Technical Bul. 1 December, 1932

THE EFFECT OF A LETHAL IN THE HETEROZYGOUS CONDITION ON BARLEY DEVELOPMENT

By D. W. Robertson

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Introduction

The appearance of chlorophyll-deficient seedlings is quite common in barley grown under Colorado conditions. Various degrees of deficiency have been found ranging from pure white to normal green. The plants lacking chlorophyll have all died in the seedling stage when in the homozygous condition.

The effect of green plants carrying a factor for chlorophyll deficiency is of economic interest.

A series of studies to determine the effect of four chlorophyll deficiencies found in barley is reported in this paper.

Literature Review

Several authors have published the results of experiments to determine the effect of lethals in the heterozygous condition on cross-fertilized crops. Mangelsdorf (1926) concluded that in maize the effect, if any, of the lethals when in combination with their dominant allelomorphs is so slight that it could be accurately detected only by a delicate test.

Garber and Rowley (1927) crossed a strain of maize homozygous for a defective endosperm character with homozygous normal plants of the same strain. Seed from ears heterozygous for this factor and from normal ears were planted and the progeny measured for height, number of nodes and yield. The authors found a significantly higher yield per plant for the normal plants when compared with plants heterozygous for the defective endosperm character pair.

Mangelsdorf (1928) studied the effect of a defective seed character on growth in maize. A slight difference was found between the height in inches of the two classes of plants, those homozygous for the normal condition (DeDe) being slightly taller than those heterozygous for the seed defect (Dede). However, the differences were well within the probable error for all stages except the height at 33 days. The height at all the other dates was slightly in favor of the normal plants. The length of ear and weight of ears were slightly higher for the normal plants, but the difference was within the probable error and could not be considered statistically significant.

Wentz and Goodsell (1929) studied 19 selfed lines of maize. No statistically significant relationship was found between number of defects present and yield. When the defects were divided into three classes, seed, seedling and plant, it was observed that the total under each of the three classes, as well as the total of all defects, was negatively correlated with yield. This might indicate a slight deleterious effect of the groups of defects upon yield but none of the correlation coefficients was large enough to be considered significant.

Karper (1930) grew the progeny of an inbred line of Standard Black Hull kafir which produced white seedlings in a mono-hybrid ratio. The genetic constitution of the various plants for the green-versus-white seedling-character pair was determined from the results obtained in the greenhouse. Previously, the following field measurements had been made: Height of plants at 20, 40, 60, 80 and 123 days, number of suckers and side branches, weight in grams of plants at maturity, weight of heads of plants at maturity, length in centimeters of heads, number of days to full boot and number of days to full bloom. No significant differences were found for the above characters between homozygous green plants (WW) and heterozygous green plants (Ww).

MATERIAL AND METHODS

COLSESS I.—Colsess I produces a white seedling in a monohybrid ratio. This seedling develops for about 10 days and dies.

BLACK HULLESS II produces a yellow seedling (Primrose yellow, Plate 30, Ridgway) which grows for about 10 days and then dies. The plants segregate in a simple Mendelian ratio of 3 green to 1 yellow.

HANNA produces a white seedling similar to Colsess. From previous studies this seedling has been found to be genetically different from the seedling-factor pair ($A_c a_c$) found in Colsess. It is inherited as a simple Mendelian factor pair.

CANADA THORPE I produces a white seedling which is very weak. The seeds producing white seedlings can be picked out before planting. After germination the endosperm turns watery while, in the seeds producing normal green plants, a pasty appearance is still prevalent. There seems to be a correlation between white seedlings and endosperm character. The seedlings produced from the watery seeds are very weak.

The effect of the lethals in the heterozygous condition on the following mature plant characters was studied: Number of culms per plant, average height of culm, average length of head, number of seeds per plant, and total weight of threshed grain. The seeds were

Table 1.—**Measurements of Plant Characters of Colsess I Grown at Fort Collins in 1930 and 1931**

