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Experiments with Winter Wheat

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EXPERIMENTS WITH WINTER WHEAT.

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THE AGRICULTURAL EXPERIMENT STATION

OF THE UNIVERSITY OF TENNESSEE.

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EXPERIMENTS WITH WINTER WHEAT.

ANDREW M. SOULE and PHARES O. VANATTER.

INTRODUCTION.

The growing of winter wheat is an industry of considerable importance to the farmers of Tennessee. At the same time, the average yield per acre is exceedingly low, being between eight and nine bushels, though on numerous farms in the State an average yield of twenty-five to thirty-five bushels is often secured. This indicates that our climate and soil are favorable for the production of excellent crops of this important cereal when properly handled and fertilized. It emphasizes the fact that there is a lack of intelligent information concerning this industry or the average yield in this State would be materially improved. This seems ample justification for the series of experiments undertaken by this Station with regard to wheat production.

SHOULD WHEAT BE GROWN.

It is thought by many that wheat growing should be abandoned in this State because we can not successfully compete with the rich lands of the western states in the production of this cereal. There are some compensating influences, however, that should be kept in mind. The western soils have lost much of their virgin richness and from this time forth will require the use of artificial fertilizers. Then, wheat produced in many sections of Tennessee is especially valuable from the fact that it yields a superior grade of flour that bears shipment through the equatorial regions. In addition, every farmer should at least produce all the wheat needed for the family supply of flour. Tennessee at the present time does not produce nearly enough wheat to supply the home markets, and this condition should be quickly reversed. It is probably true that our climate, taken one year with another, is more favorable for the production of winter wheat than in the case of some of the western states; that is, we are less likely to suffer the loss of the winter wheat crop from violent climatic changes. Again, wheat has a peculiar value in a rotation of crops, and especially in a climate so well adapted for the growth of a variety of valuable legumes to furnish free atmospheric nitrogen and to add humus to the soil in the most desirable form. Then, it has the further virtue of being a ready money crop and of giving the farmer cash at the time of the year when he most needs it. Last of all, it furnishes a considerable quantity of straw that may be used with advantage for bedding, giving bulk to the barnyard manure which is the most important and economical fertilizing medium at the farmers command.

OBJECTS OF THE EXPERIMENTS.

The purpose of the experiments undertaken at this Station is to study, primarily, methods of seed selection and plant breeding with the object of

engrafting new and desirable characteristics and giving permanence to those already possessed by the leading varieties of wheat. Some attention of course, must be given to the question of variety. In the present tests the idea was to collect some of the best varieties of wheat grown in Tennessee and to the north and south of this State. A number of varieties highly esteemed by the farmers were also obtained and tested alongside of the newer varieties and with those that have given excellent results in other sections of the country for the purpose of securing, if possible, a more prolific variety adapted to Tennessee conditions. The plan, therefore, is to continue growing only those varieties that give entire satisfaction, to limit the whole number grown to about fifty, and to test such new ones of known and promising origin as may be available. Some attention will be given to a study of foreign wheat from the fact that occasionally a variety introduced into a new soil and climate proves remarkably prolific.

It is well known that many so-called new varieties are not varieties at all, but specially good fields of wheat selected here and there and offered to the trade under a new name. It is a notorious fact that much of the seed purchased is not true to name, though purchased at exorbitant prices. A great deal of money is squandered every year by the farmers in buying useless varieties of wheat whose characters are not clearly established. The percentage of germination of much of the grain sold is away below the "standard," and in addition to this, a part of the weight of the seed is generally made up of obnoxious weeds and trash. It is economy for the farmer to grow his own seed and maintain its virtues by the practice of a rigid selection, or to buy only from reliable seedsmen who will furnish guaranteed seed. It is extreme folly to buy seed simply because they can be purchased cheaply. Not long ago the writer saw two fields of timothy, the seed being secured from two different sources. The one yielded five tons per acre; the other two, and that half white weed, ox-eyed daisy, etc. It is hoped, therefore, that this work may demonstrate to the farmer the feasibility of seed selection and the fact that he can maintain the virtues of a variety by giving it proper attention. If this can be done it will effect a remarkable saving to the farmers of the State. Other topics considered in these experiments were the influence of the date of seeding on the yield and on the attacks of the Hessian fly, the rate of seeding, the influence of wide and narrow rows where culture and no culture were practiced, and the results of fertilizer tests.

THE PLATS.

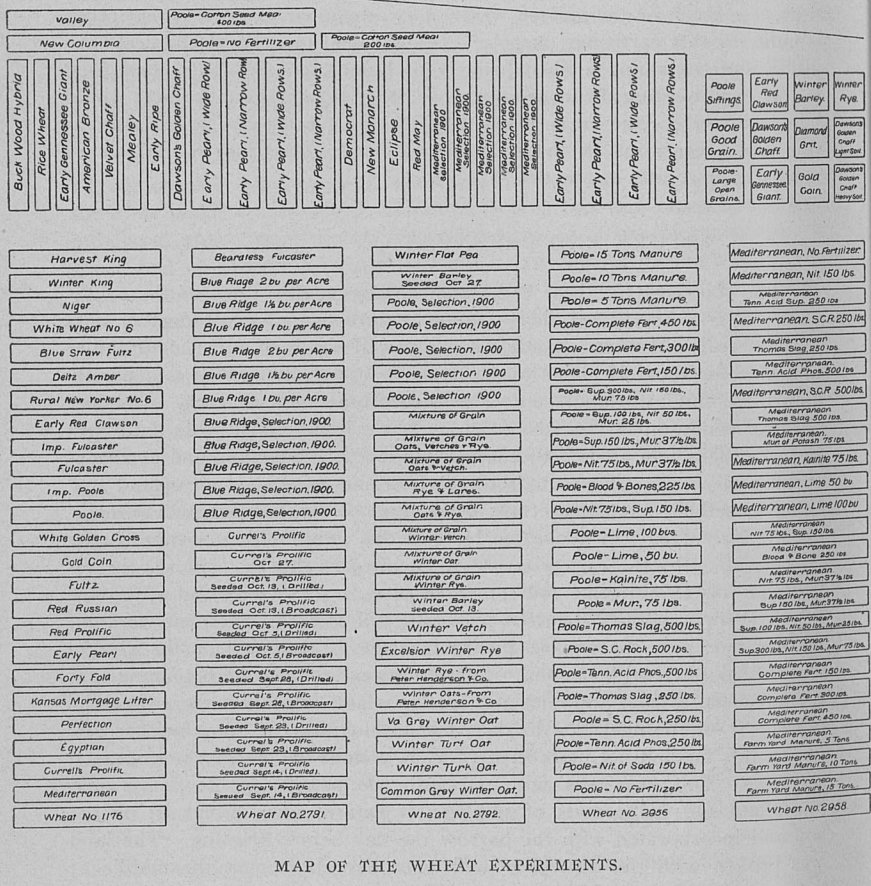
One hundred and fifty plats, ten links wide by 100 links long or 1-100 of an acre in area were devoted to this work during the past season. Paths five links wide were left between consecutive plats and roadways twenty links wide between contiguous ranges. All the plats used in the work were surveyed off and stakes driven at the four corners. A strong cord was then run around these stakes and the grain seeded broadcast at the rate of two bushels per acre on October 2. The fall of 1899 was very dry but the careful preparation of the ground had provided sufficient moisture to produce quick germination and all the plats had a uniform stand. As

