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DORMANCY IN SMALL-GRAIN SEEDS

By G. W. DEMING and D. W. ROBERTSON

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DORMANCY IN SMALL-GRAIN SEEDS

By G. W. DEMING and D. W. ROBERTSON

In wet seasons, grain often sprouts in the shock. All varieties, however, do not sprout to the same extent. This fact may be of value to farmers in selecting a variety adapted to their climatic conditions. Since sprouted grains lower the quality of the seed, to obtain a variety more or less resistant to sprouting may be of considerable economic importance.

Harrington* studied the effect of adverse weather conditions on the sprouting of the following varieties of spring wheat: Marquis, Reward, Garnet, Red Bobs, Ruby, Quality, Red Fife, Kitchener, Early Red Fife, Mindum, Renfrew, Kubanka, Peliss and Ceres. His results in 1927 show that varieties tested may be ranked as follows regarding resistance to sprouting, Marquis 70, Kitchener, Red Fife, Red Bobs, Reward, Renfrew, Pelissier, Mindum, Early Red Fife, Kubanka, Quality, Ruby and Garnet. The data presented also indicate that there may be a difference in the resistance of different strains of Marquis. The test for significance between varieties shows that the difference between Marquis 70 and Kitchener, and Marquis 70 and Red Fife are not significant. The difference between the other varieties and Marquis are, however, significant. In 1931, he carried an experiment with Marquis, Reward, Ceres and Garnet. Again Marquis ranked highest in resistance followed by the others in the order given. The difference between Marquis and Reward was not significant. All of his tests were conducted with shocked grain in the field.

A somewhat similar condition was found at Fort Collins in 1930. From August 4 to 15 the season was exceedingly wet. The temperature was also high at this time and considerable sprouting was noticed in the shocked grain. Some winter wheat varieties which were left in the field sprouted in the head before harvest. It was noted that there was a difference in the resistance to sprouting of different varieties. When the tendency to sprout was compared with a dormancy study, it was found that there was a very close correlation between dormancy and resistance to sprouting. The results of the dormancy study will be given in this paper and where possible, compared with observations in the field in 1930.

Material and Methods

Seeds were harvested from several varieties of grain about the stage at which the crop would be harvested with a binder. A few

*Harrington, J. B.—The comparative resistance of wheat varieties to sprouting. Sci. Agri. Vol. XII, pp. 635-645, 1932.

of the seeds were hard, the majority were slightly soft and a few still in the dough stage.

Plantings of 25 seeds were made each day, starting within 24 hours of harvest. The seeds were usually harvested in the afternoon and the first planting was made the next morning. The seeds were placed in sand at a uniform depth and the boxes set in the shade of a shelf to partially avoid excessive temperatures during the day time. All of the plantings were made in a green-house but facilities for the control of temperature were not available. The temperature, therefore, varied considerably during the test. The lowest morning temperature recorded for the sand was just over 10°C. The temperature at mid-afternoon was occasionally above 30°. However, in a high percentage of the days, the temperature range was from 12° to 17°C. in the morning to 24° to 30°C. just after the hottest part of the day. The sand was kept moist at all times. Counts of emerged seedlings were made each day. All seeds were planted at a uniform depth.

In summarizing the data, the plantings will be grouped for each successive 4-day period and the emergence at 10 days after planting will be used as the dividing line between domancy and lack of dormancy. In the original study, counts in many cases were made for a period of over a hundred days after planting. When the seeds were kept in moist sand for 15 or more days, many more kernels sprouted in most of the varieties tested than had emerged at the end of the first 10-day period. Tho, with the possible exception of Marquis wheat, this emergence did not occur at any definite period after planting.

EXPERIMENTAL RESULTS

Some preliminary work was started to determine if barley harvested before maturity would germinate. Some of the varieties tested showed a difference in the dormancy period after planting.

In 1928, 1929 and 1930, tests were conducted with several varieties of wheat, barley and oats. Data were taken on the varieties tested and Table I gives an example of the data obtained. In the final analysis of the data the results were calculated in percentage sprouted in 10-day intervals.

Table II gives the results obtained with Trebi barley in 1928. The data in Table II show that there is little dormancy after the seeds have been in sand for 20 days.

There is a slight dormant period when the seeds have been in moist sand for 11 days or over. After being kept for 24 days or over, the dormancy is quickly lost and a high germination percentage is obtained in 10 days.

Table I.—Form in Which Records Were Made. Copy of Record Sheet for Bark Barley.—1928.

