EFFECT OF HETEROSIS AND ITS UTILISATION IN HYBRID WHEAT

By

SALAH EL-DIN ALY ATTIA

B.Sc. (Agric.), Cairo University, 1959

M.Sc. (Agron.), Cairo University, 1968

THESIS

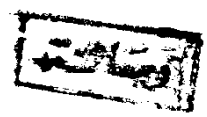
Submitted in partial fulfilment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in

GENETICS

Department of Genetics
Faculty of Agriculture
Ain Shams University



1972

Approved by : Hilal El Hattab
A. M. Omar
A. K. A.

Committee in Charge

Date 11 / 11 / 1972

A C K N O W L E D G E M E N T

The writer wishes to express his deepest gratitude and sincere appreciation to Prof. Dr. Ahmed Kamel Abdalla Selim, Head of the Department of Genetics, Dr. El-Sayed H. Hassanein, Assoc. Prof. of Genetics, Faculty of Agriculture, Ain Shams University, and Dr. Helmi Ali Ibrahim, Researcher of Wheat and Barley Research Section, Ministry of Agriculture, A.R. Egypt, for their supervision, kind assistance and constructive criticism throughout the course of these studies.

I am deeply indebted to Dr. S.M. Dessouki, Director of Wheat and Barley Research Section, Ministry of Agriculture, for his kind help and assistance.

My sincere thanks are also due to my wife for her continuous encouragement and patience. Thanks are extended to all those who provided help and criticism during the course of these experiments.

TABLE OF CONTENTS

I - I N T R O D U C T I O N

Heterosis in maize has been received considerable attention from both geneticists and breeders because of its marked effect on yield improvement. This increased productivity in maize, attracted the attention of plant breeders to utilize it in self-fertilised crops. Hence, even though hybrid combinations between cultivars have been known to display striking heterosis, as stated by Hagberg (1953) in self-fertilised species including Galeopsis and barley.

In self-fertilised crops, it seems probable that the first step in the utilisation of heterosis may practically consist of the selection of available parental cultivars having different genotypes that could produce the best combination of characters. It is important to continue breeding for the best combination of the genes that can be produced cheaply enough. Otherwise, new methods can be found to make crosses more easily, and thus heterosis can be used to obtain from the hybrid an advance in productivity over the homozygous condition. In breeding for heterosis, however, it seems evident that genetic diversity of parentage is equally as important as combining ability.

Accordingly, commercial production of hybrid wheat [illegible] a maximum degree of heterosis which will

have to be attainable, and those specific combinations of parents which express the desirable degree of heterosis.

Combining ability has been shown by various workers to be an inherited character. Moreover, it seems of special interest that some commercial cultivars despite of being the best in their agronomic characters, yet they combine very poorly when used as parents. For that reason, it is often desirable to select lines as parents of crosses, in addition to selections for other characters that are desired to produce successful hybrid wheat.

The situation now, is to discuss to what extent can hybrid wheat is utilised in wheat production. In this country, since the wheat acreage is limited to about one million and half feddans which yield only half the amount needed for the country consumption. Therefore, it is strikingly necessary to search for increasing the yield per feddan by using hybrid and by the application of suitable fertilisers on the world scale. Extensive comparisons for yield of first generation hybrids with their parental cultivars have been carried out in all parts of the world. In this instance, Briggle (1963) noted that hybrid wheat, yields up to 84 percent greater than the higher yielding parent, however, Recardo et al. (1967) pointed out that these studies, were limited in

scope and application, and hence, the results were largely of an academic nature. This increase in yield was faced in the present investigation when comparing the hybrid yields with the best yielding cultivar Giza 155 grown commercially in A.R. Egypt. The average yield of Giza 155 reached about 20.5 ardabs per feddan as compared with the hybrids under the same circumstances of the experiments which reached about 29.5 ardabs* per feddan estimated on the basis of plot yields.

The great problem which faces producing hybrid vigour in such self-fertilised crops is now devoted to searching for better single cross combination and setting up the inbreds to be used in hybrid cultivar with appropriate cytoplasm and restorer genes, so that hybrids can be produced by natural crossing. During the last eight years, hybrid wheat has made good progress in transference of sterility mechanism, while resorter mechanism requires more exploration before hybrid wheat production can become as common as hybrid maize production.

In all parts of the world, new improved cultivars of wheat continue to replace older ones. Many plant breeders are now concentrating on breeding for higher yields and are able to achieve significant improvements in a shorter [illegible] possible a decade or two

* [illegible]

ago. It is in this context that the feasibility of commercial hybrid wheat production must also be examined. There is a time lag between the development of a cultivar of wheat and its potential use in hybrid programme. Using the best cultivars or lines in advanced stages of testing, the first step in hybrid wheat production would be to cross a number of these lines in diallel to determine their combining ability and then as rapidly as possible incorporate male-sterility, and/or the restorer mechanism into the best combiners. This has to be followed by a building up of seed stocks of the male-sterile and restorer cultivars before hybrid seed can be produced in quantity. During this period, a minimum of at least five years would have elapsed. Assuming that appreciable grains in yield would also be achieved in a five years period through conventional breeding, the anticipated yield advantage of the hybrid could well be lost, in that a similar yield advantage could have become available in a new inbred cultivar at a lower seed cost, as reported by Shebeski (1971).

It was obliged now that after finishing all the systematical procedures in wheat programme, i.e., hybridization and selections, it would be possible after overcoming most hybrid wheat problems of production to follow it in- [illegible] all obstacles previously mentioned to gain the

profitable and increasing amount of heterosis that can be obtained in F_1 hybrids.

