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Kansas State Agricultural College
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**DETERIORATION OF RED TEXAS
OATS IN KANSAS.**



Pure lots of Red and Black Oats, planted in alternate rows, of twenty each.

By

H. F. ROBERTS AND GEO. F. FREEMAN.

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THE DETERIORATION OF RED TEXAS OATS IN KANSAS.

By HERBERT F. ROBERTS and GEORGE F. FREEMAN.

SUMMARY.

1. *Red Texas oats tends to "run out" after two years' growing in Kansas, giving way to a black variety, the seed of which always appears in seed of the red sort imported from Texas. In the latter state, the black-seeded plants are present, but do not supplant the red sort, as in Kansas.*

2. *The two varieties are distinct; the red sort is low and spreading, tending to "stool," and with narrower leaves than the black variety, which is upright, broad-leaved, and "stools" but little.*

3. *In nursery plots, the red oats averages 8.6 culms per plant; the black, 7 culms per plant. The red oats ripens a week the earlier of the two.*

4. *In respect to head characters, the red variety is superior in the nursery plots by 54 per cent., while the black sort is superior in average number of spikelets per head (83 per cent.), average number of heads per plant (19 per cent.), average weight of each spikelet (20 per cent.), and average total weight of spikelet per plant (43 per cent.).*

5. *In mixtures of seeds in proportions of 25, 50 and 75 per cent. of red to black oats, planted under usual field conditions, the harvest gave a total average superiority to the black oats in number of bearing heads of 6 per cent. and in weight of grain of 8 per cent. In each case the black oats increased in the mixture.*

6. *Pure lots of black and of red oats grown in forty alternate rows, and sown as is customary in the field, gave a harvest which, on the acre basis, would have yielded 1740 pounds of straw and 19.4 bushels of grain for the red, and 3000 pounds of straw and 47 bushels of grain for the black variety.*

7. *Close-pollinated plants of each sort yielded seed which came true indicating no "sporting" of one variety from the other.*

We conclude, (1) That, while the black oats is superior in yield under carefully controlled conditions, under average farm conditions its "shattering" tendency, the results of which its earlier ripening period would accentuate, would reduce its yield as the practical experience of farmers' reports, below that of the red variety. (2) That the black oats is an admixture in imported seed, that it does not originate from the red variety, and that pure-bred red oats free from the black seed can be grown.

The Department of Botany of the Kansas State Experiment Station is growing such pure-bred seed from close-pollinated plants.

AFTER the Red Texas variety of oats has been grown in this state for two or three years, it apparently becomes replaced by a sort having black chaff, said to be inferior in yield and quality to the other. This phenomenon seems to be almost universal throughout the state, and involves the constant repurchase of the red oats variety from original Texas sources.

One sample submitted to the Botanical Department for experiment came from a farmer who had taken the seed from a crop which had grown the second year in Kansas. A count of the number of black and of red-hulled kernels gave 39 per cent. and 61 per cent. as the proportion of the two sorts, respectively, in the mixture. A portion of the original sample of mixed seed was separated into lots containing the two varieties and consisting of 2309 grains of black and 1486 grains of red oats, which were sown thinly in separate rows for each sort.

The purpose of this planting was to ascertain the behavior of each variety under conditions not very different from those obtaining in the field. At the same time a similar planting was made of the original mixed lot, sown as thickly as is customary in the field. It was expected in this plot to discover which variety, if either, suffered the most in the struggle for existence among the roots and stems, carried on under average field conditions. Unfortunately, the plants in this latter plot were subsequently destroyed by an accident.

The outcome of the study of the stooling capacity of the black and red oats, however, as sown thinly in separate rows, gave some interesting results. The following table shows the plants of the two varieties which came through to harvest,