DATE PLANTED	DATE UP																														
	Aug.																								Sept.						
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7
Aug. 3	1	1	2	1	1	....	....	....	1	....	....	1	....	....	....	1	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....
4	....	3	4	1	....	2	....	....	1	....	1	....	1	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....
5	....	....	8	2	....	2	....	1	1	....	....	....	....	....	1	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....
6	....	....	....	2	2	2	4	2	....	1	....	....	1	....	....	....	....	....	....	....	1	....	....	....	....	....	....	1	....	....	....
7	....	....	....	....	1	2	5	1	3	2	1	....	1	....	....	....	....	....	2	....	....	1	....	....	....	....	....	....	....	....	....
8	....	....	....	....	....	8	2	3	4	....	1	....	1	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
9	....	....	....	....	....	3	2	4	4	....	4	....	4	....	1	....	2	....	....	....	1	....	....	....	....	....	....	....	....	....	....
10	....	....	....	....	....	....	7	9	3	....	....	3	1	....	....	....	....	2	....	....	....	....	....	....	....	....	....	....	....	....	....
11	....	....	....	....	....	....	4	17	2	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
12	....	....	....	....	....	....	....	7	13	....	2	....	1	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
13	....	....	....	....	....	....	....	....	5	13	3	1	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
14	....	....	....	....	....	....	....	....	....	....	17	2	4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
15	....	....	....	....	....	....	....	....	....	....	....	24	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
16	....	....	....	....	....	....	....	....	....	....	....	....	24	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
17	....	....	....	....	....	....	....	....	....	....	....	....	....	21	2	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
18	1	albino	....	....	....	....	....	....	....	....	....	....	....	14	11	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
19	....	....	....	....	....	....	....	....	....	....	....	....	....	....	16	9	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	17	8	....	....	....	....	....	....	....	....	....	....	....	....	....	....
21	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	3	20	2	....	....	....	....	....	....	....	....	....	....	....	....
22	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	22	2	....	....	....	....	....	....	....	....	....	....	....
23	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	24	1	....	....	....	....	....	....	....	....	....	....

Discarded Sept. 28, 1928. Eight apparently good seeds replanted; 1 up 10-28-28, 1 up 11-18-28, 1 up 1-10-29, 1 up 2-13-29, 1 up 2-18-29, and 1 up 2-23-29

In discussing the results of the dormancy study, the data will be grouped in tables giving the percentage germination at 10 days after planting.

Table II.—Trebi Barley Harvested July 24, 1928.

Planted Days After Harvest	Total Percentage Up, Days After Planting										
	10 days	11-20	21-30	31-50	51-90	91-130	131-170	171-210	211-250	251-290	291-330
0- 3*	2	37	52	72	81	....	....	....	....	....	....
4- 7*	14	40	50	67	72	....	....	....	76	77	78
8-11*	39	58	65	74	78	80	....	81	83	87	....
12-15*	39	54	66	78	81	82	84	85	88	91	....
16-19*	27	48	56	65	67	....	....	....	....	69	70
20-23**	32	45	52	57	....	....	....	....	....	....	....
24-27**	58	77	....	79	....	....	....	....	....	....	....
28-31**	94	98	....	....	....	....	....	....	....	....	....
32-35**	95	96	98	....	....	....	....	....	....	....	....
36-39**	98	....	....	....	....	....	....	....	....	....	....
40-43	100	....	....	....	....	....	....	....	....	....	....
44-47	99	....	....	....	....	....	....	....	....	....	....
48-51	96	99	....	....	....	....	....	....	....	....	....
52-55	98	100	....	....	....	....	....	....	....	....	....
56-59	100	....	....	....	....	....	....	....	....	....	....
60-62	100	....	....	....	....	....	....	....	....	....	....

*Planting discarded 353 days after harvest, one seed still apparently sound, not replanted.

**Planting discarded 66 days after harvest, 14 seeds apparently sound, of which 13 were up between 8 to 286 days after planting.

Normal germination, 200 seeds planted 124 days after harvest 99.5 percent.

WHEAT

Tests were made on the 1929 and 1930 crops of winter and spring wheat. The results of the 1929 test are given in Table III. Marquis No. 1—a selection made at Fort Collins—shows dormancy for a 10-day period after harvest. Kanred, Federation and Kubanka, however, show a high germination immediately after harvest. These data agree with the field observation of 1930 for Marquis and Kanred. Kanred sprouted very badly in the field, some of the check rows sprouted in the head before harvest. These check rows, however, were ripe and had been standing several weeks after the yield rows were harvested. Marquis, however, showed little sprouting in the shock and none in the standing grain. Standing rows of Federation sprouted badly in the field.

