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DIFFERENTIAL FEEDING ON BARLEY VARIETIES BY GRASSHOPPERS

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DIFFERENTIAL FEEDING ON BARLEY VARIETIES
BY GRASSHOPPERS

D. S. McBean

Department of Plant Science

A THESIS

submitted to the University of Alberta

in partial fulfilment of the

requirements for the degree of

MASTER OF SCIENCE

Edmonton, Alberta

April, 1948

DIFFERENTIAL FORMS ON RIEMANN SURFACES
BY G. B. F. EDWARDS

Ph.D. Thesis
Department of Mathematics

A THESIS

submitted to the University of Alberta
in partial fulfillment of the
requirements for the degree of

DOCTOR OF PHILOSOPHY

Edmonton, Alberta
April, 1948

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DIFFERENTIAL FEEDING ON BARLEY VARIETIES

BY GRASSHOPPERS

D. S. McBean

INTRODUCTION

Grasshoppers are a major pest nearly every year in parts of southern Saskatchewan and Alberta. Official figures as reported in the Annual Reports of the Field Crops Commissioner show that in Saskatchewan for the ten-year period 1936 - 1945, crops to the value of \$81,310,000 were destroyed by grasshoppers. This represents an average annual loss of 4.6 percent of the wheat and 6.3 percent of all other crops grown in the province during that period. This figure minimizes the importance of the problem in that most of the grasshopper damage occurs in the southern part of the province. Consequently the average annual loss in such areas is considerably higher. For example, when the annual loss for the province in 1939 was 6.2 percent of the wheat and 12.6 percent of all other crops, there was

KINETICS OF THE REACTION OF 2,4-DINITROPHENOL WITH HYDROXYL RADICALS

18.0 percent and 40.4 percent damage respectively in Crop District 2. No comparable statistics are available for the province of Alberta where the general situation with regard to grasshoppers is similar.

During the course of testing varieties of cereal crops at the Dominion Experimental Station, Swift Current, Saskatchewan, a natural infestation of grasshoppers caused considerable damage in some tests. Wide varietal differences in the amount of grasshopper damage were noted, especially among barley varieties. A survey of the literature concerning insect-resistant plants failed to reveal any published work on such damage, and it was evident that there was considerable difference of opinion among agronomists and entomologists who had observed differential feeding of grasshoppers. Consequently, in 1944, it was decided to investigate further the reaction of barley varieties to grasshopper damage. Tests were conducted from 1944 - 1947 inclusive. The objective of such tests has been to determine whether there are consistent differences in the amount of damage suffered by barley varieties exposed to grasshopper attack; and if so, to determine which, if any, agronomic characters may be associated with "resistance".

This thesis presents the results of the above-mentioned tests and discusses their probable significance.

19.0 percent and 60.4 percent percent respectively in 1960
Table 2. The comparative statistics are available for
the province of Alberta where the General Election with
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differences among variety varieties. A survey of the river
drainage concerning insect-resistant plants failed to reveal
any published work on such damage, and it was evident that
there was considerable difference of opinion among agronom-
ists and entomologists who had observed differential

feeding of grasshoppers. Consequently, in 1961, it was
decided to investigate further the reaction of cereal var-
ieties to grasshopper damage. Tests were conducted from
1961 - 1967 inclusive. The objective of such tests was
to determine whether there are consistent differences
in the amount of damage suffered by variety varieties ex-
posed to grasshopper attack; and if so, to determine which
if any, varieties may be associated with "re-
sistance".
This thesis presents the results of the above-
mentioned tests and discusses their practical significance.

REVIEW OF LITERATURE

Excellent reviews of the resistance of plants to insect damage have been published recently (21, 25). It is proposed to mention here only that literature dealing specifically with grasshoppers, and to mention other crop-insect relationships in the discussion of the results of the present study.

It is a common belief that grasshoppers are a menace to any and all crops, although the literature contains scattered references to the contrary. Ball (2) noted that of 250 species of Orthoptera in Arizona the majority are either beneficial or harmless, and extremely specific in their food habits. Several investigators (19, 23, 28) and more recently Brunson and Painter (7) have recorded wide differences in the amount of grasshopper damage suffered by corn and sorghum. Brunson and Painter noted several instances in which corn in one field was eaten to the ground while sorghum in an adjacent field was practically uninjured. No explanation of this preference for corn was offered by the authors, but it may be a specific characteristic of certain American Acrididae, since Uvarov (28) records an Asiatic species that feeds chiefly on sorghums.

REVIEW OF LITERATURE

Extensive reviews of the literature of plant diseases have been published recently (1, 2, 3). It is proposed to mention here only that literature dealing specifically with phytophthora, and to mention other important relationships in the discussion of the results of the present study.

It is a common belief that phytophthora are a menace to any and all crops. However, the literature indicates that phytophthora are not so common in the country. Bell (4) noted that of 250 species of phytophthora in Illinois the majority are either beneficial or harmless, and extremely specific in their host habits. Several investigators (5, 6, 7, 8, 9) and more recently Hansen and Jensen (10) have recorded wide differences in the amount of phytophthora damage suffered by corn and sorghum. Hansen and Jensen noted several instances in which corn in one field was eaten to the ground while sorghum in an adjacent field was practically unharmed. An explanation of this difference for corn was offered by the authors, but it may be a specific characteristic of certain American isolates since Hansen (10) records an isolates that results in injury on sorghum.

Isley (16) studied the interrelationship of 150 species of grasses, forbs, garden and crop plants with 40 species of Acrididae in Texas. He concluded that vigorous individuals will starve in the presence of abundance if the particular host species are not present.

Criddle (9) found that while there are some plants, for example Agropyron Smithii, which are palatable to a great many grasshoppers, there are others, such as Setaria viridis, which these insects rarely touch.

Mail (19) reported an instance of half-grown nymphs of M. bivittatus (Say) and M. differentialis (Thos.) which, when released in a greenhouse, attacked only grapefruit and palm plants which they damaged severely out of a choice of twenty-six kinds of plants. The palm plants were hard and stringy!

Andrewartha (1), studying the significance of grasshoppers in relation to soil conservation in Australia, recommended the use of Atriplex vesicarium as it is inedible for grasshoppers.

Differences in the amount of damage suffered by various cereal crops have been noted on several occasions. Jones (18) in 1937, observed two varieties of durum wheat, grown in randomly replicated plots, to be completely

Table (10) showing the distribution of the

species of grasses, forbs, ferns and other plants with
in species of Andropogon in Texas. The conclusion that
virtually all species of Andropogon are in the presence of
some of the particular grass species are not in-
cluded.

Table (11) showing the distribution of the
for species of Andropogon in Texas, which are included in
great many grasses, forbs and ferns, and in Andropogon
itself, which these insects rarely feed.

Table (12) showing an instance of Andropogon in Texas
of M. viviparus (L.) and M. viviparus (L.) which
when released in a grassland, observed only Andropogon
and other plants which were damaged severely out of a single
of twenty-five plants of Andropogon. The other plants were not
and others:

Table (13) showing the distribution of
grasshoppers in relation to soil conservation in Texas.
recommended the use of Andropogon in Texas as it is in-
cluded for grasshoppers.

References in the amount of damage suffered by
various crops/ crops have been noted on several occasions.
Jones (19) in 1937, observed the relation of Andropogon
grass in relation to damaged crops, to be extremely

stripped by a heavy infestation of grasshoppers, whereas, 100 plots of spring and winter wheat in the same test were uninjured. Smith (25) noted that, during the severe grasshopper infestation of 1938 in North Dakota, the most damage, in descending order, was in barley, oats, wheat, corn and sorghum. Riley (23) in discussing the feeding habits of the Rocky Mountain locust, listed corn, wheat, rye and oats in the order of preference.

That such specificity in the feeding habits of grasshoppers should extend to varieties of crops is not surprising. In South America several investigators (5, 14, 20) have studied the resistance of corn varieties to grasshopper attack. While the cause for the resistance of "Amargo" maize has not been definitely established, it has been shown by Marchioni (20) that it is possible to select hybrid lines from a cross between "Amargo" and a susceptible variety that are as resistant as the resistant parent.

Brunson and Painter (7) obtained outstanding instances of differential damage among corn varieties, top crosses and hybrids grown in Kansas. It is the opinion of these investigators that neither the gregarious instincts of the grasshoppers, nor differences in maturity of the tested strains, was of importance in determining the dif-

... by a heavy infection of ...
... of ... in the ...
... (19) ...
... of ...
... in ...
... (19) ...
... of the ...
... in the ...

... in the ...
... of ...
... In ...
... (19) ...
... while the ...
... is ...
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... and ...

... (19) ...
... of ...
... is ...
... of the ...
... of ...

ferential injury noted. As a rule, the varieties and inbred lines showing the most resistance originated in areas where grasshoppers are a natural element of the environment. It was suggested, therefore, that natural selection operating in the development of adapted varieties has tended to intensify resistance to grasshoppers in such varieties.

Hume (15) found that varieties of dent corn suffered more grasshopper damage than did varieties of flint corn.

Hermann and Eslick (12) reported wide differences in the amount of damage sustained by 405 selections from 28 species of grasses exposed to the attack of four economic species of grasshoppers. These differences were equally evident between selections within a species and between species. They concluded that if the inheritance of a selection influences its susceptibility to attacks by grasshoppers, it may be possible to select strains of grasses which will be more highly resistant than any now produced.

Clark (8, page 223) reported Ceres wheat to be less damaged by grasshoppers than other varieties grown in North Dakota.

Smith (25) noted wide differences in the amount of damage caused by Lesser Migratory grasshoppers feeding on varieties of spring wheat. Stage of maturity and

potential injury noted. As a rule, the varieties and
inbred lines showing the most resistance originated in
areas where grasshoppers are a natural element of the
environment. It was suggested, therefore, that natural
selection operating in the development of the host var-
ieties has tended to intensify resistance to grasshoppers
in such varieties.

Hume (13) found that varieties of dent corn sus-
tained more grasshopper damage than did varieties of Flint
corn.

Hermann and Allen (14) reported that grasshoppers
in the region of damage sustained by 408 selections from
28 species of grasses exposed to the attack of four common-
ly species of grasshoppers. These differences were usually
inherent between selections within a species and between
species. They concluded that if the inheritance of a
selection influences the insect ability to overcome the
grasshopper, it may be possible to select strains of
grasses which will be more highly resistant than any now
available.

Clark (15, 1934 1937) reported that wheat did not
lose damaged by grasshoppers the other varieties grown in
North Dakota.

Smith (16) noted that differences in the amount
of damage caused by lesser short-horned grasshoppers feeding
on varieties of spring wheat, range of maturity and

amount of rust at the time of grasshopper feeding appeared to influence the degree of damage, although exceptions to both factors were recorded.

Jacobson and Farstad (17) in a study of 41 varieties of spring wheat found distinct varietal differences in the number of heads cut off by grasshoppers.

MATERIALS AND METHODS

Barley varieties were grown in replicated tests at several locations during each of the four years, 1944 - 1947. The damage suffered by these tests resulted from naturally occurring populations of grasshoppers. Such populations were composed of varying percentages of several species, chiefly Melanoplus mexicanus mexicanus (Saus.), Melanoplus bivittatus (Say) and Camnula pellucida (Scudd.). No attempt was made to determine accurately the percentage of each species present at each location. In 1947, the author was indebted to Mr. R. M. White* for an accurate determination of the species of grasshoppers present at Burdett, Alberta. All other percentages reported are approximations only.

