Plant Breeding

This is the second article in a series of brief progress reports on the application of the science of genetics to commercial agriculture.

disease resistant genes of nonagricultural wheat transferred to commercial bread wheat

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Plant breeders developing disease resistant plants by using the sciences of genetics and cytology together may obtain genes controlling disease resistance from hybrids between species—if this is necessary.

The science of genetics is concerned with the way genes—which control heritable characters such as disease resistance, maturity and yield—are passed from parent to offspring. Cytology deals with the chromosomes—the structures in which the genes are located.

Frequently genes for the desired resistance are not available within a particular agricultural species and it is necessary to transfer them from a related noncultivated species.

Genes for superior types of stem rust resistance have been found in several noncommercial varieties or species of wheat. The best of all appear to be found in Timopheevi wheat which is resistant to more than 200 forms of stem rust.

Timopheevi wheat also possesses the highest resistance known to leaf rust, mildew, bunt, and loose smut—all important diseases of wheat.

Timopheevi wheat itself is worthless agriculturally. It belongs to a different species from bread wheats and its hybrid with bread wheat is completely self-sterile, although it yields a few seeds when pollinated with its bread wheat parent.

Timopheevi wheat has 14 pairs of chromosomes or a total of 28 chromosomes in each of the thousands of cells which make up a single plant. During the growth of the plant by cell division, this number of chromosomes is maintained because each chromosome splits in half lengthwise and each daughter cell receives an exact duplicate of each of the 28 chromosomes.

When the gametes or sex cells are formed at maturity a different type of chromosomal division occurs—a reduction division. The result is that each gamete receives only one member of each pair of chromosomes, or a total of 14 chromosomes. With fertilization the full complement of 28 chromosomes is restored, the male and female gametes each contributing one member of each pair. The same situation is true in bread wheats except that the full complement of chromosomes is 42 and gametes have 21 chromosomes.

In reductional division, two chromosomes of each pair are attracted to each other and they line up side by side along their entire length. Then one member of each pair moves into each of the daughter cells. Because the distribution of the chromosomes contributed by the male and female parents is at random, the gametes receive some chromosomes which were contributed to the plant forming these gametes by the male parent and some by the female parent. On the average, one half of the chromosomes received by a gamete originated from each parent. Since the chromosomes carry the genes, each gamete also contains a mixture of genes, usually about one-half, from each parent.

During this side by side pairing of the chromosomes, occasional breaks occur in each of the paired chromosomes and exact segments are exchanged between chromosomes originally from male and female parents. This allows genes in the same chromosome to become separated. However, genes located on the same chromosome tend to occur together frequently, especially if they are located close together, because the chance of a break occurring between them is small. The farther apart two genes are on a chromosome the greater is the chance for a break to occur between them.

Without these breaks, reductional division would result in all the genes upon any one chromosome being inherited as a unit—linked together. Such linkage would make it impossible to separate an undesirable from a desirable gene if both were located on the same chromosome.

When Timopheevi wheat and a species of common wheat were hybridized, the common wheat parent contributed 21 chromosomes and Timopheevi wheat 14 chromosomes, giving the hybrid 35 chromosomes.

A microscopic examination of the reproductive process revealed that only eight pairs of chromosomes were formed in the hybrid and 19 chromosomes remained without mates.

The result was a chaotic division which produced gametes varying from one chromosome to gametes with 35 chromosomes.

Cytological investigations revealed that only the rare gametes which received 15 to 23 chromosomes were functional so the hybrid was sterile.

By pollinating thousands of flowers of the hybrid with pollen of bread wheat, a few seeds were finally obtained. This method of mating is called backcrossing. Some of the plants from these first backcross seeds were resistant to stem rust and some were susceptible. Only resistant plants were selected as parents of the next generation.

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Stem rust resistant wheat developed through the science of genetics.

