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Varietal Experiments with Wheat, Oats, Barley, Rye, and Buckwheat : a Preliminary Report

Ralph John Garber

K. S. Quisenberry

T. E. Odland

T. C. McIlvaine

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HENRY G. KNIGHT, Director
Morgantown

Varietal Experiments with Wheat, Oats, Barley, Rye, and Buckwheat

(A Preliminary Report)

Buildings on the Agronomy Farm, West Virginia Agricultural Experiment Station, Morgantown.

BY

R. J. GARBER, K. S. QUISENBERRY,
T. E. ODLAND, and T. C. McILVAINE

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*In co-operation with the U. S. Department of Agriculture, Washington, D. C.
**In co-operation with the State Department of Agriculture, Chareston, W. Va.
***On leave of absence.
†In co-operation with the Reymann Memorial Farms, Wardensville, W. Va.
‡In charge of the Maggie Sub-Station, Maggie, W. Va.

Varietal Experiments with Wheat, Oats, Barley, Rye, and Buckwheat[*]

(A Preliminary Report)

The farmer is often confronted with the problem of choosing a crop variety best suited to his need. Such characters as yield, quality, disease resistance, hardiness,ease of handling,etc., along with the purpose for which the crop is to be grown, are of major importance in determinig what variety most nearly meets the particular demands of a certain farm. The only means of determining the relative value of these characters in different varieties for a given locality is by trial.

It is far too expensive for the individual farmer to attempt to test the varieties of the different crops grown. This is one of the duties of the Experiment Station. It is important to recognize that varietal experiments are basic to crop improvement. It is the means by which valuable new varieties, irrespective of their origin, are discovered.

In a state where there is such a wide range of conditions as in West Virginia, variety trials should be carried on in each area which is representative of a main agricultural section. This has been impossible in this study for various reasons. Even though a variety test were conducted in each main agricultural section of the state the question of what particular variety to grow on a certain farm would not be answered. The relative value of varieties does not remain the same for all seasons. Some give better results during a wet season others during a dry season, some thrive in comparatively cool weather and others in warm weather. Varietal experiments can show only what varieties are satisfactory for a particular section when considered from the standpoint of their average performance. Variety trials do not usually show what variety is best but rather what varieties are the better ones.

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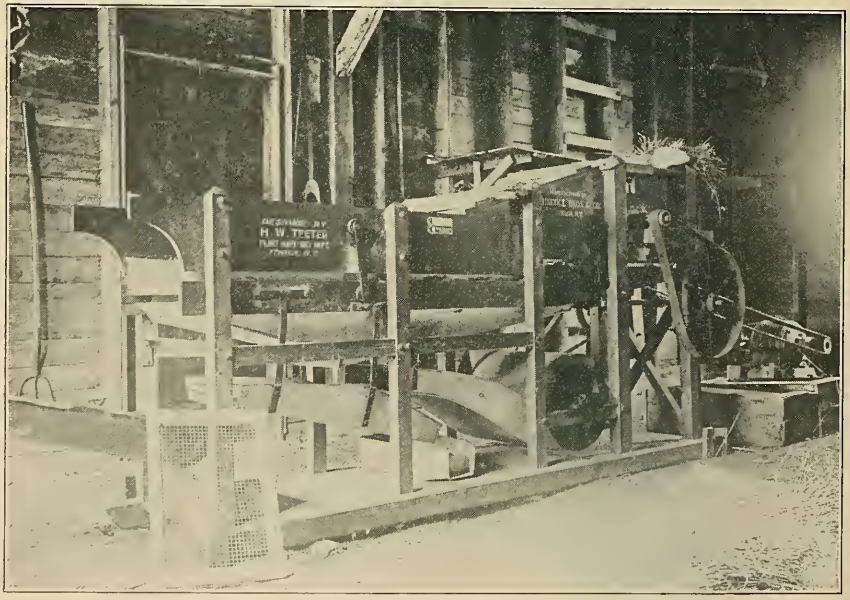
* The Ms. for this bulletin was submitted in January, 1924.

The experiments reported in this bulletin have been carried on for three years or less. It is realized that three years is hardly sufficient time in which to establish definitely the relative merits of different varieties but rather than defer publication it was deemed advisable to issue this preliminary report. In interpreting the data presented the reader should take into account the rather short period that the experiments have been under way.

METHODS USED IN EXPERIMENTS

During the last decade important changes have been made in experimental field technic. Formerly most of the variety tests were conducted on large plats and frequently each variety was grown on a single plat only. The present tendency is to use smaller plats but to grow each variety systematically repeated. (Such systematically repeated plats are frequently referred to as replicated plats.) Considerable evidence has been accumulated in recent years which indicates that the present



The Threshing Machine Which Is Used by the Agronomy Department of the West Virginia Agricultural Experiment Station to Thresh the Rod-rows of Wheat, Oats, Rye, Barley, and Buckwheat.

day method is more accurate and hence a greater degree of confidence may be placed in the results.

The varieties reported in this bulletin were tested in rod-row plats. Each plat consisted of three rows eighteen feet long and one foot apart. The different crops were seeded by hand at the following rates per acre: wheat six pecks, oats ten pecks, barley eight pecks, rye six pecks, and buckwheat four pecks. At harvest one foot of the end of each central row was discarded and the remainder of the row cut and later threshed for the yield determination. This procedure was followed in all the plats except those of oats in which the central rows were shortened to fifteen feet before being harvested. Except where otherwise noted each variety or strain tested was grown in four or more systematically replicated plats. Checks were grown in every third to fifth plat except in the oat variety test of 1921 and in the barley tests. The winter barley and rye were grown along with the winter wheat.