this work is new to many of the farmers of this State, it may be well to explain why small plats are used. 1. In a field where 500 plats are devoted to experimental tests, it would be impossible to carry on the work on a larger scale, because the amount of seed to be kept separate and the labor involved in threshing and handling the same on large plats would be too great. 2. A test maintained for several years on the same plat of land will give results so uniform that they will compare favorably with those obtained on large areas. 3. If the objection that small plats give too high yields is admitted, the case is not materially altered as the leading varieties on the small plats will generally maintain their position in field tests. 4. Much of the soil on which it is attempted to grow wheat crops is unfit for this particular purpose. 5. Only land in good mechanical condition and containing a liberal supply of humus and available plant food can be expected to grow large crops. In other words, if our farmers would materially reduce the areas cultivated and give greater care to the cultivation and preparation of the soil and its fertilization, they would secure much better results in practice.

NATURE AND PREPARATION OF THE SOIL.

The soil used for these experiments slopes gently towards the southwest. It is a heavy, red clay of good texture and of great depth. It is fairly retentive of water, stands a drought well and is of sufficient friability to enable the roots of plants to penetrate it freely. It is what is generally known as "mulatto land" and is derived from dolomite rock. The mechanical condition of this soil was very fair. It lies well and is quite uniform in character. It is well adapted for wheat production, and as an experimental area is fairly satisfactory. It would be termed an upland soil, being something like 100 feet above the level of the Tennessee river, making it nearly 1100 feet above sea level at this point. That portion of the land occupied by the variety tests was in cowpeas the year before; the remainder was an old grass sod composed of several varieties and of a number of years standing. The cowpeas were not plowed under but were cut off and fed; only the stubble and such waste as remained on the ground was incorporated with the soil. It was noticeable from the beginning that this area had greater friability and looseness and a better texture than the other part of the field, due to the rank development of the cowpea roots, but by this method not more than 15 to 25 pounds of nitrogen was secured per acre. This area was fertilized with 300 pounds of Tennessee acid phosphate and 100 pounds of sulphate of potash, sown broadcast on the soil and incorporated with the harrow the day before planting. The land was broken with the disk plow with subsoiler attachment the middle of August to a depth of fifteen inches. The land was drier than was desirable for breaking, but the advancing season made this action imperative. It was naturally very "lumpy" and was immediately rolled and harrowed to compact it and conserve the moisture. It was thoroughly rolled and cultivated with implements, tending to produce a fine texture and a deep and uniform seed bed, every week until the time of planting—from September 15 to October 1.

The early and thorough preparation of the land is of the utmost importance in wheat production. By breaking early and deep and cultivating it constantly, all the rain that falls can be absorbed and thus furnish an abundance of moisture for quick germination and a vigorous succeeding growth. The importance of mechanical condition in crop production can not be overestimated. It has been demonstrated time and again that tillage alone will produce magnificent crops even on moderately rich soils for



MAP OF THE WHEAT EXPERIMENTS.

years. It is fair to observe that the wheat growing on the portion of the field occupied by the several species of grass sod was affected somewhat. This is a new and interesting point and indicates that certain varieties of grass may injure the soil for succeeding crops very materially. This is a matter, therefore, that should be carefully considered, as it may often explain why a crop has failed when other satisfactory reasons can not be

adduced, and it is the first time that the pernicious influence of certain grasses has been observed.

APPEARANCE OF THE PLATS.

Twice during the growing season careful notes were made on the general appearance of the wheat, namely, on November 22, 1899, and April

TABLE I.—Results of Experiments with Varieties of Winter Wheat, 1900.

Varieties		Date of Ripening	Kind of Head	Color of Grain	Length of Straw—inches	Yield per Acre of		Weight per Measured Bushel—Pounds
Number	Name					Straw Tons	Grain Bushels	
		June						
1	Fulcaster	13	Bearded	Red	46	2.20	41.66	60.25
2	Early Gennessee Giant	14	Bearded	White	38	2.10	41.45	57.5
3	mproved Fulcaster	13	Bearded	Red	46	2.01	41.25	59.0
4	Niger	12	Bearded	Red	44	2.23	40.62	58.5
5	Fultz	11	Bald	Red	44	2.04	40.20	60.5
6	Poole	12	Bald	Red	42	1.24	40.20	60.25
7	Harvest King	11	Bald	Red	42	1.70	39.79	61.0
8	Perfection	11	Bald	Red	41	1.42	39.16	60.0
9	Deitz Amber	13	Bearded	Red	44	2.58	38.95	60.0
10	Improved Poole	12	Bald	Red	42	2.33	38.95	59.5
11	White Golden Cross	15	Bearded	White	39	1.59	38.54	59.0
12	Egyptian	14	Bearded	Red	46	2.11	37.70	60.0
13	Currell's Prolific	11	Bald	Red	44	2.12	37.50	59.5
14	Red Prolific	11	Bald	Red	43	1.32	37.50	58.5
15	Mediterranean	12	Bearded	Red	46	1.65	36.45	60.5
16	Red Russian	12	Bald	Red	42	1.83	33.75	59.0
17	Kansas Mortgage Litter	13	Bearded	Red	43	1.99	33.54	60.25
18	Early Red Clawson	19	Bald	Red	41	1.26	32.91	57.5
19	Rural New Yorker, No. 6	14	Bald	Red	38	1.83	32.29	56.0
20	Blue Stem Fultz	11	Bald	Red	47	1.65	31.66	60.5
21	Gold Coin	15	Bald	White	27	1.20	30.00	56.25
22	Winter King	15	Bald	White	37	2.48	29.58	57.0
23	White Wheat, No. 6	15	Bald	White	37	2.46	29.37	58.0
24	Early Pearl	9	Bald	Red	47	1.37	29.16	60.0
25	Velvet Chaff	11	Bearded	Red	35	1.65	28.33	61.5
26	American Bronze	12	Bald	Red	37	.79	26.87	59.5
27	Mealey	11	Bald	Red	34	.71	26.25	58.5
28	Beardless Fulcaster	12	Bald	Red	39	1.57	25.83	58.0
29	Blue Ridge	12	Bearded	Red	49	.86	25.41	58.0
30	Farly Fold	15	Bald	White	36	.84	25.20	57.5
31	Red May	11	Bald	Red	39	1.53	23.75	60.5
32	Early Ripe	12	Bald	Red	38	.78	23.75	60.0
33	Dawson's Golden Chaff	11	Bald	White	33	1.12	20.83	57.5
34	New Columbia	9	Bald	Red	36	1.26	20.60	57.5
35	Rice Wheat	11	Bald	Red	48	2.79	19.37	58.0
36	Democrat	12	Bearded	White	37	1.30	18.33	58.0
37	Eclipse	12	Bearded	Red	35	1.02	17.08	58.0
38	New Monarch	12	Bald	Red	36	1.26	16.25	57.5
39	Buck Woods' Hybrid	12	Bald	Red	48	2.03	13.85	57.0
40	Valley	12	Bearded	Red	39	1.05	13.75	56.0