Year Grown			No. Plants	Mean	Standard Error of M.	Difference	Standard Error of Difference	D/S. E.	S. E. in Percentage
1930	Total weight of grains in grams	Green	145	6.63	0.27				4.01
		Het	276	7.04	0.18	-0.41	0.32	1.28	2.62
	No. of grains per plant	Green	145	184.00	7.48				4.06
		Het	276	190.00	5.35	-6.0	9.20	0.65	2.82
	Average length of culm in cm.	Green	145	61.00	0.49				0.81
		Het	276	63.00	0.39	-2.0	0.62	3.23	0.62
	Average length of head in cm.	Green	145	5.99	0.06				1.01
		Het	276	6.17	0.05	-0.18	0.07	2.57	0.73
	No. of culms per plant	Green	145	4.46	0.14				3.29
		Het	276	4.73	0.16	-0.27	0.21	1.29	2.24
1931	Total weight of grain in grams Non-competitive	Green	231	13.70	0.39				2.82
		Het	411	13.80	0.30	-0.1	0.49	0.02	2.14
	No. of grains per plant Non-competitive	Green	231	462.00	11.88				2.57
		Het	411	471.00	9.32	-9.0	15.10	0.60	1.98
	Average length of culms in cm. Non-competitive	Green	231	78.00	0.44				0.57
		Het	411	79.00	0.31	-1.0	0.54	1.85	0.40
	Average length of head in cm. Non-competitive	Green	231	8.0	0.40				0.49
		Het	411	8.1	0.03	-0.1	0.049	2.04	0.38
	No. of culms per plant Non-competitive	Green	231	8.7	0.20				2.35
		Het	411	8.9	0.17	-0.2	0.266	0.72	1.92

sown in rows 1 foot apart, and spaced 2 inches apart in the rows. At harvest, competitive plants were harvested in one lot and non-competitive plants in another. Measurements of each individual plant were made and recorded. A sample of seed from each plant was planted in the greenhouse to determine whether the plants were homozygous green or heterozygous for one of the lethal-factor pairs.

The mean, standard error and coefficient of variability were determined for the homozygous green plants and heterozygous plants.

Tests were made in 1930 and 1931.

EXPERIMENTAL RESULTS

COLSESS I.—The field counts of green and white seedlings approached a three-to-one segregation in both years. The measurements for plants grown in 1930 and 1931 are given in Table 1.

In all of the characters studied the heterozygous plants had higher averages than the homozygous green plants. In 1930, only two characters, average length of culm and average length of head, had a difference greater than twice the standard error of a difference. In 1931, only one character measured had a difference greater than twice the standard error of a difference. No significant difference was found in total weight of grain, number of grains per plant, and number of culms per plant. In 1930, the difference in average length of culm was 2 cm. in favor of the heterozygous plants, which was 3.23 times the probable error of a difference and may be considered significant. In 1931, the difference in average length of culm is less than twice the standard error. The average length of head in cm. shows a difference of 0.18 in 1930 and 0.1 cm. in 1931. The difference in both years is in favor of the heterozygous plants.

The odds that such a difference would occur due to chance are over 22 to 1 indicating that the difference may be significant.

BLACK HULLESS II.—The seedling counts approached a three-to-one ratio of green-to-yellow seedling. Table II gives the plant measurement for the plants grown in 1930 and 1931.

In measuring the different plants in 1931 two sets of plants were harvested. Competitive plants are plants having normal competition. Non-competitive plants are plants having blank spaces on one or both sides. The spring of 1931 was very severe and a late frost killed some of the seedlings. The above condition together with the normal blank spaces caused by the death of the chlorophyll-deficient seedlings left many plants with larger feeding areas than would be the case with a perfect stand.

The difference between the heterozygous and homozygous green plants varied in the different measurements. The total weight of

Table II.—Measurements of Plant Characters in Black Hulless II, Grown at Fort Collins in 1930 and 1931.

Year Grown		No. Plants	Mean	Standard Error of M.	Difference	Standard Error of Difference	D/S. E.	S. E. in Percentage
1930 Total weight of grain in grams	Green	163	5.30	0.16				3.15
	Het	286	5.50	0.14	−0.2	0.21	0.95	2.53
No. of grains per plant	Green	163	150.00	4.76				3.17
	Het	286	142.00	4.05	+8.0	6.25	0.78	2.85
Average length of culms in cm.	Green	163	57.00	0.38				0.67
	Het	286	56.00	0.28	+1.0	0.46	2.17	0.49
Average length of head in cm.	Green	163	5.80	0.04				0.72
	Het	286	5.90	0.03	−0.1	0.049	2.04	0.48
No. of culms per plant	Green	163	4.68	0.14				3.04
	Het	286	4.76	0.11	−0.08	0.178	0.45	2.31
1931 Total weight of grain in grams								
Competitive	Green	85	5.95	0.39				6.60
	Het	186	6.12	0.26	−0.17	0.47	0.36	4.25
Non-competitive	Green	288	7.52	0.26				3.34
	Het	526	7.49	0.19	+0.03	0.31	0.09	2.59
No. of grains per plant								
Competitive	Green	85	236.00	16.16				6.82
	Het	186	238.00	9.42	−2.0	18.71	0.11	3.96
Non-competitive	Green	288	302.92	9.38				3.10
	Het	526	292.70	7.03	+10.2	11.72	0.87	2.40
Average length of culms in cm.								
Competitive	Green	85	79.90	0.86				1.08
	Het	186	79.10	0.58	+0.8	1.04	0.77	0.74
Non-competitive	Green	288	77.14	0.41				0.54
	Het	526	77.06	0.31	+0.08	0.51	0.16	0.40
Average length of head in cm.								
Competitive	Green	85	5.48	0.05				0.91
	Het	186	5.56	0.04	−0.08	0.06	1.33	0.77
Non-competitive	Green	288	5.85	0.04				0.60
	Het	526	5.79	0.03	+0.06	0.045	1.33	0.48
No. culms per plant—Competitive	Green	85	6.78	0.34				5.00
	Het	186	6.95	0.23	−0.17	0.41	0.41	3.30
Non-competitive	Green	288	7.94	0.21				2.70
	Het	526	7.76	0.17	+0.18	0.27	0.67	2.13