In addition to the data on yield certain field notes were taken. Date of heading, height, per cent and degree lodged just before harvest, and date harvested were recorded for the variety on each plat. Each year a note on the per cent hardness of the threshed grain of winter wheat and rye was taken. Certain botanical notes were also recorded for purposes of identification. If winter-killing occured the approximate percentage of the plants surviving was estimated in the spring.

Three of the characters mentioned, date of heading, lodging, and per cent hardness, may require some explanation. A variety was considered heading when from one-half to two-thirds of the plants were headed.

The note on lodging was taken with two objects in view; namely, to estimate the percentage of the culms of any one variety that were lodged and to determine the average degree of lodging. Culms which were down flat on the ground were considered lodged 90 degrees. For example if one-half of the culms of a variety were in a position midway between erect and prostrate, the following note was made; per cent lodged 50, degree lodged 45. The percentage lodged varied from 0 to 100 and the degree lodged varied from 0 to 90.

The per cent hardness is simply an estimate of the relative

corneousness or hardness of the threshed grain from each plat. In general, hard bread wheats have a higher market value than soft bread wheats.

Most of the variety trials reported in this bulletin were made on the Agronomy Farm near Morgantown, West Virginia. A few of the oat varieties were tested for yield on the farm of Mr. D. C. Stemple near Aurora, in Preston County. The authors desire to acknowledge their indebtedness to Mr. Stemple. Some of the varieties of wheat, oats, rye and winter barley were grown at the Maggie Substation located in Mason County.

The Agronomy Farm is about 1200 feet, the Maggie Substation about 600 feet, and the Stemple farm near Aurora about 2750 feet above sea level. The soil types on which the various experiments were conducted are; a Dekalb silt loam of medium productivity at Morgantown, a Dekalb stony loam of medium productivity at Aurora, and a Huntington silt loam of high productivity and a Wheeling fine sandy loam of low productivity at Maggie. The wheat, rye, and barley grown at the last named place in 1922 were on the Wheeling type. All the other experiments at Maggie were conducted on the Huntington type. The Huntington is a first bottom and the Wheeling a second bottom soil.

WHEAT VARIETIES

Practically all the varieties of wheat grown in West Virginia belong to the winter wheat group. Statistics issued by the United States Department of Agriculture show that the wheat acreage in West Virginia increased more or less regularly from 1909 to 1918 and that since then it has decreased. The estimated total acreage for West Virginia in 1909 was 209,000 acres; in 1918, 298,000 acres; and in 1922, 240,000 acres. The average yield per acre for the five-year period 1917-1921 was 13.3 bushels. Jefferson, Berkeley, Mason, Greenbrier, and Marshall are the leading counties in the production of wheat.

Experiments at Morgantown

In all there are twenty-one varieties of winter wheat which were grown on the Agronomy Farm reported in Table I. Of these varieties nine were grown three years, ten were grown two years and two were grown in 1923 only. The different var-

ieties are listed with the names they were introduced under recently or the names they had been grown under on the Agronomy Farm previous to 1920. Reliable 80, Fulcaster, and Fultz 7 are the only varieties which belong to the latter group. Reliable 80 is probably a selection of Gypsy as described by Clark and others.*

Ohio 127 or Fulhio, Ohio 13384, Trumbull, Portage, and Gladden were introduced from the Ohio Agricultural Experiment Station; Ashland and Kentucky Selection from the Kentucky Agricultural Experiment Station; Bearded Purplestraw, Currell's Prolific, Mammoth Red, Leap's Prolific, and China from the Maryland Agricultural Experiment Station; Red Rock from the Michigan Agricultural Experiment Station; Pennsylvania 44 from the Pennsylvania Agricultural Experiment Station; Minturki from the Minnesota Agricultural Experiment Station; Kanred from the Kansas Agricultural Experiment Station; V. P. I. No. 112 and V. P. I. No. 131 from the Virginia Agricultural Experiment Station. In general the above varieties represent the higher yielding varieties in the respective states from whence they were introduced.

Varieties of Winter Wheat Grown on the Agronomy Farm at Morgantown in 1923 Showing Rod-rows.

Considering first the nine varieties (Table I) grown during the three-year period it is evident that their yielding ability did not differ strikingly. The highest yielding variety, Ashland a selection from Fultz, produced an average yield per acre for the three years 5.2 bushels greater than the lowest yielding variety, Portage. In view of what is known regarding the probable

* Clark, J. A., Martin, J. H., and Ball, C. R. Classification of American wheat varieties. U. S. Dep. Agr. Bul. 1074, 238 pp. 1922.

TABLE I.—Average Yields and Other Characteristics of Winter Wheat Grown (1921-23) on the Agronomy Farm at Morgantown.

