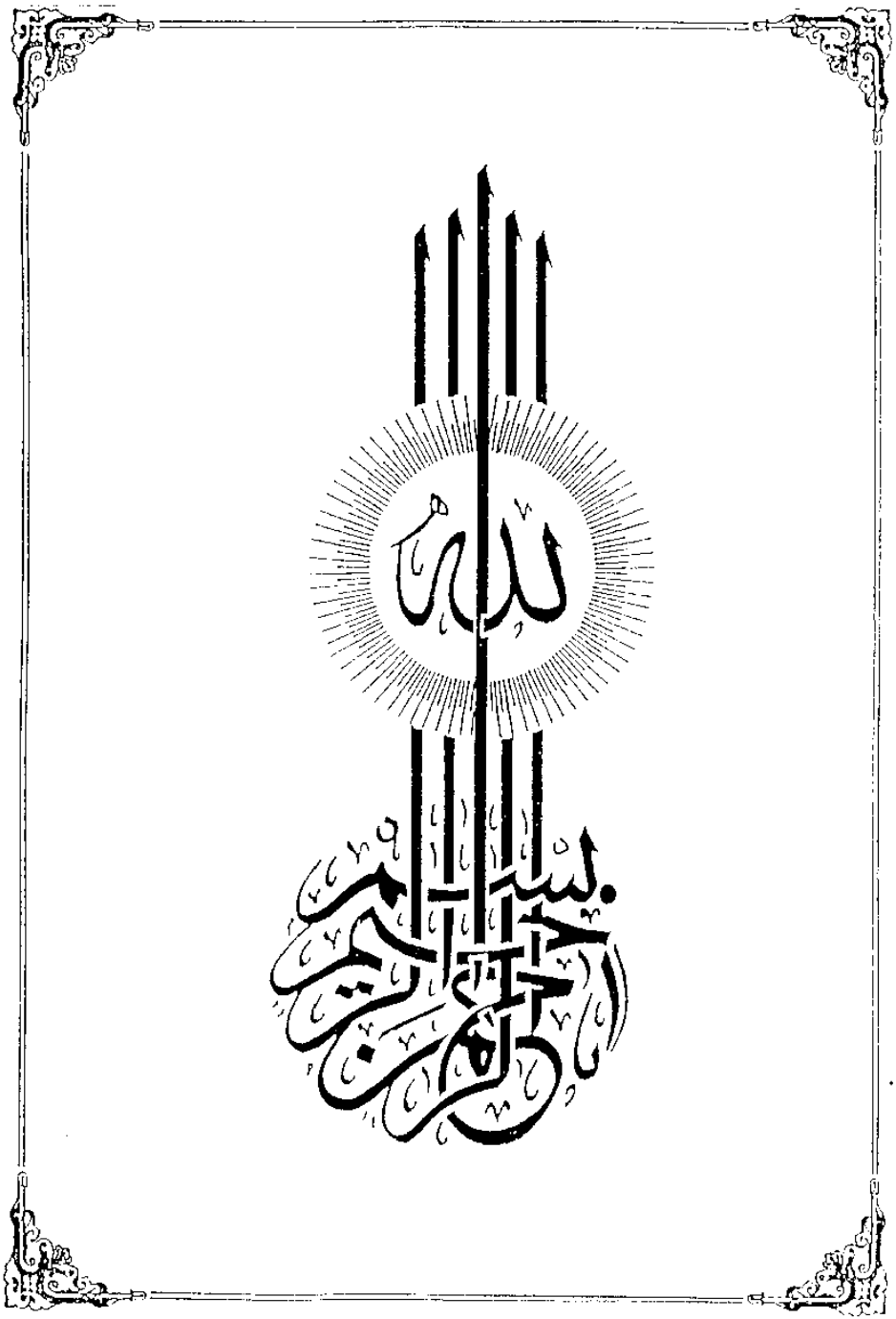

I. INTRODUCTION

Wheat occupies an outstanding position among the world major crops for its nutritional advantages. It is considered to be the essential food and protein source for millions of people in many countries. In A.R. Egypt, this crop is regarded as the most important cereal crop as it occupied in the year 1971 more than 1.3[x] million feddans (4200 m^2), yielding more than 11.5[x] million ardabs annually.

The ever-increasing human population which is reaching a very dangerous level has led the research workers in the field of plant breeding and agriculture to make more efforts aiming to secure a satisfactory food supply enough to cover the needs of the human population in the near future.

Wheat rusts are the most important diseases that cause pronounced losses in wheat yield and are an ever-present threat to high productivity of the crop. Breeding for rust

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resistance is of great importance to avoid great loss in yield caused by these diseases which approached about 40% (Mohamed 1968), in some localities in addition to the deteriorated quality of grain produced by rusted plants causing decrease in grain weight.

Since protein is an important food constituent from the stand point of nutritive value its quantity and quality in wheat are the major factors in determining the goodness of its flour and its suitability for bread making. During the past few years, no serious attempts have been made to study the inheritance of wheat quality. Sometimes sample of certain cultivars were chemically analysed and quality characters were estimated but were not used by breeders either in the course of selection or when a crossing program is designed.