The results of the 1930 test are given in Table IV.

The data in Table IV agree very well with the results of the 1929 study. Marquis again shows a dormant period of about 10 days. Kanred and Federation again show a high germination immediately after harvest. Winter Club, a medium hardy, soft, red

Table III.—Germination of Wheat Varieties Grown at Fort Collins in 1929.

Planted Days After Harvest	Germination Percentage in 10 days			
	Marquis July 31	Kanred July 31	Federation July 31	Kubanka August 4
0- 3	4	58	88	93
4- 7	22	77	98	90
8-11	41	76	97	91
12-15	72	82	79	96
16-19	86	86	99	97
20-23	99	94	92	95
24-27	99	84	96	95
28-31	100	91	93	92
32-35	100	98	97	97
36-39	100	100	100	....
Normal*	100	100	100	97

*Normal germination—germination percentage of 200 seeds tested after storage for over 100 days after harvest.

Table IV.—Germination of Wheat Varieties and Species Grown at Fort Collins in 1930.

Planted Days After Harvest	Germination Percentage in 10 days						
	Marquis July 27	Kanred July 21	Federation July 27	Winter Club July 14	Bearded W. Spelt July 21	Black W. Emmer July 21	Einkorn Aug. 1
0- 3	1	84	83	76	25	36	11
4- 7	25	68	89	93	52	33	38
8-11	48	70	95	78	87	34	95
12-15	82	84	98	76	98	51	99
16-19	90	95	100	71	100	84	98
20-23	96	99	99	87	100	98	97
24-27	90	99	99	92	100	97	99
28-31	99	97	98	91	....	99	97
32-35	100	99	100	95	....	....	98
36-40	100	100	99	99	....	....	....
Normal*	99	99.5	97.5	96.5	100	100	99.5

wheat, similar except in color and winter habit to Little Club, also germinates immediately. Bearded Winter Spelt shows some dormancy but germinates readily after being kept for 7 days before planting. Black Winter Emmer seems to have a slight dormancy for about 15 days. After this, the germination percentage rises very rapidly. Einkorn shows a slight dormancy at first, but germinates readily after being kept for 7 days. The latter three varieties were sown with the hulls on the grain.

A preliminary test was made to determine the inheritance of dormancy. One F_1 hybrid—Marquis x Federation—was tested. The results obtained are shown in Table V.

This test, while only preliminary, indicates that dormancy may be inherited. The F_1 resembles more nearly the Marquis parent indicating that dormancy is dominant over lack of dormancy. However,

Table V.—Germination Percentage of F1 Hybrid Wheat, 1930.

Planted Days After Harvest	Germination Percentage								
	10 days			15 days			20 days		
	Marquis	Hybrid	Federation	Marquis	Hybrid	Federation	Marquis	Hybrid	Federation
0- 3	1	16	83	5	25	94	11	39	99
4- 7	25	21	89	38	39	98	53	61	99
8-11	48	47	95	70	71	100	78	81	....
12-15	82	78	98	91	87	....	94	88	....
16-19	90	92	100	92	93	....	93	94	....
20-23	96	93	99	98	95	100	....	97	....
24-27	90	86	99	96	98	99	97	99	....
28-31	99	98	98	....	....	....	....	....	....
32-35	100	100	100	....	....	....	....	....	....
36-39	100	100	99	....	....	....	....	....	....
Normal*	99	98	97.5	....	....	....	....	....	....

*Normal germination—germination percentage of 200 seeds tested after storage for over 100 days after harvest.

further work is necessary before definite conclusions can be drawn.

CONCLUSIONS FOR WHEAT.—Marquis wheat shows some dormancy for the first 10-day period after harvesting. Kanred wheat, however, germinated as soon as it was ripe enough to cut with a binder. Kubanka, a durum wheat, also seems to have no rest period. Federation, a soft white wheat, also germinates immediately. Winter Spelt, Emmer and Einkorn show a slight dormancy but less than Marquis.

BARLEY

In discussing the barley studies, they will be grouped into 6-rowed and 2-rowed varieties. Studies were made with barley in 1928, 1929 and 1930. Table VI presents the data obtained from the 1928 studies with 6-rowed barley. Colsess, Trebi and Lion seem to have a dormant period of about 25 days. In the group planted 10 days after harvest, the number of seeds germinating in 10 days was very small.

Manchuria has a much shorter period of dormancy. It germinates readily 7 days after harvest. Of the 6-rowed compact-head types, Arlington Awnless shows considerable dormancy but Bark germinates almost immediately. Both of the naked barleys—Nepal and Himalaya—germinate immediately after planting.