Name of Variety	West Virginia Acession Number	Average Date Heading	Average Date Harvested	Average Height (inches)	Spike Characteristics*	Average Percentage Hardness	Average Yield in Bushels per Acre * *				
							1921	1922	1923	Aver'ge 1921-23	Aver'ge 1922-23
Ashland	32	5/28	6/30	40.6	A W S	35	19.9	28.2	24.8	24.3	26.5
Reliable 80	22	5/29	7/2	39.8	B W S	38	19.2	26.8	25.3	23.8	26.1
Fulcaster	15	5/28	7/4	42.3	B W S	39	20.3	26.5	23.0	23.3	24.8
Ohio 127 (Fulhio)	28	5/28	6/30	39.7	A W S	41	19.7	29.0	19.6	22.8	24.3
Trumbull (Checks)‡	27	5/27	6/30	40.2	A W S	41	16.1	26.6	20.5	21.1	23.6
Ohio 13384	26	5/27	7/2	39.0	A R S	35	15.7	27.0	20.3	21.0	23.7
Fultz 7	13	5/28	6/30	38.5	A W S	43	16.4	26.2	19.8	20.8	23.0
Kentucky Selection	33	5/28	7/4	35.4	A R S	36	17.9	25.8	18.8	20.8	22.3
Portage	30	5/27	7/3	38.0	A R S	39	12.3	28.3	16.6	19.1	22.5
Bearded Purplestr'w	42	5/31	7/6	42.1	B W S	43		25.8	23.1		24.5
Currell's Prolific	40	5/30	7/5	39.0	A R S	35		28.1	20.6		24.4
Mammoth Red	43	5/31	7/6	43.0	B W S	38		24.4	23.6		24.0
Leap's Prolific	41	5/31	7/2	40.2	A W S	52		26.1	21.5		23.8
China	44	6/1	7/9	44.9	A R S	34		21.7	25.7		23.7
Minturki	47	6/1	7/8	37.6	B W S	41		20.3	24.7†		22.5
Pennsylvania 44	46	6/1	7/7	40.1	B W S	38		25.6	18.0		21.8
Red Rock	45	5/31	7/7	38.6	B R S	46		21.1	15.6		18.4
Kanred	39	6/2	7/7	32.4	B W S	44		14.2	17.2†		15.7
Gladden	29	5/26	7/2	42.5	B W S	41	17.5	22.4			
V. P. I. 131	55	6/4	7/7	39.0	B W S	55			18.2		
V. P. I. 112	54	6/5	7/9	38.3	A R S	44			16.8		

*A=awnless or beardless, B=bearded, W=white glumes (chaff), R=red or brown glumes, S=glabrous glumes (without a hairy covering).
**Number of plats of each variety in 1921—5; in 1922—5; in 1923—4.
†Grown in a single plat in 1923.
‡Number of check plats grown in 1921—86; in 1922—41; in 1923—20.

error of field experiments such as the one under discussion it is doubtful whether there is a significant difference in yielding ability, under the conditions mentioned, of the four varieties Ashland, Reliable 80, Fulcaster, and Ohio 127 listed first in Table I. One may assert with a greater degree of assurance that for the particular locality the three or four highest yielding varieties may be expected to yield higher on the average than the three or four lowest yielding varieties.

Several varieties of wheat were introduced in 1921 and hence for them there is but a two-year record available. The average yield for each of the varieties grown in 1922 and 1923 is shown in the last column of Table I. On the basis of a two-year average Ashland, Reliable 80, and Fulcaster again rank first, second and third respectively, in yield. It is also apparent that several varieties did not differ strikingly in yield from the three leading ones.

Hardness or corneousness in bread wheat is usually associated with market value and therefore deserves some attention. On the basis of a three-year average of percentage hardness (Table I) Fultz 7, Trumbull, and Ohio 127, all of which are selections from Fultz, are the hardest wheats. Considering those for which a two-year average only is available Leap's Prolific, Red Rock, Kanred, and Bearded Purplestraw are the most corneous.

Another wheat character which is of considerable interest is listed in Table I in the column headed "Spike Characteristics". Of the four varieties leading in yield on the basis of a three-year average, two are bearded and two are awnless but all have white, glabrous outer glumes. Some farmers object to bearded wheats because they are more disagreeable to handle than the awnless varieties.

It will be observed that no data regarding lodging have been recorded in Table I. During the years 1921 to 1923 inclusive, practically no lodging occured among the various wheat varieties grown on the Agronomy Farm.

In some sections of the United States winter-hardiness of wheat is a character of great importance. Although some winter-killing occurs at Morgantown it is unusual to obtain as much as fifty per cent among varieties commonly grown in this local-

ity. In 1922 two varieties, Minturki and Kanred which are hardy in Minnesota and Kansas respectively, winter-killed to a greater extent than any other variety in the nursery. Apparently winter-killing was due largely to heaving of the plants. The estimated average percentage survival for Minturki was sixty and for Kanred forty-three, whereas most of the other varieties gave an average percentage survival of about ninety. It should be mentioned that Kanred and Minturki were grown here for the first time in 1922.

Experiments at Maggie

The test of winter wheat varieties at the Maggie Substation has been carried on for two years. In 1922 the crop was almost a failure as may be seen from the yields listed in Table II. On the basis of a two-year average, Ohio 127 or Fulhio and Reliable 80 are again found as at Morgantown, among the four highest yielding varieties. Trumbull, which ranked fifth on the basis of a three-year average yield on the Agronomy Farm and Gladden are also in this group of highest yielding varieties. Fulcaster, one of the higher yielding varieties at Morgantown is in the lower yielding group at Maggie.

TABLE II.—Average Yields and Other Characteristics of Winter Wheat Grown (1922-23) at the Maggie Substation.