* R. M. White. Entomologist, Dominion Entomological Laboratory, Lethbridge, Alberta

amount of loss at the time of destruction having occurred
in the course of the year, it is not possible
to determine the extent of damage, although it is
in both cases very serious.
In the case of the first (17) it is a case of a very
large of which there is no record in the
in the case of the second (18) it is a case of a very

REMARKS ON THE CASE

Barley varieties were grown in the same field
at several locations during the year 1947, 1948,
1949. The results obtained in these years are given in
the following table. The results of the first year are
given in the following table. The results of the second
year are given in the following table. The results of the
third year are given in the following table. The results
of the fourth year are given in the following table. The
results of the fifth year are given in the following table.
The results of the sixth year are given in the following
table. The results of the seventh year are given in the
following table. The results of the eighth year are given
in the following table. The results of the ninth year are
given in the following table. The results of the tenth year
are given in the following table. The results of the eleventh
year are given in the following table. The results of the
twelfth year are given in the following table. The results
of the thirteenth year are given in the following table.
The results of the fourteenth year are given in the
following table. The results of the fifteenth year are
given in the following table. The results of the sixteenth
year are given in the following table. The results of the
seventeenth year are given in the following table. The
results of the eighteenth year are given in the following
table. The results of the nineteenth year are given in the
following table. The results of the twentieth year are
given in the following table. The results of the twenty-first
year are given in the following table. The results of the
twenty-second year are given in the following table. The
results of the twenty-third year are given in the following
table. The results of the twenty-fourth year are given in
the following table. The results of the twenty-fifth year
are given in the following table. The results of the twenty-sixth
year are given in the following table. The results of the
twenty-seventh year are given in the following table. The
results of the twenty-eighth year are given in the following
table. The results of the twenty-ninth year are given in
the following table. The results of the thirtieth year are
given in the following table. The results of the thirty-first
year are given in the following table. The results of the
thirty-second year are given in the following table. The
results of the thirty-third year are given in the following
table. The results of the thirty-fourth year are given in
the following table. The results of the thirty-fifth year
are given in the following table. The results of the thirty-sixth
year are given in the following table. The results of the
thirty-seventh year are given in the following table. The
results of the thirty-eighth year are given in the following
table. The results of the thirty-ninth year are given in
the following table. The results of the fortieth year are
given in the following table. The results of the forty-first
year are given in the following table. The results of the
forty-second year are given in the following table. The
results of the forty-third year are given in the following
table. The results of the forty-fourth year are given in
the following table. The results of the forty-fifth year
are given in the following table. The results of the forty-sixth
year are given in the following table. The results of the
forty-seventh year are given in the following table. The
results of the forty-eighth year are given in the following
table. The results of the forty-ninth year are given in
the following table. The results of the fiftieth year are
given in the following table. The results of the fifty-first
year are given in the following table. The results of the
fifty-second year are given in the following table. The
results of the fifty-third year are given in the following
table. The results of the fifty-fourth year are given in
the following table. The results of the fifty-fifth year
are given in the following table. The results of the fifty-sixth
year are given in the following table. The results of the
fifty-seventh year are given in the following table. The
results of the fifty-eighth year are given in the following
table. The results of the fifty-ninth year are given in
the following table. The results of the sixtieth year are
given in the following table. The results of the sixty-first
year are given in the following table. The results of the
sixty-second year are given in the following table. The
results of the sixty-third year are given in the following
table. The results of the sixty-fourth year are given in
the following table. The results of the sixty-fifth year
are given in the following table. The results of the sixty-sixth
year are given in the following table. The results of the
sixty-seventh year are given in the following table. The
results of the sixty-eighth year are given in the following
table. The results of the sixty-ninth year are given in
the following table. The results of the seventieth year are
given in the following table. The results of the seventy-first
year are given in the following table. The results of the
seventy-second year are given in the following table. The
results of the seventy-third year are given in the following
table. The results of the seventy-fourth year are given in
the following table. The results of the seventy-fifth year
are given in the following table. The results of the seventy-sixth
year are given in the following table. The results of the
seventy-seventh year are given in the following table. The
results of the seventy-eighth year are given in the following
table. The results of the seventy-ninth year are given in
the following table. The results of the eightieth year are
given in the following table. The results of the eighty-first
year are given in the following table. The results of the
eighty-second year are given in the following table. The
results of the eighty-third year are given in the following
table. The results of the eighty-fourth year are given in
the following table. The results of the eighty-fifth year
are given in the following table. The results of the eighty-sixth
year are given in the following table. The results of the
eighty-seventh year are given in the following table. The
results of the eighty-eighth year are given in the following
table. The results of the eighty-ninth year are given in
the following table. The results of the ninetieth year are
given in the following table. The results of the ninety-first
year are given in the following table. The results of the
ninety-second year are given in the following table. The
results of the ninety-third year are given in the following
table. The results of the ninety-fourth year are given in
the following table. The results of the ninety-fifth year
are given in the following table. The results of the ninety-sixth
year are given in the following table. The results of the
ninety-seventh year are given in the following table. The
results of the ninety-eighth year are given in the following
table. The results of the ninety-ninth year are given in
the following table. The results of the one hundredth year
are given in the following table.

In 1944, thirty-seven varieties of barley were grown at four locations in single, 5-foot row plots, replicated six times. In 1945, forty-one varieties were grown at two locations in single row plots replicated six times. In 1946, forty-two varieties were grown at two locations in 7 x 6 rectangular lattices. In 1947, forty-two varieties plus ninety-eight hybrid lines from a Prospect x Hannchen population, were grown at five locations, with the 10-foot, single row plots arranged as a triple lattice repeated. The Prospect x Hannchen hybrids were pure breeding lines selected to secure a range in maturity from one parent to the other, together with as many combinations of the parental agronomic characters as possible. These hybrids were included in the 1947 tests with the view to examining the relationship between agronomic characters and grasshopper damage. The parents were chosen because they represent extremes in susceptibility to grasshopper damage and also differ widely in agronomic characters.

The damage to barley reported in this thesis refers to the percentage of heads dropped, unless otherwise stated. Estimates of damage were made by a single recorder, except for tests grown in 1945 when the average of two independent estimates was recorded. Different individuals estimated damage in 1944, 1945 and 1946. In 1944 estimates of damage at two locations were made at

In 1944, thirty-seven varieties of barley were grown at four locations in single, 5-foot row plots, replicated six times. In 1945, forty-one varieties were grown at two locations in single row plots replicated six times. In 1946, forty-two varieties were grown at two locations in 7 x 6 rectangular lattices. In 1947, forty-two varieties plus ninety-eight hybrid lines from a cross of a German population, were grown at five locations, with two 10-foot, single row plots replicated six times in each lattice. The highest x German hybrid lines were pure breeding lines selected to secure a range in maturity from one parent to the other, together with as many combinations of the parental genomic characters as possible. These hybrids were included in the 1947 tests with the view to examining the relationship between genomic characters and environmental response. The hybrids were chosen because they represent extremes in susceptibility to rust, and also differ widely in genomic characters.

The damage to barley recorded in this series refers to the percentage of heads dropped, unless otherwise stated. Estimates of damage were made by a visual assessment, except for tests grown in 1943 when the average of two independent estimates was recorded. Different individuals estimated damage in 1944, 1945 and 1946. In 1944 estimates of damage at two locations were made by

weekly intervals from the beginning of the infestation until harvest. Estimates of damage in subsequent tests were taken at the time the crop would normally be harvested.

Agronomic notes were taken on the varieties and hybrids grown at Swift Current under grasshopper-free conditions. The days required for a variety to head has been used instead of 'days to mature', since such a note is a more accurate measure of maturity under Swift Current conditions. Other notes on morphological characters such as shattering, neck strength, strength of straw, etc., are explained in footnotes to the tables concerned.

The analyses of variance in lattice designs and the determination of significant differences follow closely the methods outlined by Goulden (10). The analyses of percent damage were made after adding one to all percentages and converting to $\sin^2\theta$, as recommended by Bliss (4). Correlation coefficients were determined using the formula suggested by Hayes and Immer (11, page 329). Tests of the homogeneity of several estimates of variance, with a view to combining data collected from several stations and years, were calculated according to the method proposed by Bartlett (3).

usually intervals from the beginning of the investigation
which is very small. Estimates of damage in subsequent years
were taken at the time the crop would normally be har-
vested.

Additional notes were taken on the varieties
and methods used in the investigation under consideration. The
varieties, the area covered for a variety or seed bed
used instead of 'to be noted', since such a note
is a more accurate measure of actuality under field
conditions. Other notes on meteorological condi-
tions such as shading, seed strength, strength of
seed, etc., are included in the notes on the field
investigation.

The analysis of variance in factor designs and
the determination of significant differences which closely
the methods outlined by Cochran (19). The analysis of
variance was used in the following manner: one to all comparisons
and comparing to 10%, as recommended by Bliss (19). The
relation coefficients were determined using the formula
suggested by Hayes and Lamer (19, page 220). Tests of
the homogeneity of several estimates of variance, with a
view to combining data collected from several studies and
years, were calculated according to the method proposed
by Bartlett (19).

RESULTS

Varietal susceptibility and its relationship to maturity

1944

Grasshoppers were present in large numbers at Piapot, Sask., when the crop emerged. Emergence of the plants was slow and irregular due to drought. The plants that did emerge were kept eaten to the ground until further growth ceased. No varietal differences were apparent.

At Swift Current and Saskatchewan Landing in Sask., and at Carmangay, Alta., no appreciable damage from grasshoppers occurred until the crop was well headed. The average damage in percent for each variety at each station and the days to head as recorded at Swift Current are presented in Table I. Highly significant differences in the amount of damage sustained by varieties were obtained at each of the three stations (Table IX). Highly significant positive correlations between the percent damage as recorded at each station were obtained (Table II). There was a highly significant positive correlation between the percent damage and days to head at each station (Table II).

An analysis of estimates of damage taken at various dates at both Swift Current and Saskatchewan Landing showed no significant interaction between varieties and dates at either station. Only final estimates of damage, therefore, were recorded in subsequent years.

The five-foot row plot did not provide sufficient material upon which to base accurate estimates of damage. Plots in subsequent tests were either rod rows or ten-foot rows.

TABLE I

Percent Grasshopper Damage and Days to Head - 1944.

Variety	Percent heads dropped			Average	Days to head (4)
	Sw.C. (1)	Sask. Land.(2)	Carman- gay (3)		
Gordon	93	73	100	89	64
Glabron	80	82	100	87	63
Wisc. Ped. 38	90	72	99	87	64
Duckbill	87	72	100	86	70
O.A.C. 21	85	68	100	84	61
Michigan	90	62	100	84	67
Newal	86	57	100	81	63
Canadian Thorpe	87	55	100	81	70
Odessa	80	67	94	80	67
Alpha	92	50	99	80	64
Byng	83	56	100	80	63
Nobarb	80	58	100	79	64
Horn	73	61	100	78	63
California Mariout	77	54	99	77	57
Rex	75	63	92	77	63
Prospect 3256	73	58	98	76	57
Regal	78	68	82	76	63
H. medicum	70	55	98	74	61
Titan	58	66	96	73	59
Trebi	63	44	98	68	60
Colsess	35	74	95	68	58
Smyrna	67	38	98	68	58
Sans Barb x Trebi	57	45	99	67	60
Pros. x Stav.3825	90	42	69	67	58
Plush	42	61	96	66	61
Black Barbless	58	44	91	64	61
Rika	62	57	71	63	57
Type Pusa 21	50	33	98	60	52
H. zecofense	27	48	90	55	66
Pros. x Stav.3823	45	28	86	53	58

TABLE I (continued)

Variety	Percent heads dropped				Days to head (4)
	Sw.C. (1)	Sask. Land.(2)	Carman- gay (3)	Average	
Cape	30	48	66	48	66
Type 4 Punjab	40	26	78	48	52
Gatami	52	42	49	48	58
Glacier	30	36	70	45	56
H.persicum	22	41	68	44	61
H.pallidum	20	20	32	24	49
Lansdale	18	21	22	20	53

(1) Swift Current, average of 3 replicates.

