How Wheats Behave In Competition With One Another

By L. R. WALDRON[2]

IN the experiments reported here, Dr. L. R. Waldron, Plant Breeder of this Station, has carried forward earlier studies on the extent to which the presence of an adjacent row of a different kind of wheat affects the yields of its neighbor row of another kind, or its same kind of wheat. In short, a strong, vigorously growing variety of wheat, bred for and specially adapted to the situation in which it was bred, will yield even better in competition with wheats not developed for that particular situation than it will when in competition with similar wheats developed for the same situation. Two groups of wheats, group "B", bred at Fargo and hence presumably especially well adapted to Fargo conditions, and group "A", bred elsewhere, were included in this study. Group "B" wheats did best when competing with the lower-yielding group "A" wheats, especially at the two earlier dates of seeding. On the contrary, group "A" wheats did best when not competing with the group "B" wheats, especially at the two earlier dates of seeding. The interested reader who goes through this article carefully will discover that Dr. Waldron has measured these different types of competitive effects in terms of yield (see Table 1), in number of heads per meter of row (see Tables 2 and 3), and in milling and baking behavior (see Table 4). As a practical conclusion to these studies, it is suggested that a wheat which can stand up under strong competition with other varieties is probably able to maintain its yielding capacity in competition with weeds, or other unfavorable conditions, better than a less vigorous wheat. Wheats apparently must be tested for their behavior under competitive conditions. The behavior of Selection No. 2849 among the "B" or Fargo wheats is noteworthy.

H. L. Walster Director

Effect upon heads per row and yield of grain in two groups of wheat grown as units and in competition.[1]

[1]Presented as a partial report of work done under project, Adams 10 B.

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The principal criterion in use at present at experiment stations in determining relative yields among close-drilled varieties of grain, wheat for example, is by using plots often of fortieth-acre size and a single width of drill. This method generally gives satisfactory results used as the last test for yield before a wheat is distributed as a new variety. This method disregards the interrelationship which may exist between varieties when planted closely enough together to result in possible competitive effects. If one variety suffers in yield when competing with another it may be affected adversely at times upon the farm when it is brought into competition with weeds or meets with adverse seasonal conditions.

EXPERIMENTAL RESULTS

In 1943 10 varieties were taken and put into 2 groups in an experiment to learn if competitive effects could be recognized. The varieties were as follows:

Group A

1. C.I.12044 H-44xThatcher[a]
2. C.I.12199 H-44xThatcher
3. Merit H-44xCeres
4. C.I.12053 MeritxThatcher
5. Regent H-44xReward

Group B

6. 2857 Ceres-Minn. Double Cross x Mercury
7. 2849 Ceres-Minn. Double Cross x Mercury
8. 3103 Ceres-Minn. Double Cross x Mercury
9. 3121 Ceres-Minn. Double Cross x Mercury
10. 3113 as above x H-44-Ceres

The first five varieties were handled as one group in comparison with the second five, the latter bred at the experiment station at Fargo. The experiment was divided into two phases with the two groups of wheat in one phase sown each as unit groups. In the other phase rows of the two groups alternated which brought the varieties of one group into immediate competition with those of the other so far as adjacent rows were concerned. If competition between the varieties of the groups exerted an undue influence a difference would be expected between the two differences separating the groups in the two phases of the experiment. The entire experiment was seeded at three dates April 17, May 3 and May 17. The 10 wheats were grown without guard rows except that protection rows separated one group from another where needed.

The yields for the two groups grown as units and in competition for the three dates are found in Table 1.

What Table 1 demonstrates:

(1) That the competitive effect of planting in alternate rows was strong at the two earlier dates of seeding but not so strong at the later date of seeding.

(2) That the "A" wheats (bred outside of North Dakota) yield better when planted as unit blocks of rows of "A" wheats only, so that the competition is only between different "A" wheats.

(3) That the "B" wheats (bred at Fargo) yield better when they are planted in alternate rows with the "A" wheats.

(4) That Selection No. 2849 of "B" or Fargo wheats is noteworthy in its behavior under competition.

[a]H-44 was crossed with Thatcher and then backcrossed twice to Thatcher.

Table 1—Shows average yields in bushels per acre of group A wheats and group B wheats under three different dates of planting and under planting as unit blocks of rows of A wheats and as unit blocks of rows of B wheats in contrast with planting A wheats and B wheats in alternate rows.