Name of Variety	West Virginia Accession Number	Spike Characteristics*	Average Yield in Bushels per Acre†		
			1922	1923	Average 1922-23
Ohio 127	28	A W S	5.9	24.2	15.1
Trumbull (Checks‡	27	A W S	4.2	24.9	14.6
Gladden	29	B W S	2.7	26.2	14.5
Reliable 80	22	B W S	2.6	25.9	14.3
Mammoth Red	43	B W S	5.0	22.3	13.7
Portage	30	A R S	2.2	24.0	13.1
Fultz 7	13	A W S	1.6	24.1	12.9
Ashland	32	A W S	2.5	22.2	12.4
Pennsylvania 44	46	B W S	4.0	18.2	11.1
Fulcaster	15	B W S	1.8	20.4	11.1
Currell's Prolific	40	A R S	3.7	15.2	9.5

*A=awnless or beardless, B=Bearded, W=white glumes (chaff) R=red or brown glumes. S=glabrous glumes (without a hairy covering).

†Number of plats of each variety—4 each year.

‡Number of check plats grown each year, 21.

OAT VARIETIES

The acreage of oats in West Virginia has steadily increased during the last decade. According to the United States Department of Agriculture Yearbook for 1922 there were approximately 200,000 acres in oats that year in West Virginia. This is about double the acreage ten years previously. During the five-year period, 1917-1921, the average yield of oats in West Virginia was 24.8 bushels per acre. Preston, Marshall, Marion, Wetzel and Monongalia were the leading oat producing counties in West Virginia.

Experiments at Morgantown

In Table III are reported eighteen oat varieties which were grown during three years on the Agronomy Farm. The varieties were obtained from the following sources: Iowa 103 which has been named Albion, Gopher, and Iowa 105 which has been named Richland, from the Minnesota Agricultural Experiment Station; Victory, Iowar, White Russian, Kherson, Fulghum, Swedish Select, and Early Mountain from the United States Department of Agriculture; Silvermine, Ohio 6203 which has been named Miami, Ohio 7009, Golden Rain, and Ohio 6222 from the Ohio Agricultural Experiment Station; Japan Selection, New Zealand, and Big Four from the Pennsylvania Agricultural Experiment Station.

Varieties of Oats Grown on the Agronomy Farm at Morgantown in 1923 Showing Rod-rows.

On the basis of the three-year average yield Iowa 103 or Albion exceeds all the other varieties in the test by 4.3 bushels. Gopher, a selection from Sixty Day oats made at the Minnesota Agricultural Experiment Station ranks second in yield. The next three varieties, Victory, Silvermine, and Early Mountain do

TABLE III.—Average Yields and Other Characteristics of Oats Grown (1921-23) on the Agronomy Farm at Morgantown.

Name of Variety	West Virginia Accession Number	Average Date Heading	Average Date Harvested	Average Height (inches)	Lodged		Average Yield in Bushels per Acre *			
					Average Percentage of Plat	Average Degree	1921	1922	1923	Average 1921-23
Iowa 103 (Albion)	27	6/10	7/9	33.6	25.7	22.3	72.0	55.1	58.3	61.8
Gopher (Checks)†	25	6/13	7/11	32.9	0.2	0.2	66.1	59.9	46.6	57.5
Victory C. I. 560	8	6/21	7/21	39.7	0.0	0.0	57.1	64.0	46.8	56.0
Silvermine	4	6/16	7/14	38.1	0.7	0.3	54.6	57.7	55.3	55.9
Early Mount'n C.I.656	11	6/20	7/17	41.3	8.0	5.3	53.7	58.1	55.6	55.8
Ohio 6203	1	6/17	7/16	35.5	1.3	2.0	57.7	56.6	49.1	54.5
Ohio 7009	3	6/9	7/6	32.0	6 0	5.7	62.9	53.3	45.5	53.9
Iowa 105 (Richland)	26	6/10	7/9	31.3	8.1	12.0	63.6	51.3	45.8	53.6
Japan Selection	21	6/17	7/14	39.7	1.0	5.0	54.0	58.6	48.1	53.6
Iowar C. I. 847	15	6/14	7/10	34.0	8.7	9.0	57.8	53.5	45.8	52.4
New Zealand	19	6/21	7/20	39.1	0 0	0.0	45.7	59.0	51.0	51.9
Golden Rain	5	6/20	7/17	40.7	1.0	1.3	52.3	53.8	49.0	51.7
Kherson C. I. 459	16	6/9	7/9	31.3	20.7	18.3	60.1	49.6	43.0	50.9
Ohio 6222	2	6/20	7/16	38.0	0.0	0.0	49.7	54.8	46.1	50.2
Fulghum C. I. 1833	12	6/9	7/11	33.1	13.0	11.7	54.2	53.0	41.8	49.7
Swedish Se'ect C.I.134	9	6/19	7/18	38.5	1.3	2.0	51.5	56.3	40.2	49.3
Big Four	20	6/18	7/15	37.7	1.3	1.3	48.3	51.7	42.4	47.5
White Russian C.I.551	10	6/23	7/23	41.6	2.3	3.3	44.6	45.1	43.9	44.5

*Number of plats of each variety—5 each year.

†Number of check plats grown in 1922—51; in 1923—51; in 1921—no checks used (Gopher grown in 5 plats only).

not differ significantly in yield. White Russian, a late maturing side (or horse-mane) oats, yielded the least during the three-year period. It is significant that the two varieties of oats which showed the greatest yielding capacity are early maturing.

Ability to resist lodging is desirable in oats. The behavior of the several varieties with respect to this character is recorded in the sixth and seventh columns of Table III. It will be observed that among the early maturing oats, Gopher showed the least amount and lowest degree of lodging. Iowa 103 is somewhat objectionable because of its weak straw. On the average approximately twenty-five per cent of this variety lodged 22.3 degrees whereas only 0.2 per cent of the Gopher variety lodged 0.2 degrees. In general the mid-season and late maturing oats showed considerable less lodging than the early maturing ones.