(2) Saskatchewan Landing, average of 6 replicates.

(3) Carmangay, Alta., average of 4 replicates.

(4) Notes taken at Swift Current. Average of 5 replicates to nearest whole day.

TABLE II

Correlation Coefficients Obtained
Between Damage and Maturity; and
Between Damage Recorded at
Three Locations in 1944.

Correlation between	Swift Current	Saskatchewan Landing	Carman- gay
Days to head ⁽¹⁾ and % heads dropped at	0.549	0.657	0.537
% heads dropped at Swift Current and	-	0.628	0.649
% " " " Sask. Landing and	-	-	0.634

(1) Notes taken at Swift Current under grasshopper-free conditions.
5% level 0.325; 1% level 0.418.

1945

Fairly heavy infestations of grasshoppers occurred at both Cabri, Sask., and Nobleford, Alta. At Nobleford the grasshoppers commenced feeding as the crop neared maturity. At Cabri a somewhat different situation obtained. Feeding began early in June before any varieties had headed. This feeding

TABLE 1 (continued)

BENTLEY STARRS (1901-1974)				
QY BENT	1901	1902	1903	1904
1-1	1901	1902	1903	1904
2-1	1901	1902	1903	1904
3-1	1901	1902	1903	1904
4-1	1901	1902	1903	1904
5-1	1901	1902	1903	1904
6-1	1901	1902	1903	1904
7-1	1901	1902	1903	1904
8-1	1901	1902	1903	1904
9-1	1901	1902	1903	1904
10-1	1901	1902	1903	1904
11-1	1901	1902	1903	1904
12-1	1901	1902	1903	1904
13-1	1901	1902	1903	1904
14-1	1901	1902	1903	1904
15-1	1901	1902	1903	1904
16-1	1901	1902	1903	1904
17-1	1901	1902	1903	1904
18-1	1901	1902	1903	1904
19-1	1901	1902	1903	1904
20-1	1901	1902	1903	1904
21-1	1901	1902	1903	1904
22-1	1901	1902	1903	1904
23-1	1901	1902	1903	1904
24-1	1901	1902	1903	1904
25-1	1901	1902	1903	1904
26-1	1901	1902	1903	1904
27-1	1901	1902	1903	1904
28-1	1901	1902	1903	1904
29-1	1901	1902	1903	1904
30-1	1901	1902	1903	1904
31-1	1901	1902	1903	1904
32-1	1901	1902	1903	1904
33-1	1901	1902	1903	1904
34-1	1901	1902	1903	1904
35-1	1901	1902	1903	1904
36-1	1901	1902	1903	1904
37-1	1901	1902	1903	1904
38-1	1901	1902	1903	1904
39-1	1901	1902	1903	1904
40-1	1901	1902	1903	1904
41-1	1901	1902	1903	1904
42-1	1901	1902	1903	1904
43-1	1901	1902	1903	1904
44-1	1901	1902	1903	1904
45-1	1901	1902	1903	1904
46-1	1901	1902	1903	1904
47-1	1901	1902	1903	1904
48-1	1901	1902	1903	1904
49-1	1901	1902	1903	1904
50-1	1901	1902	1903	1904
51-1	1901	1902	1903	1904
52-1	1901	1902	1903	1904
53-1	1901	1902	1903	1904
54-1	1901	1902	1903	1904
55-1	1901	1902	1903	1904
56-1	1901	1902	1903	1904
57-1	1901	1902	1903	1904
58-1	1901	1902	1903	1904
59-1	1901	1902	1903	1904
60-1	1901	1902	1903	1904
61-1	1901	1902	1903	1904
62-1	1901	1902	1903	1904
63-1	1901	1902	1903	1904
64-1	1901	1902	1903	1904
65-1	1901	1902	1903	1904
66-1	1901	1902	1903	1904
67-1	1901	1902	1903	1904
68-1	1901	1902	1903	1904
69-1	1901	1902	1903	1904
70-1	1901	1902	1903	1904
71-1	1901	1902	1903	1904
72-1	1901	1902	1903	1904
73-1	1901	1902	1903	1904
74-1	1901	1902	1903	1904
75-1	1901	1902	1903	1904
76-1	1901	1902	1903	1904
77-1	1901	1902	1903	1904
78-1	1901	1902	1903	1904
79-1	1901	1902	1903	1904
80-1	1901	1902	1903	1904
81-1	1901	1902	1903	1904
82-1	1901	1902	1903	1904
83-1	1901	1902	1903	1904
84-1	1901	1902	1903	1904
85-1	1901	1902	1903	1904
86-1	1901	1902	1903	1904
87-1	1901	1902	1903	1904
88-1	1901	1902	1903	1904
89-1	1901	1902	1903	1904
90-1	1901	1902	1903	1904
91-1	1901	1902	1903	1904
92-1	1901	1902	1903	1904
93-1	1901	1902	1903	1904
94-1	1901	1902	1903	1904
95-1	1901	1902	1903	1904
96-1	1901	1902	1903	1904
97-1	1901	1902	1903	1904
98-1	1901	1902	1903	1904
99-1	1901	1902	1903	1904
100-1	1901	1902	1903	1904

was concentrated on certain varieties while others were practically uninjured. The more susceptible varieties were kept eaten to the ground throughout the season. Eventually most of the foliage was removed from all varieties. By the time the crop was mature, the more susceptible varieties had been completely destroyed, but the more resistant ones had lost only their leaves and less than ten percent of their heads (see Fig. 1 and 2). Gradations between these extremes were also found.

A summary of the varietal damage together with the days to head as recorded at Swift Current is shown in Table III. Very highly significant differences in the amount of varietal damage occurred in these tests (Table IX). There were highly significant positive correlations between the amount of damage at the stations, and between the amount of damage at each station and the days to head (Table IV).

Fig. 1 Cabri, 1945. Plot 98 - Pros. x Stav. 3823 - 15% damage.
Plot 99 - Prospect..... - 20% "
Plot100 - Canadian Thorpe... -100% "
Plot101 - Rex..... -100% "

Fig. 2 Cabri, 1945. Note heads dropped and straw eaten. .

TABLE III

Percent Grasshopper Damage and
Days to Head - 1945

	<u>Percent heads dropped (1)</u>			<u>Days to head (2)</u>
	<u>Cabri</u>	<u>Nobleford</u>	<u>Average</u>	
Canadian Thorpe	100	82	91	78
Gordon	100	72	86	77
Regal	94	77	86	71
O.A.C. 21	94	74	84	71
Senalta	100	63	82	74
Norbarb	97	65	81	70
Wisconsin Ped. 38	93	67	80	74
Montcalm	94	60	77	74
Glabron	93	58	76	70
Binder	99	51	75	75
Rex	98	51	74	71
Horn	98	47	72	72
Newal	79	63	71	68
Michigan	94	41	68	72
Mars	84	48	66	66
Byng	88	42	65	70
Plush	84	24	54	71
H. medicum	67	14	40	68
Sans Barb x Trebi	64	2	33	66
Velvon	46	8	27	67
Calif. Mariout	28	26	27	61
H. zecofense	16	32	24	66
Trebi	35	2	18	68
Black Barbless	33	3	18	66
Titan	26	3	14	66
Gatami	23	1	12	62
Prospect 3270	20	3	12	62
Smyrna	21	1	11	67
Prospect 3256	19	2	10	63
Pros. x Stav. 3823	16	1	8	64
Colsess	12	5	8	66
Pros. x Stav. 3825	15	1	8	67
Warrior	15	1	8	63
H. persicum	14	1	8	66
Lico	12	2	7	65

173. 13. 10. 1947. A 200.

TABLE III (continued)

<u>Variety</u>	<u>Percent heads dropped(1)</u>			<u>Days to head (2)</u>
	<u>Cabri</u>	<u>Nobleford</u>	<u>Average</u>	
Glacier	8	2	5	60
Rika	32	-	-	61
Type Pusa 21	24	-	-	58
Type 4 Punjab	18	-	-	56
H. pallidum	1	-	-	54
Lansdale	1	-	-	56

(1) Average of 6 replicates to nearest whole number.

(2) Swift Current only - average of 6 replicates to nearest whole number.

TABLE IV

Correlation Coefficients Obtained Between
Damage and Maturity; and Between Damage
Recorded at Two Locations in 1945.

<u>Correlation between</u>	<u>Cabri</u>	<u>Nobleford</u>
Days to head(1) and % heads dropped at	0.838	0.791
% heads dropped at Cabri and	-	0.881

(1) As recorded at Swift Current.
5% level 0.300. 1% level 0.388.

1946

Only light infestations of grasshoppers occurred at Cabri and Shaunavon, Sask., in 1946. Damage to varieties grown at Cabri was not sufficient to warrant making varietal comparisons. At Shaunavon damage was slightly more severe and notes on the amount of leaf damage and head dropping were made when the crop was mature.

The percentage of leaf and head damage due to grasshoppers is shown in Table V for varieties grown at Shaunavon, together

with the days to head as recorded at Swift Current. No analysis of the data has been attempted. As in 1944 and 1945, it was apparent that the later maturing varieties were most damaged.

TABLE V

Percent Grasshopper Damage at Shaunavon and
Days to Head - 1946

<u>Variety</u>	<u>Leaf damage</u> <u>%</u>	<u>Heads dropped</u> <u>%</u>	<u>Days to</u> <u>head (1)</u>
Canadian Thorpe	97	41	78
Norbarb	73	28	76
Sanalta	98	22	78
Gordon	80	22	77
Hannchen	71	17	74
Montcalm	69	9	71
O.A.C. 21	29	9	72
Wisconsin Ped. 38	23	8	70
Glabron	64	6	70
Rex	53	6	71
Horn	48	4	71
Newal	22	2	71
Michigan	21	2	72
Regal	22	1	70
Velvon	26	0	68
Rika	19	0	65
Mars	18	0	68
Plush	12	0	68
Byng	10	0	72
Type 4 Punjab	10	0	58
H. zecofense	9	0	68
S. B. x Trebi	8	0	68
Pros. x Stav. 3825	8	0	67
Type Pusa 21	8	0	59
Glacier	3	0	68
Titan	2	0	68
Pros. x Stav. 3823	2	0	62
Black Barbless	2	0	64
Colsess	2	0	66
Prospect 3256	2	0	64

with the data to which is referred as Swift County. It appears
 of the data has been corrected. In 1944 and 1945, it was
 apparent that the latter including statistics were most damaged.