Breeding of durum wheats for resistance to stem rust and for yield and quality must be practised if improvement in this type of wheat is to keep pace with the progress being made by similar means in the hard red spring wheats. This improvement in durum wheats must be soon carried out or the flour industry will suffer. Unfortunately the best durum cultivars are not sufficiently resistant to stem rust and the resistant cultivars do not have the desired quality for

the manufacture of semolina and the edible pastes, such as macaroni chiefly made from durum wheats.

The objective of the present work is to study the mode of inheritance of field reaction to stem rust and the inheritance of grain quality characters, i.e., protein content and test weight of kernel measured as the test weight per hectolitre of the yield per plant and the weight of 1000 kernels.

II. REVIEW OF LITERATURE

1) Inheritance of Field Reaction to Stem Rust in Tetraploid Wheats :

During the early period of breeding for resistance of stem rust, it was observed that einkorn, some of the durum, spelt and emmer wheats were the only source of resistance to stem rust disease.

Crosses of the emmers and durums with susceptible common wheats, involved sterility and linkage between rust resistance and the undesirable durum and emmer characters. Resistance to stem rust was found to be simply inherited in most cases. The following is a brief resume of the literature for the inheritance of resistance to stem rust in tetraploid wheats.

Hayes et al. (1920) succeeded from the cross of Iumillo (a resistant durum) and Marquis (C.I. 3641) in producing the new variety Marquillo (a vulgare wheat) which was resistant to a collection of stem rust races in the field. However, they could not obtain common wheats with the high resistance of the durum parent. They reported a proportion of 13 susceptible plants to 3 resistant. They postulated

that resistance to stem rust was partially dominant in crosses of T. vulgare with T. dicoccum. There was an apparent linkage of rust resistance and owner type of plants. However, some rust-resistant vulgare-like F_2 plants were obtained. In crosses of vulgare with durum, susceptibility was dominant and a strong linkage was observed between rust resistance and the durum characters.

Puttick (1921) explained the reaction in the F_2 generation of a cross between Marquis (vulgare) and Mindum (durum) to stem rust form 19, by a single factor plus modifiers. But one single factor did not account for the reaction of rust form 1. However, 35 out of 388 F_2 plants were resistant to both forms, indicating the possibilities of synthetic breeding for developing varieties resistant to several forms of stem rust.

Waldron (1921) found that progenies from strains of Kubanka (durum) x Power (common wheat) were intermediate in their stem rust reaction. He concluded that at least two genetic factors were responsible for rust reaction.

Harrington (1925) reported on the inheritance of resistance to stem rust in the crosses of both Mindum and Kubanka No. 8 with Reward (all durum). Mindum and

Kubanka No. 8 were susceptible, and Pentad was resistant to stem rust. Some of the hybrid families were found to be more susceptible than Kubanka. The results of infecting F_3 and F_4 strains of the Mindum x Pentad cross indicated the presence of more than one factor.

Hayes et al. (1925) concluded that the two factors which were controlling field resistance in the cross Marquis x Iumillo and probably minor modifying factors, were involved also in the lines derived from Marquis x Kanred cross which were immune in the seedling stage to 11 forms of stem rust. They obtained from these crosses homozygous lines combining seedling immunity and field resistance.

Hynes (1926) studied the reaction to stem rust in a cross between Federation (vulgare) and Khapli (emmer) to the F_4 generation. Most of the vulgare lines segregates were either susceptible or only weakly resistant. He concluded that stem rust resistance was controlled by multiple factors.

Waldron (1926) produced the variety Ceres from a cross between Marquis and Kota, a resistant Russian durum wheat, at N. Dakota.

Aamodt (1927) studied the inheritance of mature

plant reaction to stem rust in crosses including Stewart (durum). He concluded that stem rust resistance was controlled by multiple factors.

Clark and Smith (1928) found susceptibility to stem rust reaction to be dominant over resistance in the mature-plant stage of the durum wheat cross, Kodak x Kahla, with indications that at least two genetic factors were involved

McFadden (1930) crossed Yaroslav C.I. 1526 (emmer) with Marquis (vulgare). The obtained Hope and H.44, both of which were varieties of the common wheat type and were very highly resistant under field conditions not only to stem rust but also to leaf rust, bunt and loos smut.

Goulden et al. (1930) studied the reaction of 14 varieties of wheat in the seedling and mature plant stage to 16 physiologic forms of stem rust. There was good agreement in Marquis and Quality between seedling and mature plant reaction. However, there was an almost complete lack of agreement in H.44-24 and Acme (durum), the latter variety; i.e., Acme was susceptible to all the 16 forms in the seedling stage and resistant to all of them in the mature stage. Hope and Pentad (durum) were very similar to Acme and H.44-24 while Reward, Kota and Marquillo gave only moderate

indication of mature plant resistance. They concluded that one single factor controlled the resistance in them.

Macindoe (1931) crossed several resistant Australian wheats with susceptible varieties, and found the field reaction to a large number of races in the United States to depend on a single factor pair difference where resistant parents, such as Kenya - Guler, Cesa (durum), Bobin$_2$ and Egypt N.A., exhibited physiologic resistance to race 34, the prevailing race, in Australia. There was a close association between the seedling reaction to this race and field reaction to a group of races. In most cases inheritance was relatively simple and was apparently controlled by the same factor or factors.