Experiments at Maggie

There were nine oat varieties in the two-year test at the Maggie Substation. (Table IV.) The variety used as a check was an unnamed sort which had been grown locally and which was thought to have high yielding capacity. The Gopher variety here, as at Morgantown, proved to be one of the better yielding varieties. On the basis of the two-year average there is little difference between the yields of Gopher, Fulghum, and the checks. The two-year average yield of Iowa 103 is 5.8 bushels less than that of Gopher. White Russian with an average yield of only 16.5 bushels per acre ranks last.

TABLE IV.—Average Yields of Oats Grown (1922-23) at the Maggie Substation.

Name of Variety	West Virginia Accession Number	Average Yield in Bushels per Acre*		
		1922	1923	Average 1922-23
Gopher	25	24.5	39.0	31.8
Fulghum	12	21.1	39.8	30.5
Checks (Local)†	28	24.4	35.8	30.1
Victory	8	20.4	32.7	26.6
New Zealand	19	23.3	28.7	26.0
Iowa 103 (Albion)	27	17.0	34.9	26.0
Iowa 105 (Richland)	26	20.2	31.1	25.7
Golden Rain	5	22.9	23.8	23.4
White Russian	10	10.3	22.6	16.5

*Number of plats of each variety—4 each year.
†Number of check plats grown each year—13.

Experiments at Aurora

On the farm of Mr. D. C. Stemple near Aurora, seven oat varieties were tested during the years 1922 and 1923 inclusive, (Table V.) The variety used as a check in this experiment had been grown by Mr. Stemple for a number of years. On the basis of the two-year average yield, Gopher and Iowa 103 again occupied first and second places. It will be recalled that these same varieties produced the highest average yield at Morgantown.

TABLE V.—Average Yields of Oats Grown (1922-23) on the D. C. Stemple Farm Near Aurora in Preston County.

Name of Variety	West Virginia Accession Number	Average Yield in Bushels per Acre*		
		1922	1923	Average 1922-23
Gopher	25	37.8	33.5	35.7
Iowa 103 (Albion)	27	37.8	32.4	35.1
Checks (Local)†	29	35.2	32.4	33.8
Golden Rain	5	31.5	34.1	32.8
Victory	8	35.4	29.9	32.7
Fulghum	12	29.8	32.0	30.9
Iowa 105 (Richland)	26	32.1	27.6	29.9

*Number of plats of each variety—4 each year.
†Number of check plats grown each year—13.

It is of considerable significance that early maturing oats yielded the highest at all three places where the variety tests were carried on, Morgantown, Maggie, and Aurora. These three places present marked differences in altitude and soil type. The extreme difference in altitude is about 2150 feet. The soil on which the oat varieties were grown at Maggie was productive first bottom land and at Morgantown and Aurora was medium productive upland.

RYE VARIETIES

The acreage of rye grown for seed in West Virginia has diminished during the past few years. The estimated acreage as published in the Yearbook of the United States Department of Agriculture for the year 1919 and each of the three years immediately preceeding is approximately 20,000 acres whereas for each of the years 1920, 1921, and 1922 the estimate is about 10,000 acres. The average yield of rye in West Virginia for the five-year period, 1917-1921 inclusive, was 12.6 bushels per acre. Most of the rye that is grown for seed is produced in Hampshire, Morgan, Hardy, and Berkeley counties.

TABLE VI.—Average Yields and Other Characteristics of Winter Rye Grown (1921-23) on the Agronomy Farm at Morgantown.

Name of Variety	West Virginia Accession Number	Average Date Heading	Average Date Ripe	Average Height (inches)	Average Percentage Hardness	Average Yield in Bushels per Acre*				
						1921	1922	1923	Average 1921-23	Average 1922-23
Rosen	1	5/16	7/2	54.7	57	24.5	40.2	30.9	31.9	35.6
Minnesota 2	13	5/15	7/2	55.5	62		31.2	23.7		27.5
Abruzzes (C. I. 40)	2	5/19	7/1	54.8	64		20.1	18.4		19.3

*Number of plats of each variety in 1921—5; in 1922—5; in 1923—4.

Experiments at Morgantown

There were but three varieties of winter rye grown in replicated rod-rows on the Agronomy Farm. These three varieties are listed in Table VI. Rosen rye had been grown on the Agronomy Farm previous to 1920. Minnesota 2 rye was obtained from the Minnesota Agricultural Experiment Station and Abruzzes was obtained from the United States Department of Agriculture.

On the basis of a two-year average yield Rosen rye exceeded Minnesota 2 by 8.1 bushels per acre and the latter exceeded Abruzzes by 8.2 bushels per acre. The average yield of Rosen for the years 1922 and 1923 was 35.6 bushels per acre, and for the years 1921, 1922, and 1923 the average yield was 31.9 bushels per acre.

There is little difference between the three varieties with respect to average date of heading, average date ripe, and average height. Abruzzes produced the hardest seeds, with Minnesota 2 second, and Rosen third as shown in the sixth column of Table VI.

Experiments at Maggie

The varietal experiments with winter rye on the Agronomy Farm were duplicated at the Maggie Substation. On the basis of a two-year average yield (Table VII) the rank of Rosen and Abruzzes is reversed and Minnesota 2 again occupies an intermediate position. The two-year average yields per acre were as follows: Abruzzes 31.7 bushels, Minnesota 2 28.2 bushels, and Rosen 25.7 bushels.

TABLE VII.—Average Yields and Other Characteristics of Winter Rye Grown (1922-23) at the Maggie Substation.