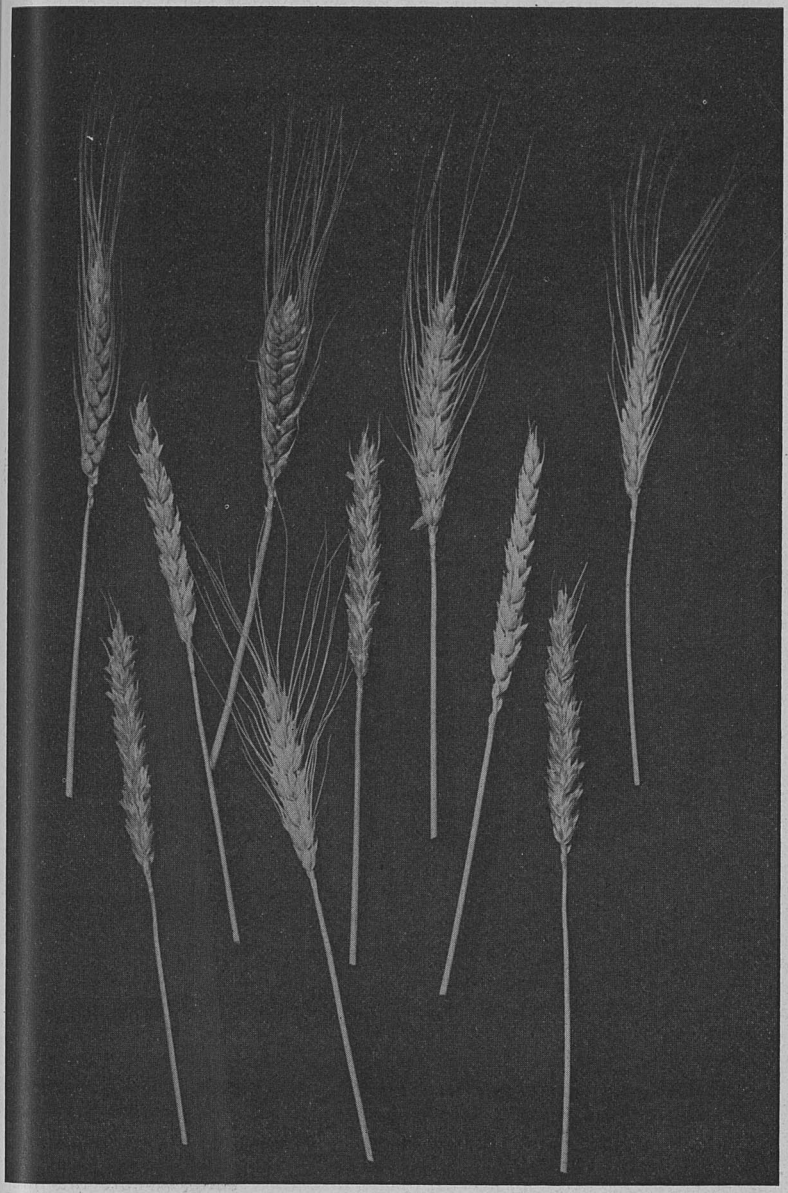
2, 1900. The stand was uniformly good and the growth vigorous and most of the varieties were healthy and strong. In fact, it seemed rather remarkable how little difference there was in the general character of the wheat during this period of the experiment. No advantage was secured by any variety on account of location and none of the plats suffered any injury, and very little, if any, of the wheat was hurt by the Hessian fly. The wheat was not treated for smut before seeding, but comparatively little of this was found. On examining the plats, Kansas Mortgage Lifter showed the most, with one and one-half per cent, while Mediterranean and Perfection followed quite closely. No smut was observed on Early Pearl or Red Prolific, while but four to eight heads with smut were seen in Early Red Clawson, Fulcaster, Fultz, Egyptian and Forty Fold. From sixteen to fifty heads were effected in Rural New Yorker No. 6, Gold Coin, American Bronze, Red Russian, White Golden Cross, etc.

VARIETY TEST.

In Table I the results of the experiments with varieties of winter wheat will be found. The results presented in this table must be regarded as preliminary in nature, and as indications, for the immediate planting season, as they constitute but one season's work. Our object in publishing this paper was to try and supply in part the demand for information concerning this important topic.

It will be seen that forty American grown varieties were tested. Four Russian varieties were grown, but the yields were unsatisfactory. Some of them are quite promising, and another year when they have become better acclimated may give results of value. In the table will be found the dates of ripening; kind of head, whether bald or bearded; the color of the grain; the height of the crop in inches; the yield of straw and grain per acre, and the weight per measured bushel. Most of the varieties tested possessed good straw and only in one or two instances did they go down. They were also comparatively free from rust. The dates of ripening varied from the 9th to the 15th of June, most of the wheat ripening on the 11th and 12th. The yield from the bearded and bald varieties was practically the same. Most of the wheat tested was red. This was more by accident than design, though we favor the red varieties, an opinion concordant with that of the miller's report. This is not intended to discredit the value of the white varieties, as many of them are noted for prolificacy and for producing a large, handsome grain.

The height of the crop varied from twenty-seven to forty-seven inches. The height of the wheat did not effect the yield, as there was only an extreme difference of eight inches between the height of the first nineteen varieties on the list. The yield of straw per acre varied considerably, from about .71 to .79 with Mealy and Velvet Chaff to 2.79 tons with Rice wheat. The leading varieties of wheat produced from one and one-half to two and one-half tons per acre, with the average running pretty close to two tons. Fulcaster led in the yield of grain, with 41.66 bushels per acre. This was followed very closely by Early Gennessee Giant, with 41.55; and Improved Fulcaster, with 40.25. The first six varieties of wheat, including the above and Niger, Fultz and Poole, averaged over forty bushels per



Fulcaster. E. Gen. Giant Improved Fulcaster. Niger.
Fultz. Poole. Harvest King.
Perfection. Deitz Amber. Improved Poole.

HEADS OF THE TEN LEADING VARIETIES OF WHEAT.

acre. The next, Harvest King and Perfection, over thirty-nine bushels; and Deitz Amber, Improved Poole and White Golden Cross over thirty-eight bushels. From this point on there was a gradual falling off, but it was not until No. 22 had been reached that the yield fell below thirty bushels. From one year's test, Valley, Buck Wood's Hybrid, New Monarch, Eclipse, Democrat and Rice, with yields varying from 13.75 to 20.12 bushels per acre, can not be classed with the leading varieties and they are not deserving of trial at the hands of our farmers until further tests have been made here.