		A						B					
Seeded	Grown as groups	12044	12199	Merit	12053	Regent	Av.	2857	2849	3103	3121	3113	Av.
April 17	A & B as units..	23.9	24.4	20.0	19.8	19.8	21.6	25.7	30.3	23.1	27.6	26.9	26.7
	A & B alternated	22.4	21.0	19.5	15.4	17.1	19.1	28.9	34.8	25.1	29.7	29.2	29.7
	Difference....	1.5	3.4	0.5	4.4	2.7	2.5	—3.2	—4.5	—2.0	—2.1	—2.3	—3.0
May 3	A & B as units..	22.9	23.5	26.3	17.0	23.0	22.5	28.7	32.4	23.4	27.3	24.5	27.3
	A & B alternated	19.2	21.0	23.0	14.8	19.1	19.4	32.4	37.5	25.3	29.8	25.4	30.1
	Difference....	3.7	2.5	3.3	2.2	3.9	3.1	—3.7	—5.1	—1.9	—2.5	—0.9	—2.8
May 17	A & B as units..	22.3	27.6	27.4	21.9	20.4	23.9	30.3	31.0	24.0	24.6	28.3	27.6
	A & B alternated	21.0	28.6	24.9	25.9	19.2	23.9	31.8	35.7	24.8	25.0	26.6	28.8
	Difference....	1.3	—1.0	2.5	—4.0	1.2	0	—1.5	—4.7	—0.8	— .4	1.7	—1.2
All	A & B as units..	23.0	25.1	24.5	19.6	21.0	22.7	28.2	31.2	23.5	26.5	26.6	27.2
	A & B alternated	20.9	23.5	22.9	18.7	18.5	20.8	31.0	36.0	25.3	28.2	27.1	29.5
	Difference....	2.1	1.6	1.6	0.9	2.5	1.9	—2.2	—4.8	—1.8	—1.7	—0.5	—2.3
General average..........		22.0	24.3	23.5	19.1	19.8	21.7	29.6	33.6	24.4	27.4	26.8	28.4

The average yields for the three experiments for dates of planting are 24.3, 24.8 and 26.1 b.p.a. respectively. This is not in accord with results usually obtained as wheat planted well into May ordinarily has a definitely lessened yield compared with earlier planting. Even the second planting, 16 days after the first, would usually show a marked reduction. The two earlier plantings were near each other with the third planting grown on land usually less desirable for good wheat yields.

The general averages show the large difference of 6.7±.4 bushels between the two groups. The wheats of group B yield in excess of group A in all cases although 12199 and 3103 yield essentially the same. Regent and 12053 are significantly lower in yield than any of the other wheats and 2849 is very significantly higher than any other wheat.

Competitive Effect

For the two early planting dates the competitive effect is very strong and in only two instances is it less than one bushel. The A wheats in all cases yield better when competing among themselves while the yields of the B wheats are heightened when their rows alternate with those of the A wheats. The net differences for the two plantings are 5.5±1.4 and 5.9±1.4 bushels, respectively. In the late planting the competitive effect, found regularly in the earlier plantings, shows exceptions with three varieties. In spite of these exceptions the three experiments taken as a unit show markedly the competitive effects of the two groups when planted alone and alternating. This is shown in the following tabulation:

Groups	Non-competing	Competing	Effect
A	22.7±.39	20.8±.36	1.9±.53
B	27.2±.47	29.5±51	—2.3±.69
Diff.	—4.5±.61	—8.7±.62	4.2±.87

Heads Per Meter

Two meter lengths of row were counted for heads and averaged for each row for each of the three experiments. It may suffice to give only the averages for the three dates of planting and these are found in Table 2.

Considering the two average differences the A wheats had 4.9 fewer heads per meter when grown competitively with the B wheats than when grown side by side. On the other hand the B wheats had 3.2 more heads per row when grown competitively with the A

Table 2—Number of heads per meter of the wheats indicated. Values are averages of 4 replications and 3 dates of planting.

	12044	12199	Merit	1597	Regent	Av.
A & B as units..........	134	126	113	96	129	119.7
A & B rows alternating...	128	124	102	97	124	114.8
Difference.............	6	2	11	—1	5	4.9

	2857	2849	3103	3121	3113	Av.
A & B as units..........	126	135	110	110	106	117.4
A & B rows alternating...	126	141	117	110	108	120.6
Difference.............	0	—6	—7	0	—2	—3.2

wheats than when grown alone. Thus the net difference in favor of the B wheats is 8.1 heads per meter. But it is only for the first and second dates of planting that the competitive effect is of importance. This accords with results already shown with yield. With lack of competitive effect in the late planting in heads per row the yield result as obtained from the late planting might be expected.