The purposes of this study were (1) to determine the extent of hybrid vigour and to make general and specific combining estimates from hybrids of five spring wheat cultivars, (2) to study the effect of heterosis and its possible utilization for producing commercial hybrid wheat by using some cytoplasmic male-sterile cultivars with their fertile counterparts, and others having a degree of pollen fertility restoration, (3) to estimate seed setting amount on male-sterile cultivar using different ratios of stripes and rings, and (4) to investigate the viability of pollen grains under field conditions.

II. REVIEW OF LITERATURE

This review includes previous and present work dealing with such topics related to this thesis as; heterosis and combining ability, restoration of pollen fertility to male-sterility system, male-sterility system in wheat, percent of seed setting on male-sterile cultivar, and viability of pollen grains under field conditions.

a- Heterosis and combining ability :

Heterosis or hybrid vigour, is an increase or developmental stimulus which often (not always) occurs in a hybrid in one or more of its characters, Briggle(1964).

In the present time, most of the world sugar production is produced by hybrid sugar cane or hybrid sugar beets. Sorghum, onions, and a number of forage and turf-grass hybrids are grown on a large scale. Regarding combining ability character, the parents should have the ability to combine easily with each other, affecting the characters giving high yielding ability.

Observations of heterosis in wheat dated back to 1917, when Freeman studied some characters in some crosses. Heterosis will be discussed with regard to the following

1- Days to ear emergence :

Freeman (1919), studied the date of first head in crosses involving a durum wheat and three common wheats. None of the hybrid plants in any of the crosses was significantly earlier than the early parent.

Rosenquist (1931), found that 11 out of 26 crosses studied headed as early as the early parent, but when F_1 performance was compared with the mean of the parents, 18 out of the 26 crosses were earlier.

Weibel 1956 (c.f. Briggle, 1963), reported that hybrid vigour was expressed in 48 % of red winter wheat crosses when this character was evaluated as (date of first bloom).

Gandhi et al. (1961), found that none of the hybrids headed earlier than the early parent in some crosses studied.

Borojević (1963), studied combining ability in wheat crosses and reported that the crosses which were better than the parental means in earliness in F_1 gave a higher number of promising lines in later generations. Later on, he also stated that earliness of plant was the most pronounced character in F_1, and it could be used as a possible indication of combining ability of varieties crossed. From

th[illegible] number of crosses during three years, there were 24.6 [illegible] crosses in which F_1 plants were earlier than the earlier parents, 21.8 % as early as the earlier parent, 46.2 % intermediate and 7.7 % crosses as late as the later parent.

Fonseca and Patterson (1968), reported that little heterosis was expressed with regard earliness since F_1 hybrids were either similar to earlier parent or were intermediate in earliness.

Singh and Kandole (1969), found hybrid vigour in five crosses over mid-parents and only one cross over the better parent. In general, negative hybrid vigour ranging from (-1.5 to -1.8 %) was present in number of days to earing.

Singh and Gupta (1969), indicated that the analysis of variance for both general and specific combining ability was highly significant for days to ear emergence character. The two cultivers S.410 and E. 173 showed lateness in their combinations. Five crosses showed specific combining ability for earliness, while others had specific combining ability for lateness.

Bhatt (1971), stated that earliness showed highly significant differences for general combining ability. He also found largest negative general combining ability effects for days to ear emergence in the two cultivars Sonora 64 A and R.K.F.63-53-7-2.

2- Days to anthesis :

Walton (1971), showed that days to anthesis character revealed highly significant differences for both general and specific combining ability in an 8 x 8 diallel cross. The cultivar Pitic 62 was a high combiner, while the cultivar Inia 66 was a low combiner for this character.

3- Number of tillers :

Rosenquist (1931), indicated that some degree of hybrid vigour was observed in 11 out of the 26 crosses when number of tillers of higher parent was the criterion. However, when F_1 performance was compared with the mean of the parents, 18 out of 26 crosses produced more tillers.

Engledow and Pal (1934), reported that among some crosses heterosis was apparent in tillering capacity in most cases, however, there were some exceptions.

Skurygina (1958), showed that F_1 plants from a cross between common wheat and T. timopheevi exceeded the parents in tillering capacity.

Gandhi et al. (1961), found that five hybrids produced significantly more tillers than the better parent. The hybrid tillers ranged from about 1.6 to 55.6 %.

4- Plant height :

Freeman (1919), found that the F_1 plants were taller in their average height than the tall parent in a cross between durum x common wheat. In another two crosses the F_1 plants were intermediate in height.

Griffee (1921), reported that some hybrids were taller than the average height of their parents, while others were shorter.

Rosenquist (1931), found that 25 out of 26 crosses were taller in the F_1 in comparison with the mean of the parents.

Kucumov (1937), obtained hybrids exceeding parental types in height by crossing contrasting wheat ectotypes.

Grandhall (1943), reported heterosis in F_1 plants of a cross between common wheat x T. turgidum L. The

average height of hybrid plants were as tall or slightly taller than the taller parent.

Skurygina (1958), stated that the F_1 plants exceeded the parents in height in some crosses.

Sikka et al. (1959), reported that the F_1 generation had the tallest plants, followed by the parental mean in twelve wheat crosses studied.

Stuber et al. (1962), found that the F_1 of a cross involving "Wichita and Atlass 66" was significantly taller than the parental mean in height.

Borojević (1963), studied combining ability in wheat crosses and recommended the crosses which were better than the parental means in plant height in F_1 giving higher number of promising lines in later generations. Afterwards, he reported that 11.7 % of the crosses showed heterosis in 1958-1959 but in 1959-1960 none, and in 1960-1961 only 7.6 %, when the height of plant has been compared with the parental mean instead of that of the taller parent. From a number of crosses, it was also found that about 50 % were taller than the parental mean; 25 % the same as the parental mean and