Considering the weight per measured bushel, Velvet Chaff heads the list with sixty-one and one-half pounds, while Valley was the lowest with fifty-six pounds. Buck Wood's Hybrid and Winter King were the next lowest with fifty-seven pounds; while three of the varieties making the best yields, Early Gennessee Giant, Improved Fulcaster and Niger, were below the "standard." Fultz, Poole, Harvest King and Deitz Amber were all equal to or above the "standard," though yielding more than thirty-nine bushels per acre.

The best milling wheat among the fifteen varieties which gave the largest yield of grain, according to Mr. T. W. Scott, of the Knoxville City Mills, are Fulcaster, Niger, Mediterranean, Improved Fulcaster and Deitz Amber. The poorest varieties were White Golden Cross, Early Gennessee Giant and Fultz. The weakest strawed variety was Egyptian and the stiffest strawed, Early Gennessee Giant. In general appearance, there was no plat surpassed Fulcaster, except that it seemed to be a little thin on the ground, but the heads were very large and gave the plat a fine appearance. There is really very little to be said under the head of general remarks, because the wheat was all standing when harvested, there was practically no smut, and all the plats were in a good, healthy condition throughout the experiment.

Some interesting conclusions may be drawn from the results shown in this table. Buck Wood's Hybrid and some of the other varieties in this list are grown largely by the farmers of Tennessee. When grown in comparison with forty other varieties under uniform conditions and on carefully prepared land, several of them failed to yield more than one-third as much as the leading varieties. It seems that this fact should be worth a great deal to our farmers and it emphasizes beyond any question that some varieties are better adapted to our soils and climate than others, and when well treated they will give remarkably good yields. If good seed, true to name, of the leading varieties of wheat grown in these trials were used by our farmers in place of some of those now employed, the average yield of their wheat would be increased anywhere from five to ten bushels per acre the coming year. Other things being equal, the wheat that ripens the earliest and can be placed on the market in the shortest time is to be preferred. It is also interesting to note the fine showing that the red wheats make, as they seem to be most useful in our climate. The fact that the amount of straw on the ground did not materially effect the yield is also interesting, and it is of course highly important to secure the greatest weight per measured bushel compatible with large yields.

FERTILIZER EXPERIMENTS WITH WINTER WHEAT.

The soil used in this experiment and its previous management has already been described, and the only feature detracting from this work was the influence of the several grasses previously mentioned. When it is remembered that this work was all done in duplicate, and that in some instances where a fertilizer failed to show favorable returns,

TABLE II.—Results of Fertilizer Experiments with Winter Wheat for 1900.

Number of Tests	Kind of Fertilizer Used	Amount of Fertilizer used per Acre, lbs.	Length of Straw. Inches.	Yield per Acre of		Gain from Fertilizer—Bushels	Cost of Fertilizer—per Acre	Cost of One Bushel of Increase
				Straw—Tons	Grain—Bushels			
1	No Fertilizer	.....	42.5	1.54	25.41	.....	.....	.....
2	Nitrate of Soda	150	42	1.90	31.66	6.25	$3.00	$ .46
3	Tenn. Acid Phosphates	250	39.5	1.53	27.18	1.77	1.50	.85
4	South Carolina Rock	250	38.5	1.51	26.25	.84	1.50	1.78
5	Basic Slag	250	37.5	1.46	29.37	3.96	1.88	.47
6	Tenn. Acid Phosphates	500	38	1.43	27.18	1.77	3.00	1.70
7	South Carolina Rock	500	39.5	1.52	27.50	2.09	3.00	1.43
8	Thomas Slag	500	38	1.38	28.75	3.34	3.75	1.12
9	Muriate of Potash	75	37	1.30	31.61	6.20	1.69	.27
10	Lime	50 Bus.	36	1.54	31.98	6.57	2.75	.42
11	Lime	100 Bus.	36	.80	28.43	3.02	5.50	1.82
12	Nitrate of Soda Tenn. Acid Phosphates	75 150	36.5	1.36	29.57	4.16	2.40	.58
13	Blood and Bone	225	33.5	1.50	26.56	1.15	2.81	2.44
14	Nitrate of Soda Muriate of Potash	75 37.5	36	1.42	31.87	6.46	2.34	.36
15	Tenn. Acid Phosphates Muriate of Potash	150 37.5	36	.92	29.47	4.06	1.74	.43
16	Nitrate of Soda Tenn. Acid Phosphates Muriate of Potash	50 100 25	37	1.49	33.48	8.07	2.16	.27
17	Nitrate of Soda Tenn. Acid Phosphates Muriate of Potash	150 300 75	39	1.73	33.95	8.54	6.49	.76
18	Complete Fertilizer	150	34	.88	24.68	.73	2.10	2.87
19	Complete Fertilizer	300	35	1.11	27.70	2.29	4.20	1.83
20	Complete Fertilizer	450	35	1.10	29.99	4.58	6.30	1.37
21	Farm Yard Manure	5 Tons	37	1.43	33.12	7.71	2.00	.26
22	Farm Yard Manure	10 Tons	41	1.88	37.13	11.72	4.00	.34
23	Farm Yard Manure	15 Tons	43	1.90	36.56	11.15	6.00	.54

that as many as six plats were taken into consideration, it is evident that the fault did not lie entirely with the soil or its previous cropping. The fertilizer was sown on the plats on October 6. It was done by hand so as to get it uniformly distributed all over the ground and carefully incorporated with the surface soil. The lime was applied after the crop was up. There was not sufficient room in the land available to test the value of organic nitrogen in cotton seed meal, and a separate experiment was

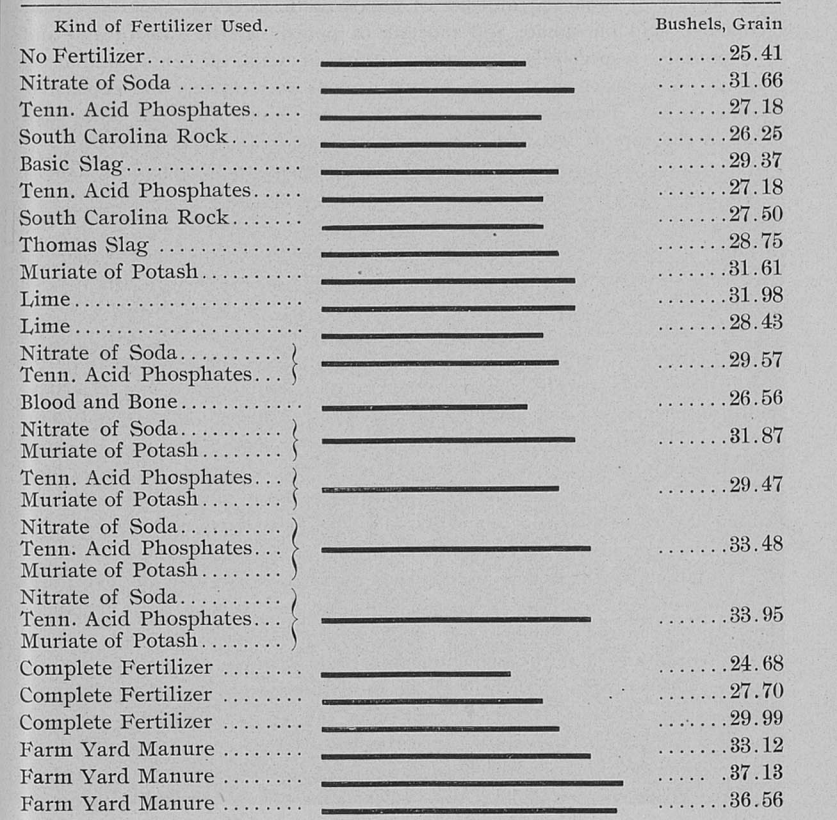
arranged for it, but it was put in so late that the results are not comparable with these tests.