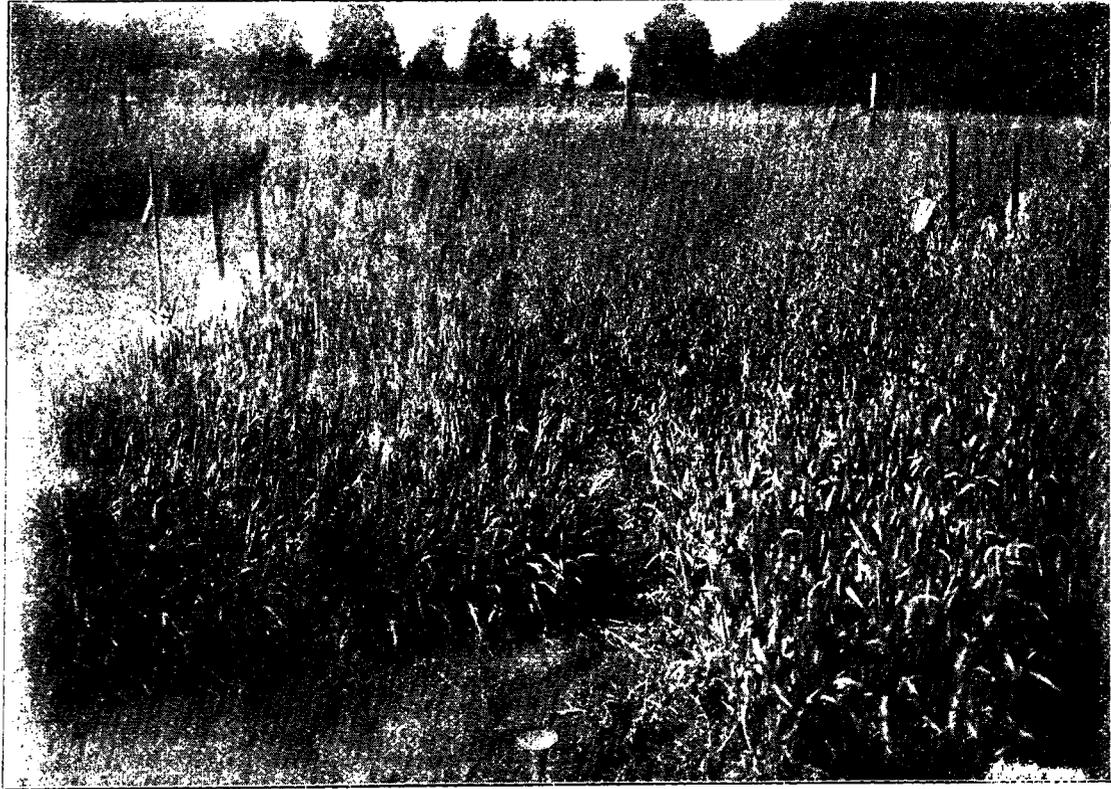


PLATE I. Nursery plot of BLACK OATS (right) and RED OATS (left). These plots are growing from seed separated from a mixture received from a farmer. Note the taller growth of the Black variety.

tabulated with respect to the number of culms produced per plant:

TABLE I. Stooling capacity of Black oats.

No. culms per plant.....	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	24
No. of plants..	4	7	15	15	13	17	17	10	9	9	6	3	2	1	5	3	1	1
Totals.....	4	14	45	60	65	102	119	80	81	90	66	36	26	14	75	48	17	24

Grand total, 966.
 Total average number of culms per plant, 7.

TABLE II. Stooling capacity of Red Texas oats.

No. culms per plant.....	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	21
No. of plants..	1	6	13	7	7	19	15	12	7	9	4	11	7	6	5	3	2	2	1	3
Totals.....	1	12	39	28	35	114	105	96	63	90	44	132	91	84	75	48	34	36	19	63

Grand total, 1209.
 Total average number of culms per plant, 8.6.

As a result of the above tabulation, it will be seen that 138 plants of the black variety bore 966 culms, or an average of 7 culms per plant; while an approximately equal number of the plants of the red variety (140) produced 1209 culms, or an average of 8.6 (virtually 9) culms per plant.

The interest attached to this problem increases if we transfer our attention to another experiment conducted at the same time. From a second lot of mixed red and black oats which had been secured, similar separations were made, and the red and black varieties were planted separately April 11, 1906, in nursery plots, standing one plant in each hill, and with hills 4 x 6 inches apart. (See plate I.) The total number of seeds planted in this manner was 5970, from which a total stand of 4546 plants (76 per cent.) was secured. Of the seeds planted, 3090 were black, and produced a stand in the nursery plots of 2429 plants, or 78 per cent. From the 2880 seeds of the red variety which were planted, was obtained a stand of 2117 plants, or 74 per cent. Whether the slight advantage of 4 per cent. in the germination of the plants in the field, in favor of the black variety, is an index to usual conditions, cannot, of course, be surmised without an extended series of tests.