Name of Variety	W. Virginia Accession Number	Average Percentage Hardness	Average Yield in Bushels per Acre*		
			1922	1923	Average 1922-23
Abruzzes (C. I. 40)	2	50	10.2	53.1	31.7
Minnesota 2	13	47	8.1	48.2	28.2
Rosen	1	38	2.9	48.4	25.7

*Number of plats of each variety—4 each year.

The percentage of hardness of the threshed grain was also recorded for the varieties grown at Maggie. From the third column of Table VII it will be observed that with respect to corneousness the varieties rank in the same order as in Table VI, namely Abruzzes first, Minnesota 2 second, and Rosen third.

BARLEY VARIETIES

Barley has never been grown extensively in West Virginia. According to the Fourteenth Census of the United States there were in 1919, 1,359 acres of barley in West Virginia which yielded a total of 24,816 bushels. More than a third of this crop was grown in Berkeley County. The next three leading counties, Randolph, Jefferson, and Hampshire together produced a little more than one-half as much as was grown in Berkeley County.

Experiments at Morgantown

The varieties of spring barley grown on the Agronomy Farm and reported in Table VIII were obtained from the United States Department of Agriculture. Chevalier is a two-rowed variety but all the others are six-rowed forms. Himalaya and Nepal have hull-less seeds. The other varieties have covered seeds and all the varieties have beards except Nepal which is a hooded barley.

It will be noted from Table VIII that Oderbrucker and Featherstone have been grown for two years only. Considering the three-year average yields per acre it is apparent that Manchuria ranks first with a yield of 31.8 bushels and Chevalier second with a yield of 27.7 bushels per acre. During the same period Himalaya and Nepal, the two hull-less varieties, did not yield nearly so well. On the basis of the average yield for the years 1922 and 1923 Manchuria again exceeded all the other varieties, but by only a small margin. The average yield per acre for Oderbrucker was 2.2 bushels less than that of Manchuria.

The data on lodging show that of the four varieties grown during the three-year period, Manchuria and Chevalier lodged considerable less than Himalaya and Nepal. The data for Oderbrucker and Featherstone are based on a two-year average only and hence are not comparable with the data for the other varieties.

TABLE VIII.—Average Yields and Other Characteristics of Spring Barley Grown (1921-23) on the Agronomy Farm at Morgantown.

Name of Variety	West Virginia Accession Number	Average Date Heading	Average Date Harvested	Average Height (inches)	Lodged		Average Yield in Bushes per Acre*				
					Average Percentage of Plat	Average Degree	1921	1922	1923	Average 1921-23	Average 1922-23
Manchuria	6	6/10	7/11	30.7	6.7	4.3	34.4	35.8	25.2	31.8	30.5
Chevalier	4	6/13	7/15	27.4	4.0	4.3	32.7	28.1	22.4	27.7	25.3
Himalaya	3	6/7	7/10	22.4	24.0	24.3	18.0	19.0	10.7	15.9	14.9
Nepal	5	6/12	7/12	24.4	37.0	25.3	13.6	10.7	4.3	9.5	7.5
Oderbrucker	9	6/13	7/12	28.5	17.5	7.0		34.2	22.3		28.3
Featherstone	8	6/12	7/12	28.9	25.5	10.5		31.3	21.3		26.3

*Number of plats of each variety in 1921—7; in 1922—5; in 1923—5. All barley yields calculated on the basis of 48 pounds per bushel.

In addition to the varieties of spring barley, reported in the foregoing paragraphs, two varieties of winter barley introduced from the Tennessee Agricultural Experiment Station were grown during 1922 and 1923 in replicated (repeated) plats on the Agronomy Farm and at the Maggie Substation. In all the tests there were four plats of each variety except on the Agronomy Farm in 1922 when there were five plats of each variety. The average yields per acre for the two-year period at Morgantown were Union 25.6 bushels and Tennessee Winter 23.8 bushels; at Maggie the average yields per acre were Union 15.1 bushels and Tennesse Winter 14.4 bushels. These yields are not comparable with those of the spring barleys as they were produced in different experimental fields.

During the two years 1922 and 1923, Tennessee Winter and Union barley winter-killed considerably at Morgantown. As an average for the two-year period it was estimated that approximately one-half of the plants of each variety survived the winters. During the same period at Maggie about one-fourth of the plants of these two varieties were winter-killed.

BUCKWHEAT VARIETIES

West Virginia is one of the leading states in the production of buckwheat. During the years 1912 to 1922 inclusive, according to the Yearbooks of the United States Department of Agriculture the area in West Virginia devoted to the crop annually fluctuated between 31,000 and 47,000 acres. The period of maximum production was during the years 1917, 1918 and 1919. Preston County produces more than three times as much buckwheat as Hampshire County which ranks second in the production of this crop. Other important counties in the production of buckwheat are Barbour, Upshur and Tucker. The average yield per acre in West Virginia for the five-year period 1917-1921 was 20.4 bushels.

Experiments at Morgantown

There were three different variety types of buckwheat tested for yield (Table IX) on the Agronomy Farm. The single representative of the Mountain type, C. I. 91, belongs to the species **Fagopyrum tartaricum.** The five strains of the Japanese type and the two strains of the Silverhull type belong to the species **Fagopyrum esculentum.** The forms listed in Table IX

are called strains simply as a matter of convenience. It is not intended to convey the usual meaning of strain.