The wheat was sown broadcast on October 7 at the rate of two bushels per acre, the plats being similar to those described in the previous experiments. The soil was in very good mechanical condition and there was sufficient moisture to insure quick germination and a vigorous growth. Observations were taken on the general appearance of these plats twice during the year, on November 30, 1899 and April 2, 1900. The only apparent advantage in location was due to the effects of the grasses already mentioned and this resulted in some of the plats being a little thin on one end, but owing to the favorable season, all the plats picked up and were remarkably uniform at the time of harvesting. Some of the plats were slightly injured by the fly, but none were seriously effected. The plats escaped injury from any other cause and the growth was uniform throughout the year and all presented a healthy, vigorous appearance at all times.

The varieties of wheat used in making all these tests were the Poole and Mediterranean, yielding forty and thirty-six bushels respectively per acre in the variety test. In Table II will be found the results of the fertilizer experiments. It will be seen that fertilizers were used in twenty-three different combinations. The form of fertilizer did not seem to effect the height of the crop materially. The tallest crop was found where barnyard manure was used at the rate of fifteen tons per acre, and next to this where no fertilizer was used. On the plats where nitrate of soda was used, the growth was also vigorous, but there was not enough difference in any instance to effect in any way the yields. The yield of straw produced was the largest on the plots fertilized with barnyard manure.

No fertilizer gave an average yield of 25.41 bushels per acre. In every instance, save one, the use of a fertilizer increased the yield, but in many instances it was too small to be of any value. Barnyard manure was the most effective agent in increasing the yield over no fertilizer. When 10 tons per acre were used, the increase was 11.72; while with 15 tons, it was 11.15 bushels. A complete fertilizer composed of 150 pounds nitrate of soda, 300 pounds Tennessee acid phosphate and 75 pounds muriate of potash increased the yield 8.54 bushels. A complete fertilizer composed of 50 pounds nitrate of soda, 100 pounds Tennessee acid phosphate and 25 pounds muriate of potash increased the yield 8.07 bushels. The highest yield given by a single commercial fertilizer was with 50 bushels of lime, namely, 6.57 bushels; followed closely by 150 pounds nitrate of soda with an increase of 6.25 bushels; while muriate of potash used at the rate of 75 pounds gave an increase of 6.20 bushels. Many of the single fertilizers used failed to improve the yield materially on our soils. The use of nitrate of soda and Tennessee acid phosphate at the rate of 75 and 150 pounds, respectively, increased the yield 4.16 bushels; while nitrate of soda and muriate of potash increased the yield 6.46 bushels. Tennessee acid phosphate and muriate of potash at the rate of 150 and 37½ pounds respectively, gave an increase of 4.06 bushels. A complete "ready-mixed" fertilizer as bought on the market, showed a loss when used at the rate of 150 pounds; 300 pounds a gain of 2.29; and 450 pounds a gain of 4.58 bushels.

The cost of the various fertilizers is shown in the table and is well worthy the careful consideration of every farmer. The cost is figured on the average trade values as agreed upon in the fertilizer bulletins of several Stations for 1900, namely, nitrogen in nitrate of soda at 12½ cents per pound with 16 per cent. available nitrogen, or $40.00 per ton. In Tennessee acid phosphate, South Carolina rock and basic slag, 4 cents is allowed for each available pound of phosphoric acid, making the two former cost $12.00 per ton and the latter $15.00 per ton. In muriate of potash available potash



GRAPHIC CHART SHOWING THE COMPARATIVE VALUE OF THE SEVERAL FERTILIZERS.

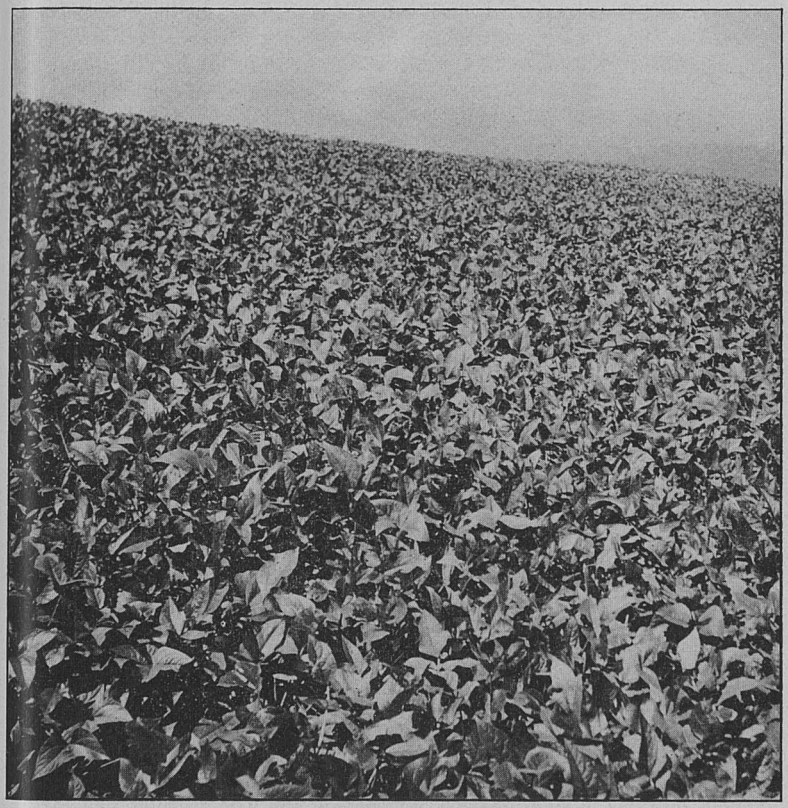
is figured at 4½ cents per pound, making this fertilizer cost $45.00. Lime is figured at the regular price which we pay for it in Knoxville, 5½ cents per bushel. Blood and bone, of which we have no analysis, is figured at the retail price of $25.00 per ton. The complete fertilizer used in these tests retails at $28.00 per ton. Barnyard manure is calculated at 40 cents per ton, the price paid for it in Knoxville. It is worthy of note that the prices assigned for commercial fertilizers are considerably below the retail quotations.