The average heads per meter for all three planting dates for the two wheat groups are shown in Table 3.

Table 3

Date planted	Grown	Wheat group A	Wheat group B
April 17	A and B as units	113	123
	A and B rows alternating	109	124
May 3	A and B as units	127	119
	A and B rows alternating	114	124
May 17	A and B as units	120	110
	A and B rows alternating	122	114
	Average	117	119

The head count for the two groups of wheat are nearly the same but there is a marked interaction effect with respect to methods of seeding for the first two seeding dates and the analysis of variance shows this to be markedly significant when the head counts for the three dates of planting are averaged. Variations due to dates are eliminated with the following tabulation.

	A	B	Av.
A and B as units	119.7	117.4	118.7
A and B rows alternating	114.8	120.6	117.7
Av.	117.3	119.0	118.1

From this it is evident that the variation among the four interior averages is much greater than between either of the two pairs. Differences are highly significant in the one case and entirely lacking in significance in the two others.

Height of Plant

Careful notes taken on height of plant showed no differential effect when the two groups were interplanted compared with the groups planted as units. For the two earlier plantings the A wheats were about 90 percent as tall as the B wheats but for the late planting difference in height had decreased with the A plants about 94 percent as tall as the B plants. It is possible the greater yield of the wheats of the B group is conditioned in part by the greater height of plants but the taller plants growing in rows adjacent to the shorter plants did not result in their lowered yields because of the height effect in competition.

Other Characters Studied

Other characters of the plants studied in this experiment were date of heading, weight of kernel, bushel weight and the number of black point and scabby kernels found in samples of threshed grain. None of these afforded any further explanation with respect to the competitive yield effects already discussed. In none of these characters was there a marked change from the early to the mid-date plantings but the late planting did show some distinct changes. The number of scabby kernels increased threefold from medium to late planting with marked differences between varieties. Wheats 2849 and 2857 had significantly the fewer. The weight of kernel decreased 8 percent from early to late planting while the decrease in bushel weight was 6 percent. Increases in scab and decreases in kernel weight would be expected to lead toward lower yields, but if this occurred there were counterbalancing factors not revealed in this study. The group A wheats increased in yield from the first to the late planting 3.5 b.p.a. or 17 percent, a highly significant amount, while the average yields for the group B wheats for the two dates were the same.

Yield Behavior of 2849

This wheat is a sib of 2857 and also of the new variety Mida. Its yield behavior in this experiment is considered in comparison with the other wheats. It outyielded each of the A wheats in each of the 3 experiments with an excess average yield of 12.1 b.p.a for the 30 possible comparisons. This wheat outyields the average of the A group by 8.6 b.p.a. when the two groups are grown as units and by 15.5 b.p.a. when the two groups are grown competitively which is a sacrifice of 6.9 bushels of the A wheats because of competition. When compared with other wheats of its own B group it is higher yielding in all comparisons. Not only is this true generally but 2849 does relatively better, compared with the other wheats of the B group when the B wheats are competing with the A wheats. This is shown in Table 4.

Table 4
(Values in b.p.a.)

Comparison:	Seeding date Apr. 17	May 3	May 17
Wheat 2849 minus the 4 others of group B when grown:			
1. Alternating with group A	6.6	9.3	8.7
2. Only in group B	4.5	6.4	4.2
Second difference	2.1	2.9	4.5

The data indicate: (1) Wheat 2849 markedly outyielded the 4 others of the group when the wheats of Group B were grown by themselves; (2) the excess of 2849 over the other 4 was still more marked when grown alternating with group A; and (3) this greater excess of 2849 increased from earlier to later planting.

The values given are averaged from four differences, one set for each of the four varieties, and these differences are uniformly of the same sign. The second differences are of the same constant uniformity as shown by the averages above. These data show 2849 is exceptional, not only in its capacity to compete with the wheats of group A but with the other four wheats of group B as well. Also, it maintains this capacity with later dates of planting, while the four other wheats show a recession as indicated by the increases of the second differences from one date of planting to the next.

Technologic Data

Composite grain samples taken of the early and late plantings of the 10 wheats were processed in the usual manner under the direction of Dr. R. H. Harris in charge of the department of Cereal Technology. Protein determinations were made and given the usual microtreatments for milling and baking. The samples of each planting were taken without regard to the groups being grown as units or competitively. Averages are given of the 5 wheats of each group for five characters besides yield. These are shown in table 5.