It will be observed that there are four strains listed as Japanese and two as Silverhull. Each strain was obtained from a different source. The sorts which were grown under West Virginia accession numbers (Table IX, second column) two, four, six, and seven were obtained from the United States Department of Agriculture. A strain from each of the Silverhull and Japanese types was obtained from T. W. Wood and Sons, Richmond, Virginia. The Japanese strain used for the checks was obtained from Mr. J. C. Cox, Summerville, West Virginia. The remaining Japanese strain was obtained from Wm. G. Scarlett and Company, Baltimore, Maryland.

Table IX.—Average Yields and Other Characteristics of Buckwheat Grown (1921-23) on the Agronomy Farm at Morgantown.

Name of Variety or Strain	W. Va. Acces'n Number	Average Date Harvested	Average Yield in Bushels per Acre*			
			1921	1922	1923	Average 1921-23
Japanese Selection	7	8/20	34.4†	16.1	25.0	25.2
Checks (Japanese)**	8	8/21	35.4	17.7	22.1	25.1
Japanese	3	8/20	34.3	17.2	18.8	23.4
Japanese	1	8/20	31.0	20.2	17.3	22.8
Japanese	2	8/20	34.4	14.0	19.8	22.7
C. I. 91	6	9/8	10.2‡	25.8	18.5	18.2
Silverhull	5	8/21	24.2	13.5	16.5	18.1
Silverhull	4	8/20	17.9	11.9	14.9	14.9

*Number of plats of each variety in 1921—10; in 1922—5; in 1923—5.
**Number of check plats grown in 1921—66; in 1922—21; in 1923—21.
†Average of two plats.
‡Average of four plats.

The last column of Table IX shows that each of the Japanese strains gave an average yield greater than C. I. 91, or the two representatives of Silverhull. This is a significant fact. In a former investigation made on the Agronomy Farm Stemple* found that the Japanese variety gave a higher yield than Silverhull.

The third column of Table IX shows that C. I. 91, was somewhat later in maturing than Japanese or Silverhull. Each year all the varieties were seeded on the same day but C. I. 91 was harvested, on the average, about three weeks later than Japanese and Silverhull.

*Stemple, F. W. Experiments with Buckwheat. W. Va. Agricultural Experiment Station Bulletin 171, 12 pp. 1919.

SUMMARY OF THE EXPERIMENTS

Varietal experiments were carried on with wheat, oats, rye, barley, and buckwheat at Morgantown for three years; with wheat, oats, and rye at Maggie for two years; and with oats at Aurora for two years.

Reliable 80 and Ohio 127 or Fulhio were among the four highest yielding varieties of winter wheat both at Morgantown and at Maggie. In average yield Ashland and Fulcaster ranked first and third at Morgantown, and Trumbull and Gladden ranked second and third at Maggie.

A pure line selection of Sixty Day oats made at the Minnesota Agricultural Experiment Station and named Gopher was one of the highest yielding varieties at each of the three places where varietal experiments were performed. At Morgantown and at Aurora, Iowa 103 or Albion was in the high yielding group. Gopher possesses considerably stiffer straw than Albion and hence is less likely to lodge. In general, early maturing varieties of oats are better adapted than late maturing ones to West Virginia conditions.

In a two-year test at Morgantown, Rosen rye produced a higher average yield than Abruzzes and Minnesota 2, whereas at Maggie, Abruzzes produced the highest average yield.

Manchuria gave a higher average yield than any of the other varieties of spring barley grown at Morgantown. The two varieties of winter barley grown at Morgantown and at Maggie were damaged considerably by winter-killing.

Japanese buckwheat produced a higher average yield than the other varieties grown at Morgantown during the three-year period, 1921-23.

APPENDIX

In order to obtain an idea of the significance of the difference between average yields reported in this bulletin probable errors were computed. In making these computations the yields of the varieties and of the checks which grew among them were used. The experiments on the Agronomy Farm only were considered.

Numerous checks were systematically distributed among the varieties so that the yields of the former would give an indication of the variability of the particular experimental field for a certain year. No checks were used in the barley trials nor in the oat test of 1921. The yields of the individual check plats of the wheat nursery in 1921 were not available owing to an error in threshing. Relatively few check plats were used in the wheat varietal experiment in 1923 and in the buckwheat varietal experiments in 1922 and 1923.

To obtain a measurement of variability in a particular experiment the yields of the checks were thrown into a frequency distribution and the probable error of a single determination calculated with the aid of the formulae ordinarily used.* The probable error of a single determination so obtained was expressed in percentage of the mean yield of the checks in order to facilitate comparison with a probable error based on the yields of the individual plats of the different varieties among which the checks grew.

A method for computing the probable error based on the yields of the varieties under test has been suggested recently.† The average yield per plat of each variety is first determined and then the deviation of the yield of each plat of a particular variety is expressed in percentage of the mean yield of that variety. In this way a deviation which is expressed in percentage is calculated for each plat of the varieties under test. These percentage deviations for all the varieties are collectively treated and the foregoing formulae are applied to determine the probable error of a single determination.

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*The formulae used were: S. D.$=\sqrt{\frac{Sd^2}{n}}$ Es$=0.6745 \times$ S. D.

In these formulae S. D. Indicates standard deviation, Sd^2 summation of deviations squared, n the number of variates, and Es the probable error of a single determination.

†Hayes, H. K. Controlling Experimental Error in Nursery Trials. In the Journal of the American Society of Agronomy 15:177-192. 1923.