Smith and Clark (1933) stated that the inheritance of stem rust reaction in three durum crosses behaved in a quantitative manner. The different degrees of resistance of the Pentad and Kodak parents were inherited as a recessive character, and susceptibility was partially dominant over resistance. However, the cross Kodak x Alkrona showed the presence of two major gene difference between the two parents.

Aamodt (1934) studied the inheritance of stem rust reaction in the cross Hope (Hamalay cross) with Marquillo

(vulgare). Fifty families segregated in the F_3 in a ratio of 1 : 3, eight in a 1 : 15 ratio, and nine in a 9 : 7 ratio. He pointed out that these abnormal ratios may be due to abnormal chromosomal behaviour of Marquillo.

Hayes et al. (1934) developed the highly resistant variety Thatcher from a double cross involving a sister selection of Marquillo and a selection from a cross between Marquis x Kanred (winter wheat). Thatcher (C.I. 10003) carried mature plant resistance from Kumillo (durum wheat), and physiologic resistance from Kanred.

Clark and Smith (1935) studied the inheritance of the three stem-rust reactions (near-immunity, resistance, and susceptibility) in three crosses from a Yaroslav emmer x Marquis wheat. The crosses were C-6-I-2 x Marquis, C-6-2-I x Marquis and C-10-35-I x Marquis. They showed that major factors principally controlled the inheritance of stem rust reaction. No additional minor or modifying factors could be directly established from the results of these crosses.

Hayes et al. (1936) reported in F_3 progenies of crosses between H.44 with double cross No. II-21-23 and Kota (Russian durum) x Marquis No. II-19-167, that mature plant resistance of H.44 appeared to depend on one single

genetic factor difference. The moderate plant resistance of lines No. II-19-167 and II-21-20 appeared to be dependent upon factors not allelomorphic to those determining mature plant resistance of H.44 type. Since susceptible lines were obtained in F_3 generation, there was indication that more than one single gene pair was necessary to explain mature plant resistance.

Pan (1940) studied mature plant resistance in crosses involving selections of Marquis x (H.44, III-31-7) (vulgare) and Pentad (durum)x (Marquis, III-34-I) , with the resistant parents; (Min-Double cross II-21-80), Hope and H.44. Resistance to stem rust appeared to be dominant to semi-resistance. Marquis x H-44 cross involved a single dominant gene which was allelomorphic to that carried by Hope and H-44.

Waddell (1940) showed in three intra-durum crosses involving Iumillo that all lines resistant in the greenhouse to race 21 of Puccinia graminis tritici proved to be resistant in the field, but a large number of F_3 lines were susceptible as seedlings and resistant as mature plants. However increasing susceptibility in seedling stage usually indicated the same trend in the mature plant; this would help to eliminate susceptible lines in the field in that case. He

concluded also that Lumillo apparently possessed a factor or factors some of which seem to be for mature resistance, while others for resistance at both stages.

Ausemus et al. (1946) reviewed more than 60 papers on the inheritance of resistance to stem rust in Triticum durum Desf., T. vulgare and emmer group wheat. Most of these studies indicated that resistance was inherited as monogenic character, yet digenic, trigenic and even multigenic ratios were reported. Instances of duplicate, inhibiting, and complementary types of gene actions had also been found.

Allard and Shands (1951) selected two lines C.I.12632 and C.I.12633 from crosses between Hard Red spring and T. timopheevi P.I.94761 which showed a high degree of mature plant resistance to stem rust, leaf rust and mildew. Rust resistance in crosses between them and Reward depended on two dominant linked genes with 23.7% and 16.9% crossing over in the two hybrids at Madison and 20% at Davis, probably due to differential reaction to races of rust. However, later in (1954), they reported that stem rust resistance in crosses between these two selections with Reward and Marquis was governed by duplicate linked genes with a recombination value of 14.78 ± 1.78%.

Koo and Ausemus (1951) studied the inheritance of

reaction to stem rust in crosses of Timstein, (derived from T. timopheevi x Steinwedel "a vulgare" made by (Prinham in Australia), with Thatcher, Newthatch, and Mida in both seedling and field conditions. In the seedling stage, the reaction to a particular race for each cross was controlled by a single genetic factor pair, and resistance was dominant in all of the three crosses. Timstein was found to carry a factor pair of resistance to all races except race 15 B, to which it was susceptible, while the varieties Thatcher and Newthatch each carried a factor pair for high resistance to six out of twenty five races used. This high resistance was epistatic to the resistance contributed by Timstein. The physiologic resistance of Timstein to twenty races could be combined with the field resistance of either Thatcher, Newthatch, or Mida in these crosses.

Hayes et al. (1955) stated that the mode of inheritance of reaction of wheat varieties to an individual race or a group of races had been found to be relatively simple. However, they added the total number of genes that interacted with these large number of races in a certain locality is very great. Thus, the problem of breeding a single variety resistant to all these races seemed to be difficult. This difficulty was solved by the discovery of several varieties