TABLE 7
 Percent Transferred from one at University and
 days to leave - 1943

Year in	Percent Transferred	Days to leave
1943	41	17
1944	38	17
1945	38	17
1946	38	17
1947	38	17
1948	38	17
1949	38	17
1950	38	17
1951	38	17
1952	38	17
1953	38	17
1954	38	17
1955	38	17
1956	38	17
1957	38	17
1958	38	17
1959	38	17
1960	38	17
1961	38	17
1962	38	17
1963	38	17
1964	38	17
1965	38	17
1966	38	17
1967	38	17
1968	38	17
1969	38	17
1970	38	17
1971	38	17
1972	38	17
1973	38	17
1974	38	17
1975	38	17
1976	38	17
1977	38	17
1978	38	17
1979	38	17
1980	38	17
1981	38	17
1982	38	17
1983	38	17
1984	38	17
1985	38	17
1986	38	17
1987	38	17
1988	38	17
1989	38	17
1990	38	17
1991	38	17
1992	38	17
1993	38	17
1994	38	17
1995	38	17
1996	38	17
1997	38	17
1998	38	17
1999	38	17
2000	38	17
2001	38	17
2002	38	17
2003	38	17
2004	38	17
2005	38	17
2006	38	17
2007	38	17
2008	38	17
2009	38	17
2010	38	17
2011	38	17
2012	38	17
2013	38	17
2014	38	17
2015	38	17
2016	38	17
2017	38	17
2018	38	17
2019	38	17
2020	38	17
2021	38	17
2022	38	17
2023	38	17
2024	38	17
2025	38	17
2026	38	17
2027	38	17
2028	38	17
2029	38	17
2030	38	17
2031	38	17
2032	38	17
2033	38	17
2034	38	17
2035	38	17
2036	38	17
2037	38	17
2038	38	17
2039	38	17
2040	38	17
2041	38	17
2042	38	17
2043	38	17
2044	38	17
2045	38	17
2046	38	17
2047	38	17
2048	38	17
2049	38	17
2050	38	17
2051	38	17
2052	38	17
2053	38	17
2054	38	17
2055	38	17
2056	38	17
2057	38	17
2058	38	17
2059	38	17
2060	38	17
2061	38	17
2062	38	17
2063	38	17
2064	38	17
2065	38	17
2066	38	17
2067	38	17
2068	38	17
2069	38	17
2070	38	17
2071	38	17
2072	38	17
2073	38	17
2074	38	17
2075	38	17
2076	38	17
2077	38	17
2078	38	17
2079	38	17
2080	38	17
2081	38	17
2082	38	17
2083	38	17
2084	38	17
2085	38	17
2086	38	17
2087	38	17
2088	38	17
2089	38	17
2090	38	17
2091	38	17
2092	38	17
2093	38	17
2094	38	17
2095	38	17
2096	38	17
2097	38	17
2098	38	17
2099	38	17
2100	38	17

TABLE V (continued)

<u>Variety</u>	<u>Leaf damage</u> <u>%</u>	<u>Heads dropped</u> <u>%</u>	<u>Days to</u> <u>head(1)</u>
Trebi	1	0	66
Calif. Mariout	1	0	58
H. persicum	1	0	66
Warrior	1	0	63
Compana	0	0	66
H. medicum	0	0	70
Gatami	0	0	70
Prospect 3270	0	0	66
Smyrna	0	0	67
Lico	0	0	67
H. Pallidum	0	0	58
Lansdale	0	0	58

(1) Notes taken at Swift Current, Sask., average of 3 replicates.

1947

No grasshopper infestation occurred at Shackelton, Sask., and consequently that test was abandoned. Fairly heavy infestations occurred at Gravelbourg, Shaunavon and Herschel in Saskatchewan, and at Burdett in Alberta. No exact counts to determine the density and composition of the grasshopper populations were made. However, it is believed that the figures shown in Table VI are sufficiently accurate for the purpose of comparisons between tests.

TABLE VI

Density and Composition of Grasshopper Populations
Infesting Barley Tests Grown during 1947.

<u>Station</u>	<u>Species present</u>	<u>Proportion of each specie in total pop.</u>	<u>Density all species per square yard</u>
Gravelbourg and Shaunavon	<u>M. bivittatus</u> (Say)	5	8
	<u>C. pellucida</u> (Scudd.)	4	
	<u>M. m. mexicanus</u> (Scuss.)	2	
Herschel	<u>C. pellucida</u> (Scudd.)	10	15
	<u>M. m. mexicanus</u> (Scuss.)	1	
	<u>M. bivittatus</u> (Say)	1	
Burdett	<u>M. m. mexicanus</u> (Sauss.)	20	15
	<u>M. bivittatus</u> (Say)	1	
	<u>M. packardii</u> (Scudd.)	1	

Occasional individuals of several other species were present at all locations but these were of no economic importance.

General feeding by grasshoppers was not apparent in any test until about the time the earliest varieties were beginning to head. Wide differences in the amount of damage suffered by adjacent plots were readily noticeable (see Figs. 3, 4, 5 and 6). The mean damage to each variety and hybrid grown at the various sites is shown in Table VII, together with the days to head as recorded at Swift Current. Highly significant varietal differences were obtained in each of the four tests (Table IX).

There were highly significant positive correlations between the percent damage to varieties at Gravelbourg, Shaunavon and Burdett, and the days to head as recorded at Swift Current.

TABLE VI

Herbivory and Composition of Grasshopper Populations
Infesting Barley Crops during 1952.

Location	Species present	Composition of each species in species per square foot	Herbivory
Gravelly and Sandy	<i>M. divinator</i> (Say)	5	B
	<i>P. pallidus</i> (Say)	4	
	<i>M. mexicana</i> (Say)	3	
Barren	<i>M. divinator</i> (Say)	10	15
	<i>P. pallidus</i> (Say)	1	
	<i>M. mexicana</i> (Say)	1	
Barren	<i>M. divinator</i> (Say)	30	15
	<i>P. pallidus</i> (Say)	1	
	<i>M. mexicana</i> (Say)	1	

Occasional individuals of several other species were

present at all locations but these were of no economic importance.

General feeding by grasshoppers was not significant in

any field until about the time the earliest varieties were begin-

ing to head. The difference in the amount of damage suffered

by adjacent crops were readily noticeable (see Table I, A, B and

C). The mean damage to each variety and type is given in the

various places is shown in Table VII, together with the days to

head as recorded at Davis Center. Early significant varieties

difficulties were observed in some of the late crops (Table II).

There were three significant positive correlations be-

tween the percent damage to varieties at Gravelly and Sandy

and Barren, and the days to head as recorded at Davis Center.

A highly significant negative correlation between the damage to varieties and hybrids grown at Herschel and the days to head as recorded at Swift Current was obtained (Table VIII). When the damage to varieties and hybrids at Herschel were each correlated independently with the days to head, the resulting correlation coefficients were obtained; for varieties -0.171 (significant) and for hybrids -0.274 (highly significant).

A highly significant negative correlation between the damage to varieties and hybrids grown at Jerez and the days to harvest was recorded at White Current and obtained (Table VIII). When the damage to varieties and hybrids at Jerez were each correlated independently with the days to harvest, the resulting correlation coefficients were obtained: for varieties -0.191 (significant) and for hybrids -0.574 (highly significant).

Fig. 3 Gravelbourg, 1947. Prospect..... 20% damage.
Hannchen.....100% "
P. x H. 4630..... 25% "

Fig. 4 Burdett, 1947. P. x H. 4614..... 5% damage.
Hannchen.....100% "
P. x H. 4653..... 50% "

Fig. 5 Burdett, 1947. Lansdale..... 5% damage.
P. x H. 4606.....100% "
H. pallidum..... 5% "

Fig. 6 Burdett, 1947. Glacier..... 25% damage.
Hannchen..... 100% "
P. x H. 4642..... 98% "

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TABLE VII

Percent Grasshopper Damage and
Days to Head - 1947.

Variety or hybrid	Percent heads dropped (1)					Days to head(2)
	G'bourg	Shaun.	H'schel	Burdett	Av.	
Hannchen	83	85	91	100	90	59
P. x H. 4690 ⁽³⁾	62	92	81	100	84	64
x 4678	75	72	87	100	84	55
Can. Thorpe	56	91	81	100	82	62
Gordon	42	60	97	100	75	61
O.A.C. 21	35	58	99	100	73	54
Glabron	42	50	98	98	72	55
P. x H. 4666	29	60	96	100	71	56
x 4616	49	42	95	99	71	53
x 4625	48	38	97	100	71	54
x 4676	38	66	76	100	70	59
Sanalta	58	66	56	100	70	59
Nobarb	36	56	89	99	70	57
Horn	43	43	94	99	70	57
P. x H. 4619	28	52	99	100	70	57
x 4640	39	39	97	99	68	54
x 4691	43	78	52	100	68	64
Wis. Ped. #38	40	44	88	100	68	57
P. x H. 4636	20	58	92	100	68	61
x 4655	41	58	68	100	67	61
x 4605	28	67	69	100	66	58
Regal	34	31	99	100	66	56
Rex	32	51	80	100	66	57
P. x H. 4672	40	41	81	100	66	59
Mars	37	31	99	95	66	52
P. x H. 4606	29	38	93	100	65	57
x 4677	42	65	52	100	65	60
x 4644	38	23	97	100	64	54
x 4641	26	44	88	100	64	54
Newal	29	29	98	100	64	54
P. x H. 4627	23	41	92	100	64	55
x 4613	28	52	75	100	64	59
Byng	16	46	96	93	63	54
P. x H. 4602	22	55	62	100	62	55
x 4651	35	23	90	100	62	56

TABLE VII (continued)

Variety or hybrid	Percent heads dropped (1)				Days to	
	G'bourg	Shaun.	H'schel	Burdett	Av.	head(2)
P. x H. 4652	28	27	92	100	62	56
x 4689	34	14	98	100	62	52
x 4601	23	44	79	100	62	56
x 4660	38	21	90	96	61	50
x 4633	28	21	96	100	61	58
x 4697	31	34	79	100	61	57
x 4694	42	40	62	100	61	54
x 4658	19	46	80	99	61	58
x 4649	23	35	85	100	61	54
x 4669	21	24	96	100	60	53
Montcalm	22	32	87	100	60	54
P. x H. 4618	24	30	86	100	60	60
x 4607	28	30	85	96	60	58
x 4671	20	41	77	100	60	55
x 4629	30	25	83	100	60	55
x 4626	27	23	86	100	59	56
x 4648	29	19	87	100	59	54
x 4684	26	14	98	96	58	52
x 4687	28	6	99	100	58	55
x 4674	14	29	90	100	58	61
x 4628	26	49	58	100	58	57
x 4637	25	14	94	98	58	53
x 4611	27	36	68	100	58	55
x 4673	18	14	98	100	58	56
x 4661	28	18	85	98	57	55
x 4679	21	13	97	96	57	52
x 4632	23	38	66	100	57	54
x 4623	25	16	86	100	57	57
x 4621	29	6	91	100	56	50
x 4603	22	11	92	100	56	55
x 4696	28	21	74	100	56	56
x 4642	19	27	78	99	56	55
x 4668	20	39	68	94	55	54
Michigan	28	20	73	100	55	60
P. x H. 4682	22	11	94	92	55	50
x 46152	14	13	94	97	54	49
x 4683	19	26	74	99	54	53
x 4681	18	12	94	95	54	51
H. medicum	8	12	95	100	54	54
P. x H. 4670	15	4	94	99	53	53

TABLE VII (continued)