When we consider the 2-rowed barleys, Table VII, we find very little dormancy in any of the varieties. Hanna, a 2-rowed covered barley, has a slight dormancy period, lasting for about 7 days after harvest. Smyrna shows about the same condition. Canada Thorpe, however, germinates immediately after harvest. Of the naked barleys, *Hordeum deficiens nudideficiens* shows a slight dormancy for an 11-day period while *Hordeum distichon nigrinudum* germinates immediately.

Table VI.—Germination Percentage of Barley Varieties Harvested in 1928.

Planted Days After Harvest	Percentage Germination in 10 days							
	Colsess July 28	Trebi July 24	Lion July 24	Manchuria July 24	Arlington Awnless July 12	Bark Aug. 3	Nepal July 19	Himalaya July 19
0- 3	6	2	1	2	14	43	61	60
4- 7	3	14	3	27	13	72	69	75
8-11	14	39	61	94	19	96	87	86
12-15	43	39	30	92	14	100	99	97
16-19	49	27	49	96	26	100	100	99
20-23	17	32	81	....	45	....	....	....
24-27	35	58	95	....	69	....	....	....
28-31	42	94	99	....	50	....	....	....
32-35	75	95	100	....	68	....	....	....
36-39	82	98	99	....	76	....	....	....
40-43	88	100	....	....	88	....	....	....
44-47	86	99	....	....	97	....	....	....
48-51	89	96	....	....	....	....	....	....
Normal*	83	99.5	99.5	100	....	100	100	....

*Normal germination—germination percentage of 200 seeds tested after storage for over 100 days after harvest.

Several varieties were tested with more than one season's crop. Colsess barley shows the same trend for the 3-year test, 1928 to 1930, inclusive.

There is a slight variation between the different years but evidently there is a resting or dormant stage after harvest in Colsess barley for the first 20 days after harvest. A similar relationship was found between the germination percentage of *Hordeum distichon nigrinudum* in 1928 and 1929.

CONCLUSIONS FOR BARLEY.—The data presented above indicate that there is a dormancy period in some barley varieties. The period, however, varied with different varieties. Colsess, Trebi, Lion and

Table VII.—Germination of Two-rowed Barley Varieties Harvested in 1928.

Planted Days After Harvest	Germination Percentage				
	Hanna July 24	White Smyrna July 24	Canada Thorpe Aug. 3	H. def. nudideficiens July 20	H. dis. nigrinudum Aug. 11
0- 3	5	18	92	38	88
4- 7	31	38	98	45	92
8-11	83	70	100	52	92
12-15	89	77	98	70	96
16-19	91	68	....	75	96
20-23	99	73	....	84	....
24-27	95	84	....	88	....
28-29	94	94	....	88	....
32-35	....	100	....	87	....
36-38	....	100	....	90	....
Normal*	100	100	100	90	97

Table VIII.—Germination Percentage of Colsess Barley—10 Days After Planting.

Planted Days After Harvest	Germination Percentage		
	1928	1929	1930
0- 3	6	12	6
4- 7	3	21	9
8-11	14	33	14
12-15	43	22	17
16-19	47	27	12
20-23	17	66	25
24-27	35	93	39
28-31	42	91	72
32-35	75	87	80
36-39	82	89	67
Normal*	83	100	100

*Normal germination—germination percentage of 200 seeds tested after storage for over 100 days after harvest.

Arlington Awnless have a dormancy period of about 20 days after harvest. Manchuria, Bark, Nepal and Himalaya germinated immediately after harvest. There seems to be little dormancy in the 2-rowed varieties tested. Hanna, Smyrna and *Hordeum deficiens nudideficiens* show a slight dormancy 7 days after harvest. Canada Thorpe, and *Hordeum distichon nigrinudum*, however, show a high germination percentage when planted immediately after harvest.

OATS

Three types of oats were tested—a midseason type; Colorado 37; an early white oat, Nebraska 21; and a red oat, Kanota. There seemed to be little, if any, dormancy period in the Colorado 37 and Nebraska 21 oats. Both of these oats belong to a species *Avena sativa*. Kanota oats (*Avena byzantina*), shows considerable dormancy. In the test made, it did not germinate readily for a period of over 40 days. The number of days left in moist sand seemed to have little effect on Kanota. The test shows less than 10 percent germination for the oats planted up to 23 days after harvest and left in moist sand for 130 days. The dormancy studies agree well with the observations in the field in 1930. Both Colorado 37 and Nebraska 21 sprouted badly in the shock. Kanota showed very little sprouting in the shocked grain.