grain in grams showed a difference of –0.2, –1.7 and +0.03. None of these differences was statistically significant. The number of grains per plant differed by +8, –2 and +10.2. As in the case of the weight of grain, none of the above differences was significant statistically.

The average length of culm differed by –1, +0.8 and +0.08 cm. The first difference was 2.17 times the standard error of a difference while the difference in average length in 1931 was in both cases less than the standard error of a difference.

The average length of head in cm. differed by –0.1 in 1930, by –0.08 and +0.06 in 1931. Again the 1930 results show a difference of over twice the standard error but in favor of the heterozygous plants. The 1931 measurements show both plus and minus differences but cannot be considered significant.

The number of culms per plant show a difference of –0.08, –0.17 and +0.18. None of these differences is statistically significant.

The above results would indicate that there is no detrimental effect of the yellow seedling factor in the heterozygous condition on the characters measured in Black Hulless Barley.

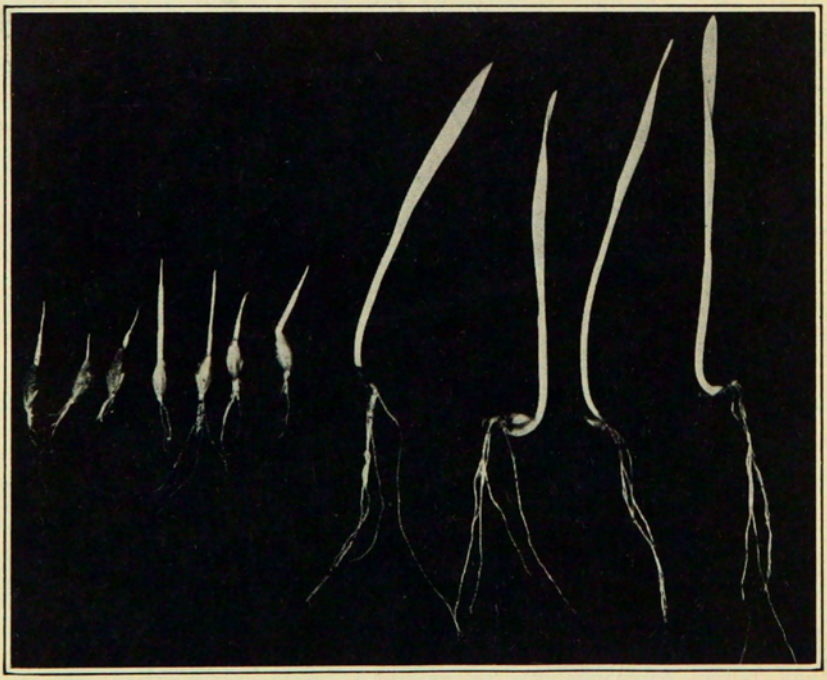

Fig. 1.—White seedlings of Canada Thorpe I (left) compared with white seedlings of Colsess I (right). Both sets are of the same age.

CANADA THORPE.—Only studies made in 1931 are presented in Table III.