Variety or hybrid	Percent heads dropped (1)					Days to head(2)
	G'bourg	Shaun.	H'schel	Burdett	Av.	
P. x H. 4635	30	54	28	100	53	57
x 4617	19	6	95	92	53	52
x 4647	13	21	78	99	53	51
x 4665	18	9	83	99	52	53
x 4620	15	6	92	96	52	49
Plush	10	10	89	100	52	54
Smyrna	12	4	98	95	52	58
P. x H. 4638	11	18	80	99	52	54
x 4604	18	5	98	87	52	52
Sans Barb x Trebi	16	14	78	100	52	53
P. x H. 4686	12	15	80	100	52	55
x 4663	12	11	86	98	52	51
Trebi	11	9	86	100	52	54
Gatami	5	2	98	100	51	51
P. x H. 4646	17	10	90	87	51	54
Titan	8	4	96	96	51	51
Type Pusa 21	7	2	98	96	51	46
P. x H. 4698	18	9	75	100	50	52
x 4639	11	4	93	91	50	52
x 46151	22	13	62	100	49	56
x 4643	8	11	77	99	49	54
x 4692	9	8	98	80	49	53
x 4680	10	4	99	82	49	54
x 4645	13	6	77	100	49	53
x 4650	8	2	98	87	49	52
x 4622	8	6	96	85	49	52
Rika	10	3	84	98	49	50
P. x H. 4654	10	4	97	83	48	54
x 4675	8	6	96	82	48	51
H. zecofense	4	10	79	99	48	54
H. persicum	4	2	98	88	48	55
P. x H. 4685	12	18	72	89	48	55
x 4630	15	18	74	84	48	57
Pros. x Stav. 3825	6	4	81	100	48	53
Pros. x Stav. 3823	8	4	92	87	48	51
Type 4 Punjab	5	4	98	84	48	46
Calif. Mariout	5	2	97	87	48	48
P. x H. 4659	15	7	69	97	47	53
x 4634	16	5	85	82	47	52
x 4615	27	6	65	90	47	55

TABLE 1.1. (continued)

No. of plants	No. of leaves	Weight of leaves (g)				Weight of roots (g)	No. of roots
		1st	2nd	3rd	4th		
14	10	100	10	10	10	100	1
15	10	100	10	10	10	100	1
16	10	100	10	10	10	100	1
17	10	100	10	10	10	100	1
18	10	100	10	10	10	100	1
19	10	100	10	10	10	100	1
20	10	100	10	10	10	100	1
21	10	100	10	10	10	100	1
22	10	100	10	10	10	100	1
23	10	100	10	10	10	100	1
24	10	100	10	10	10	100	1
25	10	100	10	10	10	100	1
26	10	100	10	10	10	100	1
27	10	100	10	10	10	100	1
28	10	100	10	10	10	100	1
29	10	100	10	10	10	100	1
30	10	100	10	10	10	100	1
31	10	100	10	10	10	100	1
32	10	100	10	10	10	100	1
33	10	100	10	10	10	100	1
34	10	100	10	10	10	100	1
35	10	100	10	10	10	100	1
36	10	100	10	10	10	100	1
37	10	100	10	10	10	100	1
38	10	100	10	10	10	100	1
39	10	100	10	10	10	100	1
40	10	100	10	10	10	100	1
41	10	100	10	10	10	100	1
42	10	100	10	10	10	100	1
43	10	100	10	10	10	100	1
44	10	100	10	10	10	100	1
45	10	100	10	10	10	100	1
46	10	100	10	10	10	100	1
47	10	100	10	10	10	100	1
48	10	100	10	10	10	100	1
49	10	100	10	10	10	100	1
50	10	100	10	10	10	100	1
51	10	100	10	10	10	100	1
52	10	100	10	10	10	100	1
53	10	100	10	10	10	100	1
54	10	100	10	10	10	100	1
55	10	100	10	10	10	100	1
56	10	100	10	10	10	100	1
57	10	100	10	10	10	100	1
58	10	100	10	10	10	100	1
59	10	100	10	10	10	100	1
60	10	100	10	10	10	100	1
61	10	100	10	10	10	100	1
62	10	100	10	10	10	100	1
63	10	100	10	10	10	100	1
64	10	100	10	10	10	100	1
65	10	100	10	10	10	100	1
66	10	100	10	10	10	100	1
67	10	100	10	10	10	100	1
68	10	100	10	10	10	100	1
69	10	100	10	10	10	100	1
70	10	100	10	10	10	100	1
71	10	100	10	10	10	100	1
72	10	100	10	10	10	100	1
73	10	100	10	10	10	100	1
74	10	100	10	10	10	100	1
75	10	100	10	10	10	100	1
76	10	100	10	10	10	100	1
77	10	100	10	10	10	100	1
78	10	100	10	10	10	100	1
79	10	100	10	10	10	100	1
80	10	100	10	10	10	100	1
81	10	100	10	10	10	100	1
82	10	100	10	10	10	100	1
83	10	100	10	10	10	100	1
84	10	100	10	10	10	100	1
85	10	100	10	10	10	100	1
86	10	100	10	10	10	100	1
87	10	100	10	10	10	100	1
88	10	100	10	10	10	100	1
89	10	100	10	10	10	100	1
90	10	100	10	10	10	100	1
91	10	100	10	10	10	100	1
92	10	100	10	10	10	100	1
93	10	100	10	10	10	100	1
94	10	100	10	10	10	100	1
95	10	100	10	10	10	100	1
96	10	100	10	10	10	100	1
97	10	100	10	10	10	100	1
98	10	100	10	10	10	100	1
99	10	100	10	10	10	100	1
100	10	100	10	10	10	100	1

TABLE VII (continued)

Variety or hybrid	Percent heads dropped (1)					Days to head(2)
	G'bourg	Shaun.	H'Schel	Burdett	Av.	
Black Barbless	4	2	82	99	47	53
Prospect 3270	13	4	83	87	47	52
P. x H. 4693	12	5	78	92	47	49
x 4653	14	10	77	86	47	56
x 4612	16	5	91	73	46	50
x 4610	11	6	78	89	46	55
x 4609	25	11	51	96	46	50
x 4624	20	8	68	86	46	54
Velvon	10	9	61	100	45	54
P. x H. 4688	7	2	94	77	45	51
x 4657	32	10	46	90	44	53
x 4667	20	12	46	97	44	56
x 4608	13	3	90	68	44	51
Colsess	2	2	87	82	43	53
P. x H. 4662	14	7	53	95	42	52
Prospect 3256	13	5	65	81	41	52
Glacier	10	1	88	63	40	51
P. x H. 4664	6	3	83	70	40	50
P. x H. 4614	11	3	72	75	40	54
Compana	4	2	88	64	40	55
P. x H. 4656	10	3	92	52	39	52
Lico	5	2	66	81	38	52
Warrior	2	2	65	82	38	49
H. pallidum	4	2	99	36	35	45
Lansdale	4	2	90	20	29	46

(1) Each station figure the average of six replicates.

(2) Notes taken at Swift Current, average of 3 replicates.

(3) Prospect X Hannchen hybrid.

TABLE IV (continued)

Year	Percentage of total population				Total population	Urban population	Rural population
	1950	1955	1960	1965			
1950	100	100	100	100	100	100	100
1955	100	100	100	100	100	100	100
1960	100	100	100	100	100	100	100
1965	100	100	100	100	100	100	100
1970	100	100	100	100	100	100	100
1975	100	100	100	100	100	100	100
1980	100	100	100	100	100	100	100
1985	100	100	100	100	100	100	100
1990	100	100	100	100	100	100	100
1995	100	100	100	100	100	100	100
2000	100	100	100	100	100	100	100
2005	100	100	100	100	100	100	100
2010	100	100	100	100	100	100	100
2015	100	100	100	100	100	100	100
2020	100	100	100	100	100	100	100
2025	100	100	100	100	100	100	100
2030	100	100	100	100	100	100	100
2035	100	100	100	100	100	100	100
2040	100	100	100	100	100	100	100
2045	100	100	100	100	100	100	100
2050	100	100	100	100	100	100	100
2055	100	100	100	100	100	100	100
2060	100	100	100	100	100	100	100
2065	100	100	100	100	100	100	100
2070	100	100	100	100	100	100	100
2075	100	100	100	100	100	100	100
2080	100	100	100	100	100	100	100
2085	100	100	100	100	100	100	100
2090	100	100	100	100	100	100	100
2095	100	100	100	100	100	100	100
2100	100	100	100	100	100	100	100

(1) Data for years 1950-1960 are based on the 1950 census.
 (2) Data for years 1965-1990 are based on the 1965 census.
 (3) Data for years 1995-2100 are based on the 1995 census.

TABLE VIII

Correlation Coefficients Obtained Between Damage and
Maturity, and Between Damage Recorded at
Four Locations in 1947

Correlation between	G'bourg.	Shaun.	H'chel.	Burd.
Days to head ⁽¹⁾ and % heads dropped at	0.566**	0.711**	-0.253**	0.483**
Days to head ⁽¹⁾ and % heads dropped at (varieties)	0.692**	0.704**	-0.171*	0.566**
Days to head ⁽¹⁾ and % heads dropped at (hybrids)	0.451**	0.621**	-2.74 **	0.394**
% heads dropped at G'bourg. and	-	0.805**	-0.098	0.442**
% heads dropped at Shaun. and	-	-	-0.188*	0.438**
% heads dropped at H'chel. and	-	-	-	-0.130

(1) As recorded at Swift Current.

* Significant at 5% level.

** Significant at 1% level.

TABLE VIII

Correlation Coefficients Obtained Between Image and
Intensity, and Between Image Recorded at
Four Locations in 1947

Correlation between			
O'Boone	Shuman	W'Chal	Boyd
Days to head (1) and heads dropped at	0.586**	0.711**	-0.733**
Days to head (2) and heads dropped at (vehicles)	0.682**	0.704**	-0.141*
Days to head (1) and heads dropped at (horses)	0.481**	0.621**	-0.774**
Days to head at W'Chal and heads dropped at W'Chal	-	0.505**	-0.398
Days to head at Boyd and heads dropped at Boyd	-	-	-0.188*
Days to head at W'Chal and heads dropped at W'Chal	-	-	-0.180

(1)
as recorded at Swift Current.
* Significant at 5% level.
** Significant at 1% level.

TABLE IX

Variety Mean Squares and Standard Errors of the
Means in Percent Obtained from the
Analyses of Grasshopper Tests,
1944 - 1947

Year		Mean square (1)	S.e.m. %
1944	Swift Current	767.03	11.5
	Saskatchewan Landing	657.50	9.9
	Carmangay	1058.18	7.3
1945	Cabri	4582.76	6.8
	Nobleford	2761.64	13.6
1947	Gravelbourg	737.37	14.1
	Shaunavon	1608.42	14.5
	Herschel	858.41	7.4
	Burdett	651.60	6.6

(1) All mean squares are significant at the 1% level.

TABLE II

Yearly Mean Temperatures and Standard Errors of the Means in Forests Obtained from the Analysis of Meteorological Data, 1942 - 1947

Year	Mean temperature (°C)	S.E.
1942	737.35	11.0
1943	837.90	9.9
1944	1038.18	7.3
1945	4587.78	5.5
1946	3241.84	13.8
1947	737.37	14.1
1948	1808.48	13.8
1949	837.41	7.3
1950	831.80	5.5

(1) All mean values are significant at the 1% level.

Varietal Susceptibility in Relation to Other
Agronomic Characters

The percentage grasshopper damage to varieties grown at Cabri in 1945, together with various agronomic characters as determined at Swift Current under grasshopper-free conditions, are presented in Table 10. The average percentage of grasshopper damage to Prospect, Hannchen and 98 Prospect x Hannchen selections grown in 1947 is shown in Table 11, along with agronomic characters as determined at Swift Current under grasshopper-free conditions.

No analyses of these data has been attempted since it is believed that, in the unlikely event that correlations between damage and certain agronomic characters were established, they would be misleading.

Vertical Distribution of Insects in Relation to Height
at various Stations

The percentage frequency of insects at various heights of trees in 1933, together with various other data, is determined at each station under various conditions, are presented in Table 10. The average percentage of insect frequency at various heights of trees in 1933 is shown in Table 11, along with other data. It is determined at each station under various conditions.

No analysis of these data has been attempted since it is believed that, in the majority of cases, the correlation between insects and certain climatic elements were established, they would be misleading.