From an examination of the table, it will be seen that the cost of producing one bushel of increase over no fertilizer in this year's trials was 26 cents when five tons of barnyard manure were used. With ten tons of barnyard manure, 34 cents; and with fifteen tons, 54 cents. The next cheapest increase was 27 cents made with a complete HOME-MIXED fertilizer composed of 50 pounds nitrate of soda, 100 pounds Tennessee acid phosphate and 25 pounds muriate of potash. Following this came 75 pounds muriate of potash with a cost of 27 cents per bushel of gain; next, nitrate of soda and muriate of potash with 36 cents; lime, 42 cents; Tennessee acid phosphate and muriate of potash, at the rate of 150 and 37½ pounds, respectively, 43 cents; nitrate of soda, 46 cents; and basic slag, 47. Lime used at the rate of 100 bushels was entirely too expensive, costing $1.82. Tennessee acid phosphate and South Carolina rock used alone at the rate of 250 and 500 pounds, respectively, were unsatisfactory. The complete fertilizer used by us and guaranteed to be a most excellent wheat fertilizer was practically worthless, and the farmer using it could only do so at a heavy loss. Better results were anticipated from the use of blood and bone, but as this fertilizer was applied in what may be termed the raw state, probably it did not have a chance to prove its value during a single season.

The above results indicate that if the farmer is to secure any returns from the use of commercial fertilizers he must study the needs of his crop and his soil very carefully and use the utmost intelligence and discrimination in purchasing and applying the fertilizer, or he will be the loser. The amount of fertilizer to use has been variously stated. The use of large quantities is urged by many, but our results for this year do not favor this method. The use of a moderate amount of a home-mixed fertilizer containing the three essential elements of plant food gave excellent results, as did also the use of five tons of barnyard manure. In most instances where a single fertilizer was used it was unsatisfactory, with the exception of nitrate of soda, muriate of potash and lime, but even in these instances the cost of securing a bushel of increase was rather more than the average farmer could afford at the present price of wheat. The table distinctly indicates in this instance, therefore, the moderate use of home-mixed combinations of artificial fertilizers. Leaving out of consideration the fact that he can buy the necessary constituents direct from the manufacturer cheaper than he can from the local dealer, the farmer is more likely to get the pure goods as handled by the larger firms. It is a common practice for the average retailer to buy, for example, a ton of Tennessee acid phosphate, guaranteed to contain 16 per cent of available phosphoric acid, and by means of a "filler" reduce this to 5 per cent., and in this way make it do service for three tons at as high a price as the farmer should pay for a ton containing the full guarantee. The best practice for the farmers, therefore, is to club together and buy the raw ingredients in carload lots. By doing this and paying cash, they can buy them cheaper, save all commissions, the expense of bagging, etc., and get through freight rates. In conclusion the results of these fertilizer tests should be regarded as suggestive and tentative until further trials have been made.

STOCK HUSBANDRY IMPORTANT.

The results further emphasize the fact that more stock should be kept on the farms of Tennessee and that a greater effort should be made to both produce and take care of that important and best known fertilizer, barnyard manure. Of all the fertilizers used, with possibly the exception of lime, this is the only one that effects the mechanical condition of the soil. The amount of moisture the soil can hold, the rate at which water can move through it or its capillary power, the uniform distribution and



COWPEAS AFTER WHEAT.

development of plant roots in the soil are all effected by the use of barnyard manure. It is well known that the humus or organic matter in barnyard manure in its decay gives lightness, fibre, and friability to the soil, makes it easier to cultivate and gives it increased water holding capacity. Besides this, it enables the uniform distribution of the plant roots through the soil, and as these are the arteries by which the plant feeds, the largest development and most uniform distribution in the soil is to be sought, thus providing a larger area from which to draw their food.

COMMERCIAL FERTILIZERS VS. SOIL TEXTURE.

The question is often asked, does a commercial fertilizer influence the texture of the soil? It does not influence it so far as the mechanical condition is concerned. A commercial fertilizer, as ordinarily understood, does nothing more than stimulate the crop growing on the land for the time being. In other words, by the use of larger amounts of commercial fertilizers a soil can be readily exhausted, because it stimulates the plant so that it will take up all the available food held in the soil as well as that supplied in the artificial form. Lime, of course, flocculates heavy soils and sets free certain elements; and it sweetens acid soils, etc. In these respects it is desirable, but if used continuously it would soon exhaust the soil of certain ingredients, leaving it in a worse condition than before. It should be remembered in looking over these fertilizer results that the crops following after barnyard manure would receive considerable benefit, as only a small

TABLE III.—Results of Experiments with Seeding Wheat at Different Dates, 1900.

No. of Tests	Variety Used	Date of		Yield per Acre of		Average for both dates, Bushels
		Seeding	Ripening	Straw Tons	Grain Bus.	
1	Currell's Prolific	Sept. 14	June 12	1.66	23.54	.....
2	Currell's Prolific	Sept. 14	June 12	.88	28.95	26.24
3	Currell's Prolific	Sept. 22	June 12	1.30	19.16	.....
4	Currell's Prolific	Sept. 22	June 12	.94	18.75	18.95
5	Currell's Prolific	Sept. 28	June 12	.69	23.54	.....
6	Currell's Prolific	Sept. 28	June 12	1.20	26.66	25.10
7	Currell's Prolific	Oct. 5	June 12	.74	25.20	.....
8	Currell's Prolific	Oct. 5	June 12	1.07	26.66	25.93
9	Currell's Prolific	Oct. 12	June 14	1.16	27.70	.....
10	Currell's Prolific	Oct. 12	June 14	1.05	27.29	27.49
11	Currell's Prolific	Oct. 27	June 20	.74	13.54	13.54
12	Currell's Prolific	Nov. 10	June 20	.52	7.50	7.50

portion would be used by the present crop. This will be true of lime, and also of the phosphates where used in large quantities. It would not likely be true of nitrate of soda and the complete fertilizer as bought on the market. With the complete home-mixed fertilizer used at the rate of 525 pounds, however, a good increase was shown, and it is probable that favorable effects would be apparent from the use of this amount another year. There does not seem to be any material difference between the forms of phosphates as used in this experiment. Apparently 250 pounds of Tennessee acid phosphate was more than could be profitably used in this instance, and 500 pounds was entirely out of the question, as it costs too much. It is quite probable that twenty-five bushels of lime would give as good results as fifty, and this would reduce the cost of a bushel of increase with this substance very materially.

In conclusion, therefore, our observations lead us to think that most of our soils will be benefited by a complete fertilizer; that the complete

fertilizer should be applied at the moderate rate of 200 to 250 pounds per acre; that the raw ingredients should be bought and mixed at home and a large saving effected in this way; and that, whenever possible, barnyard manure should be used.