The difference in weight of grain in both the competitive and non-competitive plants seems to be statistically significant. The deviation over the standard error of all other measurements is one or less. In the case of total weight of grain there is a double effect of the lethal. As has already been stated, the white seedling produced in this variety is very small, Figure 1, when compared with other chlorophyll-deficient seedlings. There is also a noticeable effect on the appearance of the endosperm. Seeds carrying the lethal in the double recessive condition can be picked out before planting. When germinating, these seeds have a watery appearance while the normal seeds are white and starchy. The following weights were obtained for 1,000 kernels of normal ($A_{t2}\,a_{t2}$) seed: 46.47 grams while 1,000 kernels of the genetic constitution ($a_{t2}a_{t2}$) weighed 23.43 grams. This difference in weight per 1,000 kernels would account for the difference in total weight per plant, since one-fourth of the seeds in the heterozygous plants carried the genetic constitution ($a_{t2}a_{t2}$).

HANNA.—The measurements of the different characters in Hanna, a two-rowed hulled barley are given in Table IV.

The differences again vary; those for total weight of grain, number of grains per plant, and number of culms per plant are in favor of the heterozygous plants. The average length of culm is slightly larger in the green plants. However, none of the differences is statistically significant.

Table III.—**Measurements of Plant Characters in Canada Thorpe I Grown at Fort Collins in 1931.**

Year Grown			No. Plants	Mean	Standard Error of M.	Difference	Standard Error of Difference	D/S. E.	S. E. in Percentage
1931	Total weight of grain in grams								
	Competitive	Green	260	7.44	0.23				3.05
		Het	508	6.76	0.14	+0.68	0.27	2.52	2.02
	Non-competitive	Green	239	7.36	0.26				3.52
		Het	468	6.64	0.18	+0.72	0.316	2.28	2.75
	No. of grains per plant								
	Competitive	Green	260	190	5.13				2.70
		Het	508	193	3.68	-3.4	6.25	0.54	1.86
	Non-competitive	Green	239	216	5.15				2.39
		Het	468	215	4.81	+1.0	7.05	0.16	2.24
	Average length of culms in cm.								
	Competitive	Green	260	72.8	0.29				0.41
		Het	508	72.8	0.24				0.33
	Non-competitive	Green	239	69.6	0.40				0.58
		Het	468	69.4	0.28	+0.02	0.488	0.0	0.40
	Average length of head in cm.								
	Competitive	Green	260	7.10	0.03				0.39
		Het	508	7.10	0.06				0.85
	Non-competitive	Green	239	7.13	0.03				0.46
		Het	468	7.06	0.02	+0.07	0.037	0.19	0.33
	No. of culms per plant								
	Competitive	Green	260	7.48	0.18				2.45
		Het	508	7.70	0.13	-0.22	0.22	1.00	1.66
	Non-competitive	Green	239	7.74	0.22				2.87
		Het	468	7.56	0.15	+0.18	0.27	0.67	1.94

Table IV.—**Measurements of Plant Characters in Hanna Grown at Fort Collins in 1930.**

Year Grown		No. Plants	Mean	Standard Error of M.	Difference	Standard Error of Difference	D/S. E.	S. E. in Percentage
Total weight of grain in grams	Green	92	5.6	0.24				4.45
	Het	215	5.7	0.18	–0.1	0.3	0.03	3.21
No. of grains per plant	Green	92	137.6	6.28				4.54
	Het	215	141.0	4.28	–3.4	7.58	0.45	3.04
Average length of culms in cm.	Green	92	61.7	0.47				0.77
	Het	215	61.6	0.30	+0.1	0.56	0.018	0.49
Average length of head in cm.	Green	92	8.9	0.06				0.70
	Het	215	8.9	0.04	0.0	0.07	0.0	0.46
No. of culms per plant	Green	92	7.1	0.67				9.46
	Het	215	7.3	0.60	–0.2	1.00	0.2	8.21

Total number of plants 307.

SUMMARY

The effect of single lethals was studied in four barley varieties. Colsess contains a white seedling factor-pair ($A_c a_c$) (Robertson 1929). In Black Hulless, a yellow seedling factor-pair ($X_b x_b$) was studied. In Hanna, a white seedling factor-pair ($A_h a_h$) was studied while in Canada Thorpe, a white seedling factor-pair ($A_{t2} a_{t2}$) which also affected the endosperm was studied.

Plant measurements were made in the field and each plant was harvested and threshed separately. The plants were then tested in the greenhouse and separated into homozygous green and those segregating for green and a lethal.

The measurements of the homozygous green plants were then compared with the measurements of the heterozygous plants.

No significant differences were found in the following characters: Number of culms per plant, average length of culm, average length of head, number of grains per plant, and total weight of grain per plant.

When the lethal seedling factor-pair was associated with an endosperm deficiency, a significant difference was obtained in total grain weight per plant.

These results indicate that there is no detrimental effect of a single seedling lethal-factor in the heterozygous condition in the development of the barley plant.

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