TABLE X

Percent Damage at Cabri and Agronomic Characters as Determined
at Swift Current, 1945

Variety	Percent damage (1)	Height ins. (2)	Angle head to stem (2)	Shattering % (3)	Head drop- ping % (4)	Leafiness (5)	Rows per head	Awn barbing (6)
Can. Thorpe	100	19	22	0	3	9	2	R
Gordon	100	20	38	2	15	6	2	R
Sanalta	100	21	42	2	8	9	2	S
Binder	99	20	65	10	7	6	2	R
Rex	98	22	40	5	7	6	2	S
Horn	98	22	72	4	5	6	2	R
Nobarb	97	22	40	1	8	9	6	S
Michigan	94	20	65	3	13	3	2	R
O.A.C. 21	94	22	52	8	27	9	6	R
Regal	94	22	40	6	13	9	6	S
Montcalm	94	22	58	6	15	9	6	S
Wisc. Ped. 38	93	23	80	8	27	6	6	S
Glabron	93	25	40	3	15	9	6	S
Byng	89	19	42	10	17	9	6	S
Mars	84	22	30	8	8	4	6	S
Plush	84	22	70	5	5	9	6	S
Newal	79	24	58	9	7	6	6	S
H. medium	67	22	50	1	5	4	2	S
Sans Barb x Trebl	64	21	20	1	0	4	6	S
Velvon	46	22	15	1	4	9	6	S

TABLE

be entered as appropriate in column 10 of the report
 (10) column 10 of the report

(1) Name	(2) Sex	(3) Age	(4) Height	(5) Weight	(6) Eye Color	(7) Hair Color	(8) Skin Color	(9) Birth Date	(10) Birth Place	(11) Death Date	(12) Death Place	(13) Cause of Death	(14) Burial Place	(15) Notes
1	M	25	5' 10"	175	Blue	Brown	Fair	1910	Chicago, Ill.	1935	Chicago, Ill.	Heart Disease	Chicago, Ill.	
2	F	30	5' 5"	120	Blue	Black	Dark	1905	New York, N.Y.	1930	New York, N.Y.	Cancer	New York, N.Y.	
3	M	40	6' 0"	200	Blue	Gray	Fair	1900	London, England	1940	London, England	Stroke	London, England	
4	F	20	5' 0"	100	Blue	Black	Dark	1915	Los Angeles, Calif.	1935	Los Angeles, Calif.	Accident	Los Angeles, Calif.	
5	M	35	5' 8"	160	Blue	Brown	Fair	1900	San Francisco, Calif.	1930	San Francisco, Calif.	Heart Disease	San Francisco, Calif.	
6	F	25	5' 2"	110	Blue	Black	Dark	1910	Chicago, Ill.	1935	Chicago, Ill.	Cancer	Chicago, Ill.	
7	M	45	6' 2"	220	Blue	Gray	Fair	1900	London, England	1945	London, England	Stroke	London, England	
8	F	35	5' 5"	130	Blue	Black	Dark	1905	New York, N.Y.	1930	New York, N.Y.	Cancer	New York, N.Y.	
9	M	50	6' 5"	250	Blue	Gray	Fair	1900	London, England	1950	London, England	Stroke	London, England	
10	F	20	5' 0"	100	Blue	Black	Dark	1915	Los Angeles, Calif.	1935	Los Angeles, Calif.	Accident	Los Angeles, Calif.	
11	M	35	5' 8"	160	Blue	Brown	Fair	1900	San Francisco, Calif.	1930	San Francisco, Calif.	Heart Disease	San Francisco, Calif.	
12	F	25	5' 2"	110	Blue	Black	Dark	1910	Chicago, Ill.	1935	Chicago, Ill.	Cancer	Chicago, Ill.	
13	M	45	6' 2"	220	Blue	Gray	Fair	1900	London, England	1945	London, England	Stroke	London, England	
14	F	35	5' 5"	130	Blue	Black	Dark	1905	New York, N.Y.	1930	New York, N.Y.	Cancer	New York, N.Y.	
15	M	50	6' 5"	250	Blue	Gray	Fair	1900	London, England	1950	London, England	Stroke	London, England	

Ident to Civil Serv
 Mortal

TABLE X (continued)

Variety	Percent damage (1)	Height ins. (2)	Angle head stem (3)	Shattering % (3)	Head drop- ping % (4)	Leafiness (5)	Rows per head	Awn barbing (6)
Trebl	35	19	25	0	2	6	6	R
Black Barbless	33	20	18	0	2	4	6	S
Rika	32	20	10	1	0	4	6	R
Calif. Mariout	28	20	50	2	12	4	6	R
Titan	26	21	12	0	3	6	6	S
Type pusa 21	24	14	10	0	0	2	6	R
Gatami	23	12	15	0	0	3	6	S
Smyrna	21	18	30	3	3	4	2	S
Prospect 3270	20	21	28	10	2	4	6	S
Prospect 3256	19	24	32	10	0	6	6	S
Type 4 punjab	18	14	10	0	0	2	6	R
H. zecofense	16	21	8	7	8	6	6	S
Pros. x Stav. 3823	16	21	22	1	2	4	6	S
Pros. x Stav. 3825	15	20	18	2	5	4	6	S
Warrior	15	20	0	5	1	6	6	hooded
H. persicum	14	20	18	0	0	6	2	S
Lico	12	21	15	0	0	4	6	S
Glacier	8	20	15	0	0	4	6	S
H. pallidum	1	14	30	0	0	1	6	R
Lansdale	1	15	38	0	7	1	6	R

- (1) Percent heads dropped - average of six replicates at Cabri.
(2) Notes taken in degrees 0° = erect, 90° = right angles to stem.
(3) Taken two weeks after maturity.
(4) Natural head dropping recorded 2 weeks after maturity
(5) Rated 1 to 12 in order of leafiness. Very leafy = 12.
(6) Rough classification - two classes only.

(continued) 2 21414

Yacht	Owner	Class	Age	Length	Beam	Depth	Displacement	Engine	Speed	Notes
1	1941	10	10	10	10	10	10	10	10	10
2	1942	11	11	11	11	11	11	11	11	11
3	1943	12	12	12	12	12	12	12	12	12
4	1944	13	13	13	13	13	13	13	13	13
5	1945	14	14	14	14	14	14	14	14	14
6	1946	15	15	15	15	15	15	15	15	15
7	1947	16	16	16	16	16	16	16	16	16
8	1948	17	17	17	17	17	17	17	17	17
9	1949	18	18	18	18	18	18	18	18	18
10	1950	19	19	19	19	19	19	19	19	19
11	1951	20	20	20	20	20	20	20	20	20
12	1952	21	21	21	21	21	21	21	21	21
13	1953	22	22	22	22	22	22	22	22	22
14	1954	23	23	23	23	23	23	23	23	23
15	1955	24	24	24	24	24	24	24	24	24
16	1956	25	25	25	25	25	25	25	25	25
17	1957	26	26	26	26	26	26	26	26	26
18	1958	27	27	27	27	27	27	27	27	27
19	1959	28	28	28	28	28	28	28	28	28
20	1960	29	29	29	29	29	29	29	29	29
21	1961	30	30	30	30	30	30	30	30	30
22	1962	31	31	31	31	31	31	31	31	31
23	1963	32	32	32	32	32	32	32	32	32
24	1964	33	33	33	33	33	33	33	33	33
25	1965	34	34	34	34	34	34	34	34	34
26	1966	35	35	35	35	35	35	35	35	35
27	1967	36	36	36	36	36	36	36	36	36
28	1968	37	37	37	37	37	37	37	37	37
29	1969	38	38	38	38	38	38	38	38	38
30	1970	39	39	39	39	39	39	39	39	39
31	1971	40	40	40	40	40	40	40	40	40
32	1972	41	41	41	41	41	41	41	41	41
33	1973	42	42	42	42	42	42	42	42	42
34	1974	43	43	43	43	43	43	43	43	43
35	1975	44	44	44	44	44	44	44	44	44
36	1976	45	45	45	45	45	45	45	45	45
37	1977	46	46	46	46	46	46	46	46	46
38	1978	47	47	47	47	47	47	47	47	47
39	1979	48	48	48	48	48	48	48	48	48
40	1980	49	49	49	49	49	49	49	49	49
41	1981	50	50	50	50	50	50	50	50	50
42	1982	51	51	51	51	51	51	51	51	51
43	1983	52	52	52	52	52	52	52	52	52
44	1984	53	53	53	53	53	53	53	53	53
45	1985	54	54	54	54	54	54	54	54	54
46	1986	55	55	55	55	55	55	55	55	55
47	1987	56	56	56	56	56	56	56	56	56
48	1988	57	57	57	57	57	57	57	57	57
49	1989	58	58	58	58	58	58	58	58	58
50	1990	59	59	59	59	59	59	59	59	59
51	1991	60	60	60	60	60	60	60	60	60
52	1992	61	61	61	61	61	61	61	61	61
53	1993	62	62	62	62	62	62	62	62	62
54	1994	63	63	63	63	63	63	63	63	63
55	1995	64	64	64	64	64	64	64	64	64
56	1996	65	65	65	65	65	65	65	65	65
57	1997	66	66	66	66	66	66	66	66	66
58	1998	67	67	67	67	67	67	67	67	67
59	1999	68	68	68	68	68	68	68	68	68
60	2000	69	69	69	69	69	69	69	69	69
61	2001	70	70	70	70	70	70	70	70	70
62	2002	71	71	71	71	71	71	71	71	71
63	2003	72	72	72	72	72	72	72	72	72
64	2004	73	73	73	73	73	73	73	73	73
65	2005	74	74	74	74	74	74	74	74	74
66	2006	75	75	75	75	75	75	75	75	75
67	2007	76	76	76	76	76	76	76	76	76
68	2008	77	77	77	77	77	77	77	77	77
69	2009	78	78	78	78	78	78	78	78	78
70	2010	79	79	79	79	79	79	79	79	79
71	2011	80	80	80	80	80	80	80	80	80
72	2012	81	81	81	81	81	81	81	81	81
73	2013	82	82	82	82	82	82	82	82	82
74	2014	83	83	83	83	83	83	83	83	83
75	2015	84	84	84	84	84	84	84	84	84
76	2016	85	85	85	85	85	85	85	85	85
77	2017	86	86	86	86	86	86	86	86	86
78	2018	87	87	87	87	87	87	87	87	87
79	2019	88	88	88	88	88	88	88	88	88
80	2020	89	89	89	89	89	89	89	89	89
81	2021	90	90	90	90	90	90	90	90	90
82	2022	91	91	91	91	91	91	91	91	91
83	2023	92	92	92	92	92	92	92	92	92
84	2024	93	93	93	93	93	93	93	93	93
85	2025	94	94	94	94	94	94	94	94	94
86	2026	95	95	95	95	95	95	95	95	95
87	2027	96	96	96	96	96	96	96	96	96
88	2028	97	97	97	97	97	97	97	97	97
89	2029	98	98	98	98	98	98	98	98	98
90	2030	99	99	99	99	99	99	99	99	99
91	2031	100	100	100	100	100	100	100	100	100
92	2032	101	101	101	101	101	101	101	101	101
93	2033	102	102	102	102	102	102	102	102	102
94	2034	103	103	103	103	103	103	103	103	103
95	2035	104	104	104	104	104	104	104	104	104
96	2036	105	105	105	105	105	105	105	105	105
97	2037	106	106	106	106	106	106	106	106	106
98	2038	107	107	107	107	107	107	107	107	107
99	2039	108	108	108	108	108	108	108	108	108
100	2040	109	109	109	109	109	109	109	109	109

1. The above information is for informational purposes only and should not be used for any other purpose.

2. The above information is for informational purposes only and should not be used for any other purpose.

(1)

