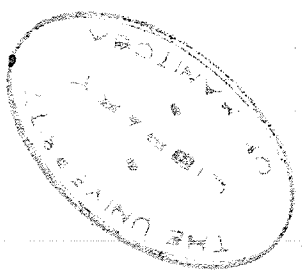
A CYTOGENETICAL ANALYSIS OF SOME INDUCED ERECTOIDES MUTATIONS IN MONTCALM BARLEY

A Thesis Submitted to
the Faculty of Graduate Studies and Research
in Partial Fulfilment of the Requirements
for the Degree of Master of Science

by

Norah Sally Brigstocke Hitchings, B.Sc.

The University of Manitoba,
April, 1956.



ABSTRACT

Eight erectoid mutations were selected from an irradiation programme in Montcalm barley. Crosses were made amongst the erectoides, and the F_1's were examined cytologically. One of the erectoides was found to be associated with a translocation which involved chromosomes a and d. All the F_1 plants had lax heads. The F_2 of crosses between Montcalm and erectoides segregated in a 3:1 ratio lax:dense. The F_2 of crosses between different erectoides segregated in a 9:6:1 ratio lax:dense:very dense. Thus erectoidy is due to simply inherited, recessive genes at different loci. Four loci have been definitely established, but it is quite possible that each of the eight erectoides is governed by a gene at a different locus. More crosses are being investigated to test this. Two lines from one erectoid gave a significantly higher yield than Montcalm. Only one erectoid gave a lower yield. Further tests for agronomic adaptation will be made.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES Continued

LIST OF FIGURES

I INTRODUCTION

Interest in induced mutation work in agricultural plants has greatly increased in recent years, and the mutagenic effect of irradiation is being studied in a wide variety of plants. It now seems that a certain amount of control of the mutation process is possible (1), and thus studies of mutations will take an increasingly important role in plant breeding.

As a result of reports from Sweden that beneficial mutations could be induced in barley at will by irradiation treatment, an induced mutation programme was initiated by Shebeski and Lawrence in 1950 (18), in Montcalm, the leading malting barley of Western Canada. Amongst the wide variety of mutants obtained were eight erectoids. These are viable morphological mutants characterised by compact heads and stiff straw, and with potentially good agronomic qualities. This report is concerned with the cytological, genetical, and agronomic analyses of these erectoides.

The chief objectives of this study were as follows:

1) To search for any major cytological disturbances in the erectoides caused by the X-ray treatment.
2) To compare the morphology of the erectoides with Montcalm.
3) To study the inheritance of the erectoides by means of

F_1 and F_2 analyses of progeny from crosses between the mutants and Montcalm, and between the different mutants.

4) To make preliminary agronomic tests of the erectoides by means of a yield trial.

II LITERATURE REVIEW

Induced mutation work in agricultural plants was initiated by Nilsson-Ehle and Gustafsson in 1928 in the hope of improving agricultural varieties (2,3,4). Until recently most of the work has been carried out in Sweden at the Swedish Seed Association in Svalöf.

The most extensively studied plant, with regard to induced mutations, is barley. Many different viable mutations have been produced. One of the commonest viable morphological mutants is the dense-headed type known as erectoides.

Barley erectoides and dense-headed mutants have been reported by a number of workers (2,3,5,7,8,9,10,12,13,14,15, 16,17,18,20,22). About 100 such mutants have been reported from Svalöf (8, ⁂), 65 of which have been more or less analysed. The Swedish erectoid material, all from two-row barley varieties, is described in detail by Gustafsson (2). The different mutants vary considerably in the compactness of the ear. The character is associated with pronounced pleiotropy, which is shown by differences in yield, straw strength and length, 1,000 kernel weight, and other more complex characters.

⁂ Personal communications with Hagberg.

Genetical studies of these erectoides are reported by Hagberg et al. (9). To date mutations at nineteen different loci have been found to influence ear density.*

The symbol "ert" was suggested to denote the erectoid factor (11). This is followed by a letter for the particular ert locus, and a number which is the original number given to the erectoid on discovery. These letters are in no way related to the letters that Dr. Burnham of Minnesota has assigned to the different chromosomes in his translocation stocks (8). A series of mutations at the "a" locus as described by Hagberg (7) illustrates this system, e.g., ert a 6; ert a 11; ert a 13; ert a 29; or at the "b" locus: ert b 2; ert b 4; ert b 5, etc. Eleven erectoides have been found for the "a" locus which appears to be more mutable than the others.

The question arises as to whether the mutations at a single locus are identical, or whether they represent different alleles. Hagberg et al. (9) studied this by measuring the ear density. They found that different ert mutations at one locus produced significantly different head densities, and thus concluded that they were allelic rather than identical. To date no two mutations have proven to be

---

*Personal communications with Hagberg.

absolutely identical, except possibly ert b 2, ert b 4, and ert b 5 (7). In all cases so far studied the normal allele is dominant or partially dominant to the ert factor (8).

Linkage studies with some ert mutations in Gull (Golden) barley (8) have shown that loci b and d are not linked inter se, or with any other ert locus in this variety. Further linkage studies which are still in progress will make it possible to place the different loci on genetical chromosome maps.

Cytological studies have shown that ert c 1 and ert d 7 are closely associated with reciprocal translocations (Tr_1 and Tr_7). Here the "mutation" responsible for erectoidy may be due to either a chemical change in the gene caused by the disturbance of the chromatin, or else an alteration in the gene environment---i.e., a position effect (21). However, as Hagberg (7) pointed out, there are other ert mutations at the d locus which are not associated with a translocation, therefore mutations at this locus cannot be solely due to a position effect. Other ert mutations appeared with translocations, but in these cases the two were found to be inherited separately. The translocations are readily observable, as they cause partial sterility in the F_1, and their presence can be confirmed by a cytological study of the pollen mother cells.