From the outset, or soon after the development of the third or fourth leaf, a marked difference in the habit of growth between the plants of the two varieties was observed, both in the rows and in the nursery plots. In the plants of the red sort, the leaves were narrower, and the young stems were spread out flat upon the ground, after the well-known manner of the Tur-



PLATE II. BLACK OATS. Nursery plot, near view.

key type of winter wheat. (Plates III and V.) The black oats, on the other hand, with broad leaves, sent up erect stalks from the beginning, so that the appearance of the two stalks in the field was strikingly different, as will readily be seen by reference to the accompanying figures. (Plates II and IV.) Plants of the black variety stood six inches high at a time when the red oats had not reached a height of more than two or three inches. That this difference was associated with a greater stooling capacity in the red oats was anticipated, and the results verified the expectation. The difference in habit just mentioned was further associated with a difference in the time of ripening. The nursery plots of both varieties were planted on the same date, April 11. The red variety was but 25 per cent. in head on June 15, while the black oats were nearly in full head. On June 22 the black oats had come into full head, became ripe July 15, and were harvested on July 17; while the red oats came into full head June 26, were ripe July 21, and were harvested July 23, making a total period of 95 and 101 days from the planting to the ripening of the seed for the black and for the red oats, respectively; a difference of nearly a week in point of earliness in favor of the black variety.

Before the heads had escaped from the "boot," plants of both the red and the black sorts were sacked to prevent the possibility of cross-pollination, and the ripened close-fertilized seed obtained in this way was saved for the continuance of the experiment.

At maturity, all of the plants from each of the nursery plots were carefully pulled and taken to the laboratory for critical study. It was found at once that there was a difference in habit in the heads of the two sorts. The panicles of the black oats were seen to be loose and spreading, bearing the spikelets on long ray-branches, while the heads of the red variety were characteristically more compact, bearing the spikelets on shorter rays of more nearly uniform length. The spikelets themselves (the commercial "seed" of oats) showed characteristic differences as well. The enclosing glumes or chaff of the red oats spikelets were seen to hold the florets of the spikelets closely enwrapped within, so that the latter were not easily to be freed from them by loose rubbing between the hands, as was the case with the black oats, in which at maturity the chaff becomes loosened from the spikelet and curls back, exposing the florets.



PLATE III. RED OATS. Nursery plot, near view.

It was also observed that, as a whole, the spikelets were more firmly attached to the stalks in the red oats than in the black variety, a distinct pull being necessary to release them from the rays in the case of the former, while the spikelets of the black oats fell off almost at a touch.

The individual florets, or grains, with their enclosing glumes, were, as a whole, shorter and plumper in the case of the red than in the case of the black oats, but it was found that there was every possible variation and intergradation in form between the two types in this respect.

All of the nursery-plot plants of each of the two supposed varieties were subjected to a careful statistical study with respect to the number of heads per plant, the number of spikelets per head, and the weight of the spikelets. The results are given in the following tables:

TABLE III Comparative table of head characters.

	Number of plants counted.....	Total No. of bearing heads.....	Total No. of spikelets.....	Total wt. of spikelets, grams.....	Average No. of heads per plant.....	Average No. of spikelets per head.....	Average No. of spikelets per plant.....	Average wt. of each spikelet, grams.....	Average total wt. of spikelets per plant, grams.....
Red.....	223	906	14,227	491.16	4	15.7	62.8	0.0845	2.17
Black.....	143	374	10,767	145.77	2.6	28.78	74.88	0.0414	3.10
Percentage of superiority:									
Red.....					54.				
Black.....						83	19	20	43

Recalculating and arranging the results for the red oats on the basis of the same number of plants as were counted for the black variety (143), the differences are perhaps more strikingly represented:

TABLE IV.