The excellent results secured with our variety tests may be partly attributed to the effect of the previous pea crop on the soil. Nitrogen is the most expensive element the farmer has to buy, and as the legume, such as the pea and bean, has the power of absorbing this element freely from the air by means of the tubercles on its roots, such crops should be grown and plowed under occasionally to supply the necessary nitrogen and give the all-important and essential humus to the soil. It is sometimes stated that there are three essential fertilizing constituents—nitrogen, phosphoric acid and potash, and sometimes lime. In one sense of the word this is true, but in another sense, it is erroneous. Lime will benefit most of our soils if used judiciously, while humus is an essential fertilizing element, because in its decay it aids in freeing unavailable forms of potash and phosphates in the soil. In addition, it effects the whole mechanical condition of the soil, and the relation of the different constituents to one another, and is thus, even if indirectly, one of the most, if not the most, important factor in soil fertility.

SOURCE OF NITROGEN IN COWPEAS.

With regard to the use of the cowpea as a nitrogen gatherer, it is important to explain that most of the nitrogen will be found in the leaves of this plant. It is a mistake to think that it is found in the nodules on the roots. A crop of peas sown in drills and carefully cultivated, if plowed under will provide the soil with anywhere from 75 to 150 pounds of nitrogen per acre. If the same crop is cut off from the soil not more than fifteen to twenty-five pounds will be secured to the soil in the roots, stems and leaves that are left on the ground. This is not sufficient to produce even an ordinary crop of wheat. The best practice is to FEED THE COWPEAS WHENEVER POSSIBLE AND RETURN THE DROPPINGS TO THE SOIL, but this can not always be done, and as humus is so essential, especially in the soils of Tennessee which are depleted of it, it is advisable to plant the cowpeas as early in the spring as possible, cut off the first crop and plow under the second crop or aftermath to be followed with wheat. In this way, sufficient nitrogen can be added to the soil for the needs of the succeeding wheat crop, an abundance of humus will be provided, and a rich crop of green fodder or hay secured.

DATES OF SEEDING.

There has been a good deal of discussion as to the best time of seeding wheat. For the purpose of determining this an experiment was undertaken, the results of which will be found in Table III. The variety of wheat used was Currell's Prolific, seeded in duplicate from September 14th to November 10th. That seeded on September 14th, 22nd and 28th and October 5th was harvested July 12th; and that seeded on October 12th and 27th and November 10th was harvested June 14th and 20th. The yield from all these plats except the last was fairly satisfactory. The average

yield of that sown September 14th was 26.24 bushels; September 22nd, 18.95 bushels; September 28th, 25.10 bushels; October 5th, 29.93 bushels; and October 12th, 27.45 bushels. This year's work indicates that between the 1st and 12th of October would be the most desirable time to seed wheat in this State. None of the plats were effected by the fly to speak of, so nothing was gained from the experiment so far as that point was concerned. But it is evidently too late to sow wheat from October 27th to

NODULES ON THE ROOTS OF THE COWPEA.

November 10th, as it does not make sufficient growth to withstand the effects of the winter freezes. It is a well known fact, however, that one of the best ways to escape the ravages of the Hessian fly is to seed as late as possible, little damage being done after the first hard frost. It is therefore interesting to know that seeding can be done from October 1st to 15th with satisfactory results. The wheat in the experiments was broad-

casted and drilled alternately, at the rate of two bushels per acre. There was but little difference between the yields of wheat broadcasted and drilled. The previous cropping of these plats was cowpeas, but no commercial fertilizer was used in this instance. There was no difference so far as location was concerned and the character of growth was uniform and vigorous all through the season, with the exception of those plats seeded so late that they were injured by the hard freezes.

TABLE IV.—Results of Experiments with Winter Wheat when Intertilled.

No. of Tests	Method of Seeding	Date of Seeding	Date of Ripening	Yield per acre of grain Bushels	Average for both plats Bushels	Difference Bushels
1	Wide	October 4	June 7	23.95	20.67	.....
2	Narrow	October 4	June 7	18.54	18.54	2 13
3	Wide	October 4	June 7	17.39	.....	.....

INTERTILLAGE EXPERIMENTS.

As it is often dry in this State at the time of seeding fall wheat, an experiment was undertaken to study the value of intertillage. Duplicate plats of wheat were sown in wide and narrow rows on October 4th and harvested June 7th. The wheat was harrowed with a Breeds weeder to break the crust, preserve a dust blanket and conserve moisture on October 21st, November 3rd and 27th. The results of the first year's work are shown in Table IV. The wide rows and cultivation gave the best returns,

TABLE V.—Results of Experiments with Winter Wheat when Seeded in Wide and Narrow Rows.

No. of Tests	Method of Seeding	Date of Seeding	Date of Ripening	Yield per acre of grain Bushels	Average for both plats Bushels	Difference Bushels
1	Wide	October 4	June 7	16.14	14.62	.51
2	Narrow	October 4	June 7	15.41	.....	.....
3	Wide	October 4	June 7	13.12	.....	.....
4	Narrow	October 4	June 7	12.81	14.11	.....

there being a gain of 2.13 bushels per acre. As a very large area could be gone over in this way very rapidly and with but slight expense, this experiment indicates that there may be something in this method of culture, but the results this year are inconclusive.

In Table V is given the results of experiments with winter wheat seeded in wide and narrow rows and not cultivated. This was seeded on October 4th and ripened on June 7th. There was but slight difference in the yields of the wide and narrow rows.

RATE OF SEEDING.

The influence of using different amounts of seed on the yield of wheat was made the subject of a separate experiment, the results of which will be found in Table VI. Blue Ridge wheat was sown in duplicate plats on October 4th at the rate of one, one and a half and two bushels per acre. The plats were all harvested June 14th. The results of the duplicate test slightly favors the use of two bushels of wheat per acre, but the difference shown is so small that the question still remains unsettled, though, owing to the attacks of the fly and the probabilities of bad weather, it would be wiser to use two bushels, as a serious mistake is often made in not seeding thick enough. A uniform stand should be the object sought, and a little seed can be wasted rather than fail in this particular.

SEED SELECTION.

As before mentioned, a series of experiments were undertaken for the purpose of improving wheat by means of seed selection. This character of

TABLE VI.—Results of Using Different Amounts of Seed.