CONCLUSIONS FOR OATS.—There is considerable dormancy in Kanota oats (*Avena byzantina*) but little, if any, in the types of *Avena sativa* tested. The test agrees with field observations regarding sprouting in the shock. Both Colorado 37 and Nebraska 21 sprout readily in the shock under unfavorable weather conditions.

RYE

One test was made with winter rye. When Rosen rye was planted immediately after harvest, little dormancy was noted in grain planted 7 days after harvest.

Table IX.—Germination Percentage of Oat Varieties Tested in 1930.

Planted Days After Harvest	Germination Percentage at 10 days		
	Kanota July 14	Nebraska 21 July 21	Colorado 37 August 12
0- 3	1	66	52
4- 7	0	44	58
8-11	0	34	80
12-15	2	56	89
16-19	1	79	92
20-23	3	94	94
24-27	11	99	100
28-31	28	92	....
32-35	35	100	99
36-39	5	99	94
40-43	27	....	....
44-47	92	....	....
48-51	97	....	....
52-55	96	....	....
56-59	98	....	....
60-63	100	....	....
64-67	100	....	....
Normal*	100	99.5	99

DISCUSSION

The data presented agree very well with observations in the field. In 1930 several varieties were grown in plats at Fort Collins and the shocked grain was subjected to an abnormal rainy period in August, combined with high temperatures. During the entire period, August 4 to 15, the shocks did not thoroly dry out. Considerable sprouting was noticed on Kanred and Kubanka wheat, Colorado 37 and Nebraska 21 oats. Very little sprouting in comparison was found in Marquis wheat and Kanota oats. The greenhouse tests, while showing the presence of a dormant period after harvest, were made with uniform moisture conditions. The effect of wetting and drying of seeds was noted in Nebraska 21 and Colorado 37 oats. After drying, dormant seeds were induced to germinate. This latter behavior may have some influence on sprouting in the shock. Temperature relations are also important and require further study in relation to dormancy and sprouting in the shock.

In the studies it was noted that there was a very marked break in the dormancy of Marquis seeds 40 days after harvest, regardless of the time they had been in moist sand. All of the dates showing dormancy showed a high emergence about this date. Similar results were found in the 1929 and 1930 tests.

Some seeds from the following varieties were found to emerge after being in moist sand for over 100 days. Coast, Colsess, Trebi, Nepal, Himalaya, *Hordeum deficiens nudideficiens*, White Smyrna, Hanna, Manchuria, Lion, Bark and Arlington Awnless barleys; Mar-

quis wheat, Colorado 37, Nebraska 21 and Kanota oats. The studies indicate the possibility that a total failure of the crop in one season might not necessarily cause the disappearance of the variety since seeds have retained their viability in moist sand for over 500 days in some cases.

SUMMARY

Germination studies were carried out to determine if there was a dormant period immediately after harvest in many of the small-grain varieties grown in Colorado.

Wheat, barley and oat varieties were harvested when ripe enough to be cut with the binder. Some of the seeds were hard, the bulk of the seeds were in the hard-dough stage.

The percentage of seeds germinating in 10 days after planting in moist sand was used to determine if there was a dormant period after harvest.

By this method, Marquis showed considerable dormancy for the first 10 days. Kanred, Kubanka and Federation showed a high germination when planted immediately after harvest.

Winter Emmer, Winter Spelt and Einkorn showed slight dormancy, but less than Marquis.

One F_1 hybrid of Marquis x Federation indicated that dormancy might be an inherited character. Dormancy seemed to be dominant.

In 6-rowed barley, Colsess, Trebi, Lion and Arlington Awnless had dormant periods of about 20 days after harvest.

The hulless 6-rowed barleys, Nepal and Himalaya and the hulled 6-rowed barley, Manchuria, had a high germination immediately after harvest.

Of the 2-rowed barleys, Hanna, Smyrna and *Hordeum deficiens nudideficiens* show slight dormancy up to 7 days after harvest. Canada Thorpe and *Hordeum distichon nigrinudum*, however, show a high percentage of germination when planted immediately after harvest.

Colorado 37 and Nebraska 21 oats germinate immediately after harvest and also sprout badly in the shock under unfavorable weather conditions.

Kanota has a long dormancy period after harvest and resists sprouting in the shock.

The results of the above study indicate that there is a difference in the dormancy period after harvest in different varieties. There is also some indication that there is a relationship between the length of the dormancy period and resistance to sprouting in the shock under favorable conditions.