(2)

(3)

(4)

(5)

(6)

(7)

TABLE XI

Percent Damage, 1947, and Agronomic Characters⁽¹⁾ of
Ninety-eight Prospect x Hannchen Hybrids

Hybrid	Percent Damage ⁽²⁾	Angle head to stem ⁽³⁾	No. rows per head	Awn barbing	Height ins.
Hannchen	90	90	2	R	26
P. x H. 4690	84	5	6	R	30
x 4678	84	10	2	S	26
x 4666	71	90	6	R	27
x 4616	71	90	6	S	28
x 4625	71	90	6	S	28
x 4676	70	10	2	S	27
x 4619	70	75	6	S	27
x 4640	68	100	2	R	20
x 4691	68	20	2	R	23
x 4636	68	20	2	R	23
x 4655	67	30	2	R	26
x 4605	66	75	6	S	25
x 4672	66	90	6	S	28
x 4606	65	60	2	R	25
x 4677	65	5	6	R	29
x 4644	64	90	2	R	26
x 4641	64	80	6	R	26
x 4627	64	90	2	R	28
x 4613	64	75	6	S	28
x 4602	62	45	6	S	24
x 4651	62	80	2	R	26
x 4652	62	45	6	S	27
x 4689	62	75	6	R	27
x 4601	62	30	2	R	24
x 4660	61	90	6	R	26
x 4633	61	90	seg.	S	24
x 4697	61	90	seg.	seg.	26
x 4694	61	50	2	S	27
x 4658	61	90	6	seg.	26
x 4649	61	45	6	R	27

TABLE XI

Yields of Corn, 1947, and Average Yields of
Twenty-eight States and District of Columbia

State or District	Yield (bushels per acre)	Percentage of national yield	Percentage of national yield (a)	Percentage of national yield (b)	Percentage of national yield (c)
Alabama	40.0	100	100	100	100
Alaska	1.0	3	3	3	3
Arizona	15.0	38	38	38	38
Arkansas	35.0	88	88	88	88
California	45.0	113	113	113	113
Colorado	30.0	75	75	75	75
Connecticut	40.0	100	100	100	100
Delaware	40.0	100	100	100	100
District of Columbia	40.0	100	100	100	100
Florida	35.0	88	88	88	88
Georgia	30.0	75	75	75	75
Idaho	15.0	38	38	38	38
Illinois	40.0	100	100	100	100
Indiana	35.0	88	88	88	88
Iowa	45.0	113	113	113	113
Kansas	30.0	75	75	75	75
Kentucky	35.0	88	88	88	88
Louisiana	30.0	75	75	75	75
Maine	40.0	100	100	100	100
Maryland	40.0	100	100	100	100
Massachusetts	40.0	100	100	100	100
Michigan	40.0	100	100	100	100
Minnesota	45.0	113	113	113	113
Mississippi	30.0	75	75	75	75
Missouri	35.0	88	88	88	88
Montana	15.0	38	38	38	38
Nebraska	30.0	75	75	75	75
Nevada	15.0	38	38	38	38
New Hampshire	40.0	100	100	100	100
New Jersey	40.0	100	100	100	100
New Mexico	15.0	38	38	38	38
New York	40.0	100	100	100	100
North Carolina	30.0	75	75	75	75
North Dakota	15.0	38	38	38	38
Ohio	35.0	88	88	88	88
Oklahoma	15.0	38	38	38	38
Oregon	15.0	38	38	38	38
Pennsylvania	40.0	100	100	100	100
Rhode Island	40.0	100	100	100	100
South Carolina	30.0	75	75	75	75
South Dakota	15.0	38	38	38	38
Tennessee	30.0	75	75	75	75
Texas	30.0	75	75	75	75
Utah	15.0	38	38	38	38
Vermont	40.0	100	100	100	100
Virginia	30.0	75	75	75	75
Washington	15.0	38	38	38	38
West Virginia	30.0	75	75	75	75
Wisconsin	40.0	100	100	100	100
Wyoming	15.0	38	38	38	38

TABLE XI (continued)

<u>Hybrid</u>		<u>Percent Damage⁽²⁾</u>	<u>Angle head to stem⁽³⁾</u>	<u>No. rows per head</u>	<u>Awn barbing</u>	<u>Height ins.</u>
P. x H.	4669	60	60	2	R	28
x	4618	60	90	2	R	24
x	4607	60	15	6	S	27
x	4671	60	30	6	R	26
x	4629	60	90	2	S	24
x	4626	59	30	2	R	26
x	4648	59	90	6	S	26
x	4684	58	90	6	R	27
x	4687	58	45	seg.	seg.	30
x	4674	58	5	6	S	28
x	4628	58	5	2	R	27
x	4637	58	90	6	S	24
x	4611	58	90	2	R	27
x	4673	58	80	seg.	seg.	27
x	4661	57	15	2	S	27
x	4679	57	90	6	R	28
x	4632	57	90	2	S	27
x	4623	57	5	2	S	26
x	4621	56	60	6	R	28
x	4603	56	90	2	R	26
x	4696	56	75	2	S	28
x	4642	56	15	6	R	27
x	4668	55	10	6	S	26
x	4682	55	90	2	R	27
x	46152	54	45	6	R	26
x	4683	54	45	6	S	27
x	4681	54	90	2	R	27
x	4670	53	90	6	S	27
x	4635	53	45	2	S	24
x	4617	53	10	6	S	29
x	4647	53	15	6	R	25
x	4665	52	60	2	S	27
x	4620	52	15	6	R	28
x	4638	52	45	6	S	23
x	4604	52	30	2	R	24

(continued) in 2012

TABLE XI (continued)

Hybrid		Percent Damage (2)	Angle head to stem (3)	No. rows per head	Awn barbing	Height ins.
P. x H.	4686	52	90	2	S	29
x	4663	52	30	6	seg.	27
x	4646	51	15	6	S	27
x	4698	50	20	6	S	29
x	4639	50	75	6	S	20
x	46151	49	10	2	S	27
x	4643	49	30	6	R	26
x	4692	49	30	2	S	26
x	4680	49	90	6	S	27
x	4645	49	5	6	S	27
x	4650	49	80	6	S	27
x	4622	49	60	6	R	28
x	4654	48	90	2	S	26
x	4675	48	20	6	R	27
x	4685	48	20	6	S	27
x	4630	48	20	6	S	23
x	4659	47	15	2	S	26
x	4634	47	30	2	R	24
x	4615	47	10	2	S	28
x	4693	47	20	6	R	27
x	4653	47	90	2	R	28
x	4612	46	60	6	S	28
x	4610	46	20	2	S	27
x	4609	46	60	2	S	29
x	4624	46	20	2	S	28
x	4688	45	75	6	S	27
x	4657	44	30	2	S	26
x	4667	44	10	2	seg.	25
x	4608	44	15	6	R	28
x	4662	42	15	6	S	27
Prospect		41	5	6	S	26
P. x H.	4664	40	25	6	S	27
x	4614	40	10	6	S	28
x	4656	39	15	6	R	27

- (1) Determined at Swift Current - average of three replicates.
- (2) Percent heads dropped - average of 4 tests grown in 1947.
- (3) Note taken at maturity in degree; 0° = erect, 90° = right angles to stem.

Born (died) 12 1894

DISCUSSION

The results obtained under the conditions prevalent during the time when these experiments were conducted clearly indicate that highly significant differences in susceptibility to grasshopper damage exist among barley varieties. As might be expected, the expression of these differences is dependent upon both the time and severity of the grasshopper infestation. The most striking differences in varietal susceptibility occur when a moderate infestation takes place just before the earliest maturing varieties begin to head. Under such conditions a range of damage from one to one hundred percent was obtained, (Cabri 1945). On one occasion, Piapot in 1944, a heavy infestation of grasshoppers, occurring when the varieties were in the seedling stage, resulted in complete destruction of the test with no apparent varietal differences. Severe infestations occurring when the earliest maturing varieties have headed, have resulted in a range of damage from twenty to one hundred percent with the majority of the varieties damaged, (Herschel and Burdett, 1947).

DISCUSSION

The results obtained under the conditions
described during the time when these experiments were
conducted clearly indicate that slight differences in
temperature in susceptibility to grasshopper damage exist
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tions occurring when the earliest maturing varieties have
headed, have resulted in a range of damage from twenty
to one hundred percent with the majority of the varieties
damaged. (Gardner and Emdin, 1947).

Such varietal differences in susceptibility are of little economic importance unless they prove to be consistent under conditions prevailing both at different locations over a fairly wide area and at the same locations at different years. The varietal reaction to grasshopper damage in ten tests, conducted over a period of four years, has been remarkably consistent, with one exception which will be discussed later. Correlation coefficients have been used as a measure of varietal consistency between tests since it was impossible to make a combined analysis of the data due to lack of homogeneity of the individual standard errors, unequal number of replicates or unequal number of varieties tested.

Grasshopper damage to barley varieties can be divided roughly into four types:

- (1) leaf chewing - this is usually the first type of damage noticeable in a field provided that the crop is not mature when the infestation takes place.
- (2) head dropping - as the crop nears maturity this is the predominant type of damage. Grasshoppers feed on the neck of the culm with the result that the head is left hanging or is completely severed. Such damage results in the greatest loss since the grain cannot be recovered.
- (3) kernel chewing - instead of feeding as in (2), the grasshoppers feed on the glumes and kernels, usually from the apex of the seed towards the

Such varietal differences in susceptibility
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exception which will be discussed later. Correlation
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number of replicates or unequal number of varieties tested.
Crashhopper damage to barley varieties can be

divided roughly into four types:

- (1) Leaf chewing - This is usually the first type of
damage noticeable in a field. Growth of the
crop is not retarded when the infestation is
light.
- (2) Head dropping - As the crop nears maturity this
is the predominant type of damage. Crashhoppers
feed on the back of the culm with the result that
the head is left hanging or is completely severed.
Such damage results in the greatest loss since
the grain cannot be recovered.
- (3) Kernel chewing - Instead of feeding on the
the crashhoppers feed on the glumes and kernels,
usually from the apex of the seed towards the

base. The head is left standing but contains half-eaten kernels. Such damage usually occurs at the same time as head dropping.

- (4) stem chewing - this type of damage occurs after the head has been dropped, and in severe cases the straw is eaten down to the ground level.

The percentage of heads dropped has been used as the criterion of damage in this study for several reasons. Such damage can be easily and accurately determined, it is highly correlated with leaf chewing and it is of the most economic importance. While leaf damage has often been considered of little importance, White (29) has recently shown that wheat plants defoliated when they are heading out or blooming suffer a loss of from 20 - 30 percent in yield. Stem chewing is of little economic importance since it usually occurs after the grain is a total loss. The limited observations on kernel chewing show some indication that such damage may be a varietal characteristic. Jacobson and Farstad (17) have reported kernel chewing as characteristic of Caesium wheat, whereas, in their tests, such feeding on other varieties of wheat was absent or negligible in comparison. On the basis of the limited data now available concerning this type of damage on barley varieties, it would appear that there is a high correlation between

best. The seed is left standing on a surface
half-dry for several days before being
of the type of seed required.

(4) after showing - This type of damage occurs
after the seed has been trodden, and in some
cases the straw is bent down to the ground level.

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head dropping and kernel chewing. However this is not true in every instance and the problem should be investigated further.