This method bases the probable error of a varietal experiment upon the variability of the yields of the plats used to grow the varieties rather than basing it upon the variability of the yields of contiguous plats as when checks are used to determine the probable error. In the former method it is assumed that all varieties are equally variable, an assumption which is not entirely justifiable but one which probably does not introduce a serious error. When the checks are used to calculate the probable error a smaller number of variates is usually available than with the other method.

In Table X the probable errors calculated by the two methods just discussed are tabulated for each varietal experiment. For a particular experiment there is in general a close correspondence between the probable error based on the yields of the checks and that based on the yields of the varieties other than the variety used as a check. This relationship between the two probable errors does not obtain for the wheat varietal experiment in 1923 and the buckwheat varietal experiment for 1921. In both cases the probable error based on the yields of the varieties is considerable greater than that based on the yields of the checks.

TABLE X.—The Probable Errors in Percentages for Varietal Experiments Which Were Performed on the Agronomy Farm as Measured by the Yields of the Checks and by the Deviations from the Mean Yield of Each Variety Except the Checks.*

Crop	Year Grown	Basis of Comparison			
		Checks		Deviations from Mean Yield of Each Variety Except the Checks	
		Number of Plats	Probable Error Percentage	Number of Plats	Probable Error Percentage
Wheat	1921			160	11.6
	1922	41	9.5	90	9.0
	1923	20	12.9	80	18.9
Oats	1921			135	10.8
	1922	50	8.6	220	7.4
	1923	51	12.8	205	11.3
Buckwheat	1921	57	8.0	56	16.0
	1922	21	9.6	35	9.3
	1923	11	16.0	35	16.4

*All computations were made by the aid of a calculator and checked separately by two persons. The authors are indebted to B. L. Wade, a graduate assistant, for aid in making the calculations.

For the wheat experiments in 1922 and 1923 the average probable error based on the yields of the checks is 11.2 per cent and that based on the yields of the varieties is 14.0 per cent. The average of all the probable errors calculated for this crop is 12.4 per cent.

For the oat experiments of 1922 and 1923 the probable errors based on the yields of the checks are somewhat greater than the probable errors based on the yields of the varieties. The average probable error for the oat experiments, irrespective of the method of calculation, is 10.2 per cent.

The buckwheat varietal experiments show considerable variability with respect to the probable errors. The number of plats involved in these experiments is relatively small. The average of all the probable errors calculated for the plat yields of buckwheat is 12.6 per cent.

The probable errors mentioned above show that the average probable error of a single plat yield for the varietal experiments reported in this bulletin is somewhat greater than 10 per cent. If the average probable error of a single plat yield is 10 per cent the question arises, what is the least difference in yield which may be considered statistically significent between varieties that have been grown in four systematically distributed plats.

The usual procedure in such cases is to divide the probable error of a single determination by the square root of the number of variates. In this particular case the number of plats is four, hence to obtain the probable error of the average, 10 per cent is divided by $\sqrt{4.}$ The quotient is 5 per cent. Since the probable error of a difference between two quantities, each of which is liable to the same probable error is equal to the product of that probable error times $\sqrt{2}$ and since a difference should be at least three times its probable error to be significant, 5 per cent, or the probable error for the average yield of four plats, is multiplied by $3\sqrt{2.}$ The product is about 21 per cent. On the basis of a yield of 25 bushels the least number of bushels that constitutes a significent difference is 21 per cent of 25 bushels or approximately 5 bushels.

In the same manner a least significant difference between average yields may be determined for each experiment each

year. By means of the least significent difference so determined it is possible to ascertain the significantly lower yielding varieties. The varieties which fall into this group for each of several years may be considered, with a high degree of certainty, as distinctly inferior yielders for the particular conditions.

Another method which may be used to determine the significance of a difference between averages has been explained by Student.* This method was evolved to measure the realiability of averages based on a small number of variates and hence is particularly applicable to most plat experiments. A few investigators have used this method in connection with field experiments and it likely will find a more general use in the future.†

The method may be illustrated by taking an example from Table I. To determine the significance of the difference between the average yields of Ashland and Ohio 127 the procedure is as follows:

	1921	1922	1923	
Yields of Ashland	19.9	28.2	24.8	
Yields of Ohio 127	19.7	29.0	19.6	
Algebraic differences	+0.2	—0.8	+5.2	
Mean difference				+1.5
Standard deviation of differences				2.6

M(1.5)/S.D.(2.6)=0.58

Now, looking up the value of Z(0.58) under n=3 in the table of probabilities, we find by interpolation that it is 0.751, The odds are about 3 to 1 that the difference between these two varieties is significant.

Applying a similar test to the difference between the average yields of Ashland and Kentucky Selection, both of which were introduced from the Kentucky Agricultural Experiment Station, we find that the odds are 17 to 1 that the difference in

*Student. The Probable Error of a Mean. In Biometrika 7:1-12. 1908. Tables for Estimating Probabilities Based on Small Samples. In Biometrika 11:414-417. 1915-17.

†Since this bulletin was written two papers dealing with Student's method have appeared. For the advantages of the method see Love, H. H., and Brunson, A. M. Student's Method for Interpreting Paired Experiments. In the Journal of the American Society of Agronomy 16:60-68, 1924. For some of the limitations to the method see Salmon, S. C. Some Misapplications and Limitations in Using Student's Method to Interpret Field Experiments. In the Journal of the American Society of Agronomy 16:717-721. 1924.

yield is owing to inherent characteristics of the varieties rather than to chance. In this way any two varieties of the wheat experiment may be compared.

The above two instances of the application of Student's Method serve to illustrate the method and at the same time show the need of care in interpreting field experiments, particularly ones which have been carried on for a short time only.