Most of the cytological studies have been reported

by Hagberg (8), Hagberg and Tjio (10,11), and Tjio and Hagberg (21). They attempted to locate the chromosomes involved in the erectoid translocations. They established the standard karyotype in the normal type Gull, and compared this with that of the homozygous translocation stocks. Where chromosomes of the latter deviate from the standard this indicates that these chromosomes are involved in the translocation. For example, they concluded that Tr_7 probably involves chromosomes b and a of the standard karyotype.

Further work on the location of translocations has been done by Hagberg (8). He used known translocation stocks, and his results agree with those obtained by the cytological methods described above. Once the cytological position of the translocations is known it will be possible to map the already well known linkage groups cytologically.

The most important agronomic character associated with all erectoid mutations is increased straw-stiffness. In addition, some mutants show increased earliness as compared with the mother lines (2). Especially noticeable is ert 16 which is up to 7 days earlier than Maja. A few erectoides equal or surpass the mother lines in yield, under some conditions, but extensive trials have not shown any one mutant to be sufficiently superior to warrant its being named as a commercial variety.

Erectoides also form useful material for theoretical studies, such as those published by Hagberg on pleiotropism and heterosis (7), and by Gustafsson (4) on theories of species formation.

III MATERIALS AND METHODS

Montcalm and the eight erectoides mutants shown in fig. 1 were used in this study. The erectoides result from mutation work initiated at Saskatoon and continued at both the Universities of Saskatchewan and Alberta (13,14,18).

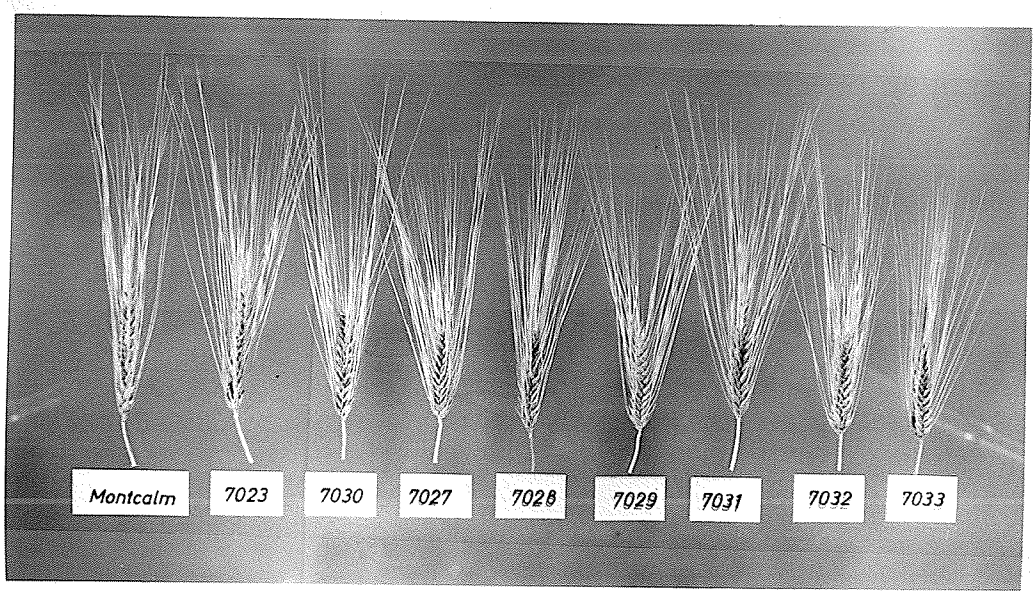


Fig. 1. Typical heads of Montcalm barley and the eight erectoides in order of density.

Montcalm is a six-rowed, smooth-awned barley with nodding heads. The erectoid character is due to shortened internodes of the head and often the culm, giving a shorter straw than usual. The erectoides are distinguished by their compact heads, often with projecting kernels and awns, especially at the base. There is also a tendency for the lateral florets to form two distinct vertical rows on the

spike, so that the six rows are clearly delimited right to the tip. Table I lists the eight erectoides with the source of irradiation, and remarks on some more obvious characteristics.

Table I: The erectoides used in the study, with source of irradiation and notes on some characteristics.

Plant no. in crossing block	Saskatoon number	Source of irradiation	Remarks
7023	5203	P^{32}	Quite lax, difficult to distinguish from Montcalm
7027	5301	Betatron	
7028	5302	X-ray	High degree of sterility
7029	5303	X-ray	
7030	5304	X-ray	
7031	5305	Co^{60}	Showed sterility at the tip of the spike. Entirely erect.
7032		X-ray	
7033	5220	Radium-beryllium	Very dense and very short strawed. Entirely erect. Showed much sterility in field

A programme of diallel crosses was planned in the summer of 1954. Crosses were made between normal Montcalm

and the eight erectoides and also amongst the different erectoides. Seed was obtained from 21 of the possible total of 36 crosses. Line 7028 was rather sterile, and produced only two seeds in the cross with Montcalm. Better results were obtained when it was used as a female parent in crosses with other erectoides in the fall of 1955. This suggests that the pollen is sterile.

The parental identity was maintained throughout the experiment. The crosses with the amount of seed obtained are shown in Table II. The methods and results are discussed under four headings.

Table II: Crosses made between erectoides and Montcalm and number of F_1 seeds obtained.

	Mont-calm	7023	7027	7028	7029	7030	7031	7032	7033
7033	-	13	8	-	5	3	-	2	
7032	14	A5 B18	10	-	11	3	-		
7031	14	-	11	-	15	8			
7030	A14 B7	-	-	-	15				
7029	7	-	-	-					
7028	2	-	-						
7027	15	5							
7023	10								