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Because most of the first backcross plants were highly sterile it was again necessary to backcross the stem rust resistant plants to common wheat to obtain progeny. Some of the second backcross plants so obtained were resistant to stem rust and most of them were partly fertile, setting a few seeds. During three additional backcrosses of stem rust resistant plants to common wheat, complete fertility was restored and plants which resembled bread wheat very closely were finally obtained.

After the last backcross to bread wheat the constitution of the resistant plants was as follows: The chromosome number of 42, or 21 pairs of chromosomes, typical of bread wheats had been restored. Of these 21 pairs, 20 pairs were essentially identical to the bread wheat parent used for the recurrent parent. The two members of the other pair of chromosomes differed in that one member of the pair, contributed at the backcross by the bread wheat parent, carried the gene for susceptibility to stem rust, and the other member included the segment of a Timopheevi chromosome which carried the genes for stem rust resistance.

Such a plant, after self pollination produced approximately three stem rust resistant plants to one susceptible plant. When progeny of the resistant plants were grown it was found that approximately one-third bred true for resistance and two-thirds retained the ratio of approximately three resistant plants to one susceptible.

The true breeding resistant rows constituted a new strain of common wheat. This new strain is completely fertile with common wheat varieties and is a source of resistance to stem rust for the practical plant breeder.

A careful genetic analysis of the new resistant selection was made. It is revealed that not one, but two genes—located very closely together upon the same chromosome—govern the stem rust resistance. In the process of crossing-over, the breaks in the chromosomes—which allow the exchange of segments to occur at random throughout the length of the chromosome—are not as likely to occur between two genes close together as between two genes farther apart. Consequently, these two genes tended to be inherited together.

Similarly, a gene which governs resistance to mildew disease was also located upon the same chromosome. Although the mildew disease did not occur during the breeding program, this gene was maintained just because it was located very close to the stem rust genes. When selection was practiced to retain stem rust resistance, the mildew gene was automatically transmitted—pulled along much as one Siamese twin must go where the other goes.

The gene or genes controlling resistance to leaf rust disease and also resistance to loose smut disease probably are located upon the same chromosome. As a result many more plants resistant to all four diseases were obtained than would have been the case had the genes concerned been located on entirely different chromosomes.

Disease resistance genes are now available to plant breeders separated from unfavorable Timopheevi genes. These disease resistance genes will be called upon to protect the wheat crop whenever need arises.

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APRICOTS

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The possibility of applying DDT—one pound of 50% wettable powder per 100 gallons—or DDD—two pounds of a 50% wettable powder per 100 gallons—in the jacket period and followed by an application of parathion in the second application has not been tested as yet though it will be tested the coming season. It should not cause a residue problem at harvest due to the weathering, chemical decomposition and loss of spray residue deposit through growth of the fruit. Further field investigations will be carried on during the coming season to determine the timing factors under another season's conditions and to obtain additional data on the spray residue problem.

Parathion is a toxic material and must be handled accordingly. All of the precautions given on the labels for the handling of this material and for the protection of the spray operators should be carefully followed.

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NEW PUBLICATIONS

A copy of the publications listed here may be obtained without charge from the local office of the Farm Advisor or by addressing a request to Publications Office, College of Agriculture, University of California, Berkeley 4, California.

LAND DRAINAGE, 1949, by Walter W. Weir, Cir. 391, April 1949.

Land needs draining if drainage results either in better crops or in making arable swamps, ponds, and alkali areas.

ELIMINATING TILLAGE IN CITRUS SOIL MANAGEMENT, by J. C. Johnston and Wallace Sullivan, Cir. 150.

This circular describes the method of complete nontillage of citrus groves and gives the results in groves where tried.

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L. F. Corbett	1 registered Hampshire gilt	Division of Animal Husbandry
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Lederle Laboratories Division	10 grams folvite powder	Division of Poultry Husbandry
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Merck & Company	$200.00	Division of Food Technology
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Poultry Producers of Central California	Six 25-pound samples of fish meals	Division of Poultry Husbandry
San Diego Coöperative Poultrymen's Association	50 pounds of yeast	Division of Poultry Husbandry

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