No. of Tests	Variety Used	Date of		Quantity of Seed Sown per Acre, Bushels	Yield of		Average of Both Plats, Bushels
		Seeding	Ripening		Straw Tons	Grain Bus.	
1	Blue Ridge	Oct. 4	June 14	1	1.79	23.54	24.68
2	Blue Ridge	Oct. 4	June 14	1½	.69	23.33	24.58
3	Blue Ridge	Oct. 4	June 14	2	.54	23.54	25.41
4	Blue Ridge	Oct. 4	June 14	1	.80	25.83	.....
5	Blue Ridge	Oct. 4	June 14	1½	.92	25.83	.....
6	Blue Ridge	Oct. 4	June 14	2	1.18	27.29	.....

work is of necessity tedious and requires several years to secure results of any value. This is due in part to the fact that it is difficult to secure desirable new characteristics and the permanent engrafting of these is a long and difficult task. In attempting cross fertilization many failures will be encountered for one success. It is a hard matter to determine beforehand the characters in distinct varieties of wheat that will "nick" well when crossed, and this makes the work rather empirical in nature and uncertain in its results. While considerable attention was therefore given to this subject the past year, nothing could be accomplished beyond securing the seeds on which to base our future work, and this accounts for the fact that nothing is offered for publication concerning this important line of research.

Seeds were sown in duplicate of four promising varieties with a view of studying the following questions: Large, medium and small heads were selected from these plats before harvesting. threshed by hand and the yields determined. The entire plat was then harvested and threshed, and large, medium and small grains selected. The samples secured by these two methods will be sown in duplicate this year and the question of selec-

tion from the head and from the grain for the purpose of improvement will receive consideration in this way.

A comparative test of the yields from coarse open grains, of good, uniform seed and of siftings was conducted in duplicate this year and seeds from these plats will be again sown. In addition, samples of grain as bought on the market were sown and compared with the same seed as carefully selected and freed from weeds and impurities in our seed laboratory. Seeds from all the different plats will be sown in separate rows to study the stooling of the wheat and the peculiarities of the different varieties. The work will be considerably enlarged this year by commencing some original studies in breeding wheat. Particular emphasis will be placed upon this line of investigation as the question of seed selection and improvement is undoubtedly of vital importance to the farmer, as the results secured this year indicate great possibilities for this line of investigation. The idea, therefore, is to first study the utility of simple methods

TABLE VII.—Results of Experiments with Winter Grown Cereals and Legumes.

No. of Tests	Variety	Date of Seeding	Date of Ripening	Quantity of Seed Sown per Acre, Bushels	Yield of Straw Tons	Yield of Grain Bushels
1	Common Gray Winter Oat	Sept. 30	June 30	2	.99	39.31
2	Winter Turf Oat	Sept. 30	June 30	2	.93	22.42
3	Winter Turk Oat	Sept. 30	June 30	2	1.53	21.32
4	Va. Winter Gray Oat	Sept. 30	June 30	2	1.17	20.58
5	Excelsior Winter Rye	Sept. 30	June 23	1½	2.45	51.78
6	Winter Rye	Sept. 30	June 23	1½	2.52	45.08
7	Winter Barley	Oct. 5	May 28	1⅔	not taken	56.66
8	Winter Barley	Oct. 13	June 30	2	"	32.50
9	Winter Barley	Oct. 27	June 30	2	"	21.87
10	Winter Vetch	Sept. 30	Failed	2	.....	.....
11	Winter Flat Pea	Oct. 6	May 28	2½	cut green	weighed 7,500 lbs

of selection that can be effectively employed on any farm for the improvement of both the quality of the grain and the yield of the crop, so that the farmer can grow his own seed, maintain all its good qualities and save the money that he now so often wastes in the purchase of so-called new varieties.

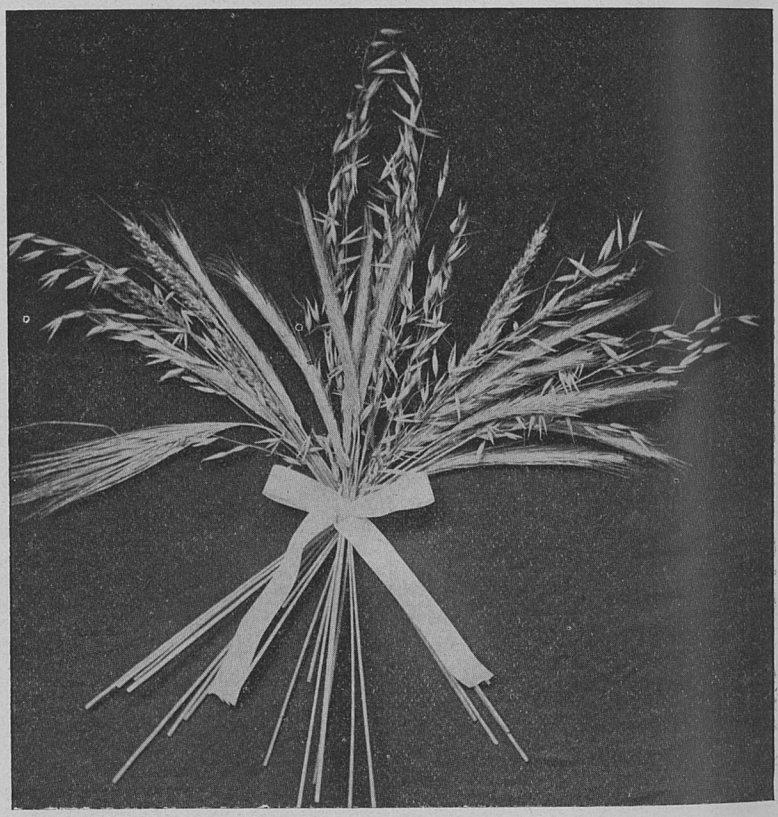
GROWING WINTER CEREALS FOR GRAIN.

In Table VII will be found the results of experiments with winter grown cereals and legumes. Only a limited number were tested this year but those grown gave highly satisfactory results, and by an examination of the table it will be seen that Common Gray Winter oats yielded 39.31 bushels and that the plat of Winter Turf Oats yielded over 22 bushels.

The highest yield of rye was made with the variety known as Excelsior, namely, 51.78 bushels, though Common Winter rye yielded 45.08 bushels. The flat pea gave but indifferent results and the winter vetch was an

entire failure. Highly satisfactory results were obtained with winter barley, the best yield being 56.66 bushels; while other plats yielded 32.50 and 21.87 bushels respectively.

This is one of the most important demonstrations that could possibly be made as it indicates that Tennessee is admirably adapted for the production of winter cereals, such as oats, barley and rye, but especially the two latter. It has been urged that it was necessary to send all the "stockers" produced in this State to the states of Kentucky and Virginia to be fed dur-



A BOUQUET OF WINTER GROWN CEREALS.

ing the winter, as the valleys of Tennessee could not produce sufficient forage and grain to fatten them. This seems to be entirely at variance with the results secured by this experiment, and if the farmers will give careful attention to their soils and grow winter barley, rye, oats and wheat they can produce all the grain needed for fattening cattle during the winter. It is an assured fact that an abundance of green forage for making ensilage, hay and shredded fodder can be produced in this State. If these questions receive the attention at the hands of our farmers that their importance

merits a large and profitable industry in feeding cattle, sheep and swine during the winter months will soon be built up in the valley lands of the State of Tennessee. This means a vast increase in wealth, because