From table 5 a sharp distinction is found between agronomic behavior

Table 5

Date seeded	Group	Protein	Test wt.	Flour yield	Loaf vol.	Color score	Yield
		%	lbs.	%	cc.		b.p.a.
April 17............	A	16.8	58.8	72.0	212	7.6	20.4 ± .39
	B	16.3	59.7	72.3	182	7.8	28.2 ± .54
							7.8 ± .67
May 17............	A	16.2	55.3	70.1	212	7.2	23.9 ± .46
	B	15.2	56.5	73.1	178	6.9	28.2 ± .54
							4.3 ± .71

and quality. The B wheats are sharply higher in yield while in protein content and especially in loaf volume the A wheats are ahead. The problem of merging into one variety the two characters of high yield and high quality of gluten is commonly difficult and often some compromise is necessary in the final selection of a variety. The Merit variety in the A group was relatively low in protein and volume while 3103 of group B had loaf volume above the average of its group. Wheat 12199 compared favorably with 3121 for while it averaged three b.p.a. lower in yield its loaf volume was about one-fifth higher. The data suggest that the very high yielding 2849 could not qualify as a suitable variety due to the low loaf volume. But the problem remains to learn if high yield and high quality may not be compatible within one variety. If the two characters cannot co-exist in a variety the physiological reasons preventing this should be studied. Meanwhile, continued work is being done by the method of trial and error in testing selections from new crosses which will embody the two characters in a greater degrees than has been done in the past.

Discussion and Summary

If two wheat varieties are otherwise satisfactory a greater competitive value of one of them, as shown possible in this experiment, would seem to be desirable. A wheat variety under field conditions has to meet competition with weeds which likely correspond with other wheat plants as competing agents. And so in breeding a wheat variety attention could well be paid to its competitive capacity. Special experiments, perhaps similar to the one under discussion, would need to be set up to furnish the desired information. It was shown that the relatively larger and smaller yields were conditioned by differences in heads per row. The greater number of heads among the wheats of the B group, grown alternately with the group A wheats, is probably due to increased tillering. If the root systems of the two groups of plants had been studied similar relations would likely have come to light. Christian and Gray[3] in competition trials involving seed size and an early and late variety found differences in tillering and head production of more importance in modifying yields than the number of kernels per head or weight of kernel. In the present experiment weight of kernel no doubt had an influence upon the yields of the two groups of wheat, A and B, when grown comparably but did not influence yields of the wheats of group A when grown in the two phases, by themselves and in competition with the B wheats.

Five wheats bred at Fargo were found to have superior competitive value, expressed in higher yields, when grown in rows alternating with rows of wheats not bred at Fargo than when grown intraplanted. This differential effect was marked in seedings of April 17 and May 3 but was not in evidence in the experiment seeded May 17. The differences in yield were evidently conditioned by similar differences in number of heads per row.

Agencies Cooperating with the North Dakota Agricultural Experiment Station

THE **North Dakota Agricultural Experiment Station** has cooperative relationships with many agencies both federal and state. The Experiment Station receives part of its support in federal grants hence its federally sustained projects and accounts are subjected to annual inspection and audit by the Office of Experiment Stations, Agricultural Research Administration, United States Department of Agriculture. Helpful advice is given the director and project leaders by the several administrators in the Office of Experiment Stations, and annual progress reports are submitted to the Office of Experiment Stations.

The United States Department of Agriculture helps the Station in a still more direct way by assigning United States Department of Agriculture staff members, wholly federally paid to this State and Station. At the present time the following research workers serve both the North Dakota Station and the Nation:

Stationed at Fargo

Glenn S. Smith—Agronomist, Division of Cereal Crops & Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture. Mr. Smith devotes his entire time to durum wheat improvement.

Dr. H. H. Flor, Plant Pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture. Dr. Flor devotes his entire time to flax diseases in North Dakota and surrounding flax areas. He has given special attention to flax rust, and the newer diseases.

C. L. Englehorn, Associate Soil Scientist, Soil Conservation Service, United States Department of Agriculture. Mr. Englehorn is in charge of cooperative tillage experiments at the Langdon and Edgeley Substations where special attention is being given to surface types of tillage operations.

Stationed at Dickinson

Leroy Moomaw, Associate Agronomist, Division of Dry Land Agriculture, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture and Superintendent of the State Substation. Mr. Moomaw gives special attention to crop rotations and tillage methods, grass testing, and the testing of orchard fruits, shrubs, and ornamental trees.

Ralph Smith, Associate Agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering,

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