	Number of plants.	Total No. of heads.	Total No. of spikelets.	Total weight of spikelets, grams.
Red.....	143	572	8,980	309.81
Black..	143	374	10,767	445.766
Percentage of superiority:				
Red.....			58	
Black.....				20 44

The experiment thus far leaves us in a peculiar quandary. We start out with the general popular assumption that the Red Texas oats is superior, and that the black sort which appears in its midst is inferior, and yet the statistical evidence seems to point to the superiority of the black variety in every essential point except stooing capacity, which, of course, involves the number of heads borne per plant. In the number of spikelets per head, and the number of spikelets per plant, the weight of the spikelets, individually and for the entire plant, the black oats is superior. In fact, in table IV, in which the results are calculated for an identical number of plants for the two sorts, we find a superiority of 53 per cent. for the red oats in stooing capacity, *i. e.*, in the total number of heads; but we find, on the other hand, a superiority of 20 per cent. and 44 per cent. for the black oats in total number of spikelets and total weight of spikelets, respectively; which means, in an agricultural sense, a superiority in bushels per acre. Now, it may be that the number of plants studied are too few for the computation of correct averages, but the extremely wide differences in the tabulated results for the two varieties make it appear improbable that we are dealing with other than two forms fundamentally very different in their characters and capacities.

It will be noticed that the wide advantage of the red oats in stooing capacity, as shown in the nursery plots, is materially cut down when the plants are grown under approximately field conditions, as is shown in tables I and 11, in which the superiority of the red variety over the black amounts to but 23 per cent.

In 1907 the experiments were continued in such a way as to test the degree and rate of change from red to black oats in the variety plots. From pure seed grown in 1906, 8767 grains of black and 8300 grains of red oats were carefully separated by hand, only the largest grains of each spikelet being taken. From these pure lots, artificial mixtures were made up in proportions of 25, 50 and 75 per cent. of the two varieties, as follows :

TABLE V.

Lot No.	Per cent. of red oats in mixture.	No. grains red oats.	No. grains black oats.
1	75	3,800	1,267
2	50	3,000	3,000
3	25	1,500	4,500

These different mixtures were sown in rows twelve inches apart, and to the usual thickness, on March 30, 1907, and a good stand had appeared on all the plots by April 8. The results of this experiment are shown in the following table, in which it will be seen that there were four plots of the 25 per cent. proportion of red oats, three of the 50 per cent. and three of the 75 per cent. mixture:

TABLE VI. Results from sowings of definite mixtures of Black and Red oats.
Red oats seed in original mixture sown, 25 per cent.

Plot No.	Total wt. of sheaf, grams.....	No. of bearing culms in sheaf.		Per cent. of bearing culms to total No. harvested.		Total percentage stooling superiority of black variety.....	Weight in grams of oat culms.....	Weight in grams of grains from red oat culms.....	Per cent. of total seed harvested.		Weight of grain: per cent. superiority in yield of black oats.
		Black.....	Red.....	Black.....	Red.....				Black.....	Red.....	
1.....	2,070	775	139	85	15	10	837.10	34.20	91	9	16
2.....	1,985	916	197	82	18	7	217.20	30.00	83	12	13
3.....	1,985	742	197	79	21	4	258.30	50.10	84	16	9
4.....	2,920	838	205	80	20	5	308.70	46.10	87	13	12
Total av.....	2,240	818	185	82	19	7	280.32	40.10	87	13	11

Red oats seed in original mixture sown, 50 per cent.

1.....	3,189	703	531	57	43	7	241.80	176.00	58	42	8
2.....	3,204	678	560	55	45	5	223.25	136.70	63	37	13
3.....	3,161	718	674	52	48	2	233.55	210.30	53	47	3
Total av.....	3,185	700	588	55	45	5	234.53	174.33	58	42	8

Red oats seed in original mixture sown, 75 per cent.

1.....	2,005	478	768	38	62	13	97.00	144.00	40	60	15
2.....	2,687	855	870	29	71	41	78.90	211.90	27	73	2
3.....	2,410	301	804	27	73	2	93.55	267.40	26	74	1
Total av.....	2,351	378	814	31	69	6	90.00	208.00	31	68	6

Total average superiority of black oats in number of bearing heads, 6 per cent.
Total average superiority of black oats in weight of grains, 8 per cent.

From the above table it will be seen that in the number of bearing stalks, and in weight of grain produced, the black oats surpassed the red variety. The facts may be summarized as follows:

TABLE VII.

	Lot 1.	Lot 2.	Lot 3.
Proportion of black oats sown.....	75%	50%	25%
Percentage of black oats stalks in the ripe stand.....	82%	55%	31%
Percentage weight of black oats seed in total harvested.....	87	58	31
Proportion of red oats sown.....	25	50	75
Percentage of red oats stalks in the ripe stand.....	19%	45%	69%
Percentage weight of black oats seed in total harvested.....	13	42	69

The results from table VI would seem to contradict the results of the experiments for 1906, in which the red variety was found to exceed the black in the number of stalks produced per plant by 54 per cent. It must be remembered, however, that the plants in table VI were not counted separately. Where cereals grow in the usual way in the field, it is an impossibility, in most cases, to separate the individual plants with any certainty. In the plots of 1906, summarized in tables III and IV, all of the plants were grown in nursery plots, and were easily separated. The method followed in the experiment reported in table VI was necessarily different. The plants in the plots were cut, and the sheaves taken to the laboratory, where the bearing stalks of red and black oats, respectively, in the mixture were distinguished by examination of each separate head in turn. Of course it is impossible to say whether the results for 1907 from seed sown in the customary field rows support the results for 1906 or not in respect to the inferior stooling capacity of the black oats. The evident fact of the production of a proportionately greater number of bearing stalks in each mixture certainly goes far to corroborate the results from the sowing of the two varieties in separate rows in 1906 (tables I and 11), in which the superiority of the red variety in respect to the number of bearing culms per plant, which was 54 per cent. when the plants were grown in nursery rows, was cut down to 23 per cent. when grown under average field conditions.

In the 1907 experiments, in which the red and the black varieties were mixed together in the same row, instead of being grown in separate rows as in 1906, the red oats seem to have been completely surpassed by the black variety, which has a total average superiority of 6 per cent. for all the plots in the experiment in respect to the total number of bearing strains.

A second experiment was undertaken as follows, to test further the relative yield of the two varieties. Pure lots of red and of black oats were taken from the nursery plots of 1906 and planted in alternate rows. The entire plot contained, in all, forty rows, each thirty feet long, in an alternating series comprising twenty of each variety and standing twelve inches apart. In these rows the seed was sown as thickly as is usual in the field. (See plate VI.)

The results of this experiment are embodied in the following table:

TABLE VIII. Comparative yield in total straw and grain and in grain alone of Red and Black oats grown in separate alternate rows.

Red Oats.			Black Oats.		
Row No.	Wt. of straw and gram grams.	Wt. of grains alone, grams.	Row No.	Wt. of straw and gram, grams.	Wt. of grains alone, grams.
1	694.56	168.5	2	1,304.08	453.0
3	609.51	187.2	4	1,516.70	535.0
5	538.64 (1)	100.2	6	1,204.85	454.5
7	694.56 (2)	160.7	8	1,289.90	437.5
9	595.34 (1)	109.5	10	1,304.08	475.5
11	850.49	216.0	12	1,417.48	513.2
13	765.44	248.2	14	1,374.95	507.5
15	524.47 (3)	33.5	16	1,417.48	503.5
17	453.59	64.0	18	1,204.85	431.5
19	921.36	343.5	20	1,445.83	559.5
21	779.61	287.0	22	1,275.73	482.7
23	893.01	190.2	24	1,445.83	470.2
25	737.09 (1)	116.2	26	1,530.87	475.5
27	751.26	171.5	28	1,587.57	506.7
29	609.51	186.0	30	1,119.81	318.5
31	978.06 (4)	257.5	32	1,176.50	306.0
33	680.39 (1)	162.7	34	1,559.22	522.5
35	1,006.41	297.7	36	1,289.90	330.5
37	807.96	121.7	38	1,275.73	394.2
39	722.91 (5)	71.5	40	2,012.82	647.5
Average.	730.71	194.97	Average.	1,387.71	463.2

1. Badly injured. 2. Slightly injured. 3. Weight of straw only; grain practically all destroyed. 4. Very slightly injured. 5. Rather badly injured.

NOTE.—omitting rows Nos. 15, 17, 39, the injury referred to above was due to mice in the granary.

From the above table the superiority of the black oats in the struggle for existence stands forth as a sharp and evident fact, confirming the results obtained from the plots of the mixed grains, as shown in tables VI and VII; of the thinly planted rows of the varieties in tables I and II; and of the nursery-plot test in tables III and IV.

In table VIII, in other words, we see, side by side, the exact results that would come from growing on a large scale fields from seed of the two sorts respectively. In each case, the black oats is seen to excel the red variety in amount of straw and in weight of grain produced by equivalent stands in equal lengths of row.

The differences exhibited in table VIII, calculated in terms of pounds of straw and bushels of grain to the acre, would read as follows:

	Straw, pounds per acre.	Threshed grain, bushels* per acre.
Average, red variety.. .. .	1,740	19.4
Average, black variety.	3,000	47.0

* Thirty-two pounds to the bushel.

There can be no denying the fact that all of the experimental evidence proves conclusively that in point of yield, both of straw and of thrashed grain, the black variety that appears constantly in the commercial seed of the Red Texas oats is, *under experimental conditions*, the superior sort.

Now to the *practical* fact, recognized and maintained by the farmers and seedsmen, that the *Red Texas variety is superior, is the more desirable of the two, and as a matter of practical experience yields better.*

So far as the relative feeding value of the two varieties is concerned we are not prepared to speak.

In respect, however, to the question of yield, we believe that our experiments offer a valid explanation. It has been noted above that the seed-bearing spikelets of the black oats are very weakly attached to their stalks. This would mean, in an agricultural sense, that the black oats would "shatter" badly in harvesting, which would result in a lower yield of grain from the black than from the red variety, and would lower the yield per acre in those fields that contained considerable admixtures of the black oats.

That such was not the case in experiments conducted on our plots was due to the fact that each row was carefully reaped by hand immediately after ripening, so that the loss which would occur in ordinary farming operations was avoided. The fact, however, that the black oats ripens about a week before the red variety would give additional opportunity for the shattering of its grain by the time the field as a whole would be ready to cut under ordinary farming operations.

As to the reason for the fact that in the field the black oats finally supplants the red variety, if this be not entirely answered by the fact of the superior yield from seed of the black sort, it may be further explained by the differences in the habit of growth of the two varieties. As has been stated, the black oats has an upright habit from the outset, while the red sort is low and spreading. In a mixed culture the black oats would tend to shade and "smother out" many of the intermingled plants of the red variety, during the time that the leaves and stems of the latter lay prostrate upon the ground in the "rosette" stage. The necessary amount of light being excluded from the low-lying "red" plants, assimilation is retarded, root growth is consequently checked, and, as a final result, we have a diminished number of bearing stalks. Add this result of



PLATE IV. BLACK OATS. Single plant. Note upright habit of the plant and absence of any "stooling" tendency.

shading and overcrowding, and we have an ample explanation of the manner in which the struggle for existence takes place between the two kinds in the field, as attested by the practical experience of farmers, and as exemplified by our experiments with definite mixtures, the results of which have been given in tables VI and VII.

Finally, we have to deal with the fundamental question, Whence does the black variety come?

So far as our information goes, it appears that the original Texas seed possesses the black variety as a constituent. From the Texas Seed and Floral Company, of Dallas, Tex., we have the statement that, for some unknown reason, the black variety appears in fall-planted oats in Texas. They state further, however, that in Texas the proportionate amount of the black sort is never large, and that it does not greatly increase at the expense of the red sort.

The Barteldes Seed Company, of Lawrence, Kan., further informs the writers that the Red Texas oats, when shipped into this state, are ordinarily *almost* free from the black seed, but that the black sort almost invariably appears in the home-grown seed within a year or so. The samples which they submit, as well as those that farmers have sent in, clearly illustrate this fact.

We therefore have it as a well-defined fact that the black seed is *already present* in the original Red Texas oats as grown in that state, and presumably is present in small quantities (therefore overlooked) in the original shipments from Texas. For reasons unexplainable, except by means of experiments conducted on the spot, the climatic conditions in Texas where the red oats are grown do not seem to favor the development of the black variety as greatly as do the conditions in Kansas. For this reason, the Texas seed remains always comparatively pure when grown in that state, while in our region the black variety finally conquers in the struggle for existence.

The reasons for this survival have been sufficiently analyzed, and need not be recapitulated. There remains the practical question of the elimination of the black oats from our fields of the red sort. To determine whether this be possible, it was decided to grow pure isolated cultures of the two varieties by the "pedigree" method.

In the spring of 1906, a considerable number of plants of the two sorts, growing in nursery plots planted with selected "red"



PLATE V. RED OATS. Single plant. Note the prostrate, flattened habit of growth and tendency to form a thick clump or "stool."

and "black" seed, were enclosed within parchment-paper sacks just before the heads appeared from the "boot." In this way close-fertilization was secured, and all possibility of chance hybridization eliminated. But few of the offspring of these plants produced seed, owing to weather conditions at the time of ripening. The following table summarizes the results:

TABLE IX.
 Parent plant No. 1, Black variety.

Progeny plant No.	No. of bearing culms.	No. of spikelets.	Wt. of spikelets, grams.	Av. wt. of spikelets, grams.
1	2	31	0.173	0.0055
2	4	61	.220	.0036
3	6	128	.932	.0074
4	2	24	.164	.0068
5	2	44	.333	.0077
6	3	95	.923	.0097
Average,				0.0068

Parent plant No. 2, Red variety.

1	5	68	0.539	0.0079
2	3	74	.561	.0076
3	2	22	.135	.0061
4	2	8	.080	.0037
Average,				0.0063

Parent plant No. 3, Red variety.

1	2	8	0.038	0.0047
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From the above table it is seen that two pure-bred plants of the red, and one of the black sort, survived and produced progeny in 1907.

From the single black oats plant surviving from 1906 came six plants in 1907, which produced altogether 19 bearing heads with 383 spikelets.

From the two surviving original red oats plants of 1906 came 11 progeny in 1907, which produced altogether 14 bearing stalks with 180 spikelets.

Each "spikelet" of oats contains from one to two perfect seeds. We have therefore already the foundation of a pure-bred stock of red oats plants.

It should be stated that the close-breeding experiment had primarily in view the testing of the question as to whether the black oats was a "sport" or ("mutation" which was being thrown off by the red variety. It is well known that such a phenomenon occurs in plants; and, indeed, as Professor De Vries has shown, there are certain "ever-sporting" varieties of plants, which always, in each generation, throw off a certain propor-

tion of the sportive types. In the case of such varieties, no amount of "selection" or "rogueing" will ever result in eliminating this tendency.

None of the progeny of the red oats thus far include any of the black type. Should the progeny remain pure for one or two generations more, it may safely be assumed that the Red Texas oats is not an "ever-sporting" variety, and that the black sort does not originate *within* the red variety by sporting, but from without it by some original accidental admixture of seed in the Texas habitat.

Moreover, if our Red Texas cultures continue thus pure, we shall have in a very few years pure Red Texas oats seed for distribution, to replace the imported and domestic mixtures that are sold under the name of that variety.

FOLLOWING BULLETINS ARE AVAILABLE FOR DISTRIBUTION
 TO RESIDENTS OF KANSAS WHO DESIRE THEM:

- No. 12. . . . Preliminary Experiments with Fungicides for Stinking Smut of Wheat.
- No. 15. . . . Additional Experiments and Observations on Oat Smut.
- No. 17. . . . Crossed Varieties of Corn, Second and Third Years.
- No. 38. . . . Preliminary Report on Rusts of Grain.
- No. 46. . . . Rusts of Grain, II.
- No. 52. . . . Kansas Weeds—Preliminary Circular on Distribution.
- No. 54. . . . Experiments with Oats.
- No. 117. . . . Bacteria of the Soil.
- No. 120. . . . Tests of Forest Trees.
- No. 121. . . . Treatment and Utilization of Flood-damaged Lands.
- No. 122. . . . Blackleg and Vaccination.
- No. 123. . . . Crop Experiments in 1903.
- No. 127. . . . The Roots of Plants.
- No. 129. . . . Kansas Mammals in their Relation to Agriculture.
- No. 130. . . . Steer Feeding Experiment, VII—1903-'04.
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Address, CHARLES W. BURKETT, DIRECTOR,
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