In attempting to link varietal damage with some agronomic character exhibited by the barley varieties in these tests, the most obvious relationship to study has been maturity and damage. The late maturing varieties grown in 1944, 1945 and 1946 always suffered the most damage. Such an observation might lead to the supposition that earlier maturing varieties escape damage because of unpalatability due to some character such as lack of moisture. However, the fact that grasshoppers will select out susceptible varieties even when none of the varieties have headed would indicate that some character other than actual maturity was involved. In order to examine this possibility further, the Prospect x Hannchen hybrids tested in 1947 included as many combinations of parental characters as possible. As might be expected, a significant positive correlation between damage and maturity was obtained, (ignoring for the moment data obtained at Herschel). A close examination of the data, however, shows some early maturing hybrids, for example, 4678, that suffered considerable damage; and some late maturing hybrids, for example, 4674, that suffered relatively

seed dropping and kernel shriveling. However this is not true in every instance, and the problem should be investigated further.

In attempting to link varietal damage with some agronomic character exhibited by the barley varieties in these tests, the most obvious relationship to study has been maturity and damage. The late maturing varieties grown in 1945, 1946 and 1947 always suffered the most damage. Such an observation might lead to the supposition that earlier maturing varieties escape damage because of unpalatability due to some character such as lack of maturity. However, the fact that grasshoppers will select not susceptible varieties even when none of the varieties have headed would indicate that some character other than actual maturity was involved. In order to examine this possibility further, the Harpegen x Harpegen hybrids tested in 1947 included as many combinations of parental characters as possible. As might be expected, a significant positive correlation between maturity and damage was obtained, (figuring for the parent data obtained at Harpegen). A closer examination of the data, however, shows some early maturing hybrids, for example, 4575, that suffered considerable damage; and some late maturing hybrids, for example, 4574, that suffered relatively

little damage. These examples, it is believed, give further indication that some factor other than maturity is responsible for the degree of grasshopper damage suffered by varieties of barley. A just criticism of the above discussion lies in the fact that the relative maturity of the hybrids was determined at Swift Current, while the damage was recorded in tests grown from 100 to 200 miles from Swift Current. However, an examination of the plots at the time the damage was estimated gave no reason to suspect that the relative maturity of the varieties and hybrids as recorded at Swift Current was in any way different at the test locations.

The results obtained at Herschel in 1947 were most surprising in view of the experience in other tests. There was a significant negative correlation between damage and maturity, even when the varieties and hybrids were studied separately. Lansdale, a very early maturing variety which was consistently resistant to grasshopper attack, even when exposed to severe infestations, lost ninety percent of its heads. On the other hand, Sanalta, a variety which matures at least two weeks later than Lansdale, and ordinarily is severely damaged, lost only fifty-six percent of its heads. Hybrid 4635, a medium late maturing line, proved to be the

little damage. These examples, it is believed, give further indication that some factor other than activity is responsible for the degree of grasshopper damage suffered by varieties of barley. A last criticism of the above discussion lies in the fact that the relative maturity of the hybrids was determined at Swift Current, while the damage was recorded in tests grown from 100 to 200 miles from Swift Current. However, an examination of the plots at the time the damage was estimated gave no reason to suspect that the relative maturity of the varieties and hybrids as recorded at Swift Current was in any way different at the test locations.

The results obtained at Herschel in 1947 were most striking in view of the experience in other tests. There was a significant negative correlation between damage and maturity, even when the varieties and hybrids were sown simultaneously. Moreover, a very early maturing variety which was consistently resistant to grasshopper attack, even when exposed to severe infestation, lost ninety percent of its heads. On the other hand, variety, a variety which matures at least two weeks later than Hansdale, and ordinarily is severely damaged, lost only fifty-six percent of its heads. Hybrid 4435, a medium late maturing line, proved to be the

most resistant under Herschel conditions, even though it was still green when the estimates of damage were made.

In the light of present knowledge, no explanation of this phenomenon is offered. Since the grasshopper population at Herschel was composed almost entirely of Camnula pellucida (Scudd.), it might be argued that such feeding was characteristic of this species. If such were the case however, it would be logical to expect some indication of similar feeding in plots at Gravelbourg and Shaunavon, where Camnula pellucida (Scudd.) was also present in considerable numbers. A more likely explanation lies in the fact that Herschel is 100 miles north of any of the other tests and consequently, since the soil type and environment are correspondingly different, the reaction of the barley varieties to grasshopper attack may vary accordingly. Further tests will have to be conducted, however, before arriving at any definite conclusions.

It is quite possible that significant correlation coefficients could be established between damage and several of the agronomic characters listed in Table 10. Such correlations, it is believed, would be spurious since the varieties under test do not represent a con-

most resistant under lateral conditions, even though it was still green when the estimates of damage were made.

In the light of present knowledge, no explanation of this phenomenon is offered. Since the grasshopper population at Hattah was somewhat almost entirely of Gambusia affinis (Laceped.), it might be argued that such feeding was characteristic of this species. If such were the case however, it would be logical to expect some indication of similar feeding in those Gambusia and Gambusia populations. A (Laceped.) was also present in considerable numbers. A more likely explanation lies in the fact that Hattah is 100 miles north of any of the other tests and consequently, since the soil type and environment are correspondingly different, the reaction of the barley varieties to grasshopper attack may vary accordingly. Further tests will have to be conducted, however, before arriving at any definite conclusions.

It is quite possible that significant correlation coefficients could be established between damage and several of the agronomic characters listed in Table 10. Such correlation, it is believed, would be significant since the varieties under test do not represent a con-

tinuous range of characters from one extreme to the other. For example, a significant correlation coefficient probably could be obtained between damage and the number of rows per head. Such a correlation would be misleading however since no early maturing, 2-rowed varieties were included in the tests. The agronomic characters of the Prospect x Hannchen hybrids, listed in Table 11, are not subject to the same criticism, however, and it is obvious that such agronomic characters as height, angle of the head to the stem, number of rows per head and awn-barbing, are not correlated with susceptibility to grasshopper damage.

In view of the results obtained in this study, it may be concluded that the susceptibility of barley varieties to grasshopper damage is closely associated with maturity of the plants, but that the reaction of all hybrids and varieties cannot be explained on this basis alone. The striking differences in damage recorded in Table 7, and the consistency of the injury to individual hybrids and varieties in the various replicates, suggest a genetic basis for the differential injury noted. Such conclusions are in general agreement with the results of other investigators who have studied differential feeding of grasshoppers in other crops, (7, 12, 15, 17).

various forms of abnormality from one extreme to the other. For example, a significant correlation coefficient was partly due to the obtained between the number of rows per head, and a correlation with the number of rows per head. Since no early testing, 2-rowed varieties were included in the test. The economic characters of the prospect 1. Hatched hybrids, listed in Table II, are not subject to the same criticism, however, but it is obvious that some economic characters are being, such as the head to the stem, number of rows per head and two-seeded, are not correlated with susceptibility to grasshopper damage.

In view of the results obtained in this study, it may be concluded that the susceptibility of wheat varieties to grasshopper damage is closely associated with maturity of the plant, but that the correlation of all hybrids and varieties cannot be explained on this basis alone. The striking differences in damage reported in Table 7, and the consistency of the injury to individual hybrids and varieties in the various tests, suggest a genetic basis for the differential injury noted. Such variations are in general agreement with the results of other investigators who have studied differential feeding of grasshoppers in other crops, (7, 12, 13, 14).

The fact that grasshoppers need specific hosts for maximum longevity and fecundity has been demonstrated by several investigators, especially by the researches of Criddle (9), Isley (16), Sanderson (24), Hodge (13), Tauber (27), and Brett (6). A common characteristic of these studies lies in the fact that different crops were tested as food for grasshoppers. As far as is known, no literature is available on the effect of feeding different varieties or selections within a species. In view of the striking effect on the longevity and fecundity of grasshoppers when fed different crops, and the fact that grasshoppers show a marked preference for certain varieties within a species, it would not be unreasonable to expect similar, but perhaps less striking, differences in these characters if the grasshoppers were fed on varieties for which they have a natural aversion.

Since the grasshoppers in the present study had a free choice of many varieties and hybrids, it must be kept in mind that the results probably indicate preference rather than resistance. The full importance of the wide differences in varietal injury recorded in these tests is dependant upon further investigations.

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these animals lies in the fact that different crops were
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literature is available on the effect of feeding different
varieties of melons within a species. In view of the
existing interest on the longevity and fecundity of grass-
hoppers when fed different crops, and the fact that grass-
hoppers show a marked preference for certain varieties
within a species, it would not be unreasonable to expect
differences in longevity, fecundity, and perhaps also in other
characters if the grasshoppers were fed on varieties for
which they have a marked aversion.

Since the grasshoppers in the present study had
a free choice of many varieties and hybrids, it would be
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SUMMARY

1. A study was undertaken in 1944 to determine whether there are consistent differences in the amount of damage suffered by barley varieties exposed to grasshopper attack; and if so, to determine which, if any, agronomic characters may be associated with "resistance".
2. A number of varieties and hybrids of barley were grown in replicated tests exposed to natural infestations of grasshoppers during the period 1944 - 1947 inclusive.
3. There were consistent varietal differences in the amount of grasshopper injury sustained in 10 of the 11 tests. No explanation for the exceptional results obtained at Herschel in 1947 is offered.
4. As a general rule, late maturing varieties and hybrids suffered the most damage. Evidence is submitted to show that some factor other than maturity alone must be responsible for differences in varietal susceptibility.

ABSTRACT

1. A study was conducted in 1947 to determine the effect of temperature on the development of the pupae of the housefly, *Musca domestica*. The pupae were reared at 10°C, 15°C, 20°C, 25°C, and 30°C. The results showed that the pupae developed most rapidly at 25°C and least rapidly at 10°C. The duration of the pupal period was inversely proportional to the temperature.

2. A number of varieties and hybrids of barley were grown in replicated plots exposed to natural infestations of grasshoppers during the period 1947-1948 inclusive. The results showed that the varieties and hybrids differed in their resistance to grasshopper infestation.

3. There were significant vertical differences in the amount of grasshopper injury sustained in 1947 and 1948. The results for the experimental plots and the results obtained at a ranch in 1947 are compared.

4. As a general rule, fast maturing varieties and hybrids suffered the most damage. It is suggested that some factor other than maturity alone must be responsible for differences in vertical susceptibility.

5. There did not appear to be any correlation between damage and such agronomic characters as height, leafiness, angle of head to stem, number of rows per head, awn barbing, or susceptibility to shattering.
6. The results obtained in this study indicate preference rather than "resistance". The full significance of the differential injury recorded will be dependent upon further investigations.

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The writer wishes to express his sincere thanks to Mr. A. W. Platt, Dominion Experimental Station, Swift Current, Saskatchewan, under whose direction this work has been carried out, for his helpful suggestions and criticisms during the progress of this investigation.

The writer is also indebted to Mr. L. B. Thomson, Superintendent, Dominion Experimental Station, Swift Current, Saskatchewan, whose interest and

3. There did not appear to be any correlation between degree and such physical characteristics as height, leanness, color of head or skin, shape of nose, ear, hair, eye, mouth, or susceptibility to shattering.

4. The results obtained in this study indicate tolerance rather than "resistance". The total significance of the differential injury reaction will be dependent upon further investigation.

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The writer wishes to express his sincere thanks to Dr. A. W. West, Dominion Experimental Station, Swift Current, Saskatchewan, under whose direction this work has been carried out, for his helpful suggestions and criticisms during the progress of this investigation. The writer is also indebted to Dr. L. H. Thomson, Superintendent, Dominion Experimental Station, Swift Current, Saskatchewan, whose interest and

encouragement has made possible the present scope of this study; and to Dr. A. G. McCalla, Department of Plant Science, University of Alberta, for his criticism and suggestions during the preparation of the manuscript.

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suggestions which have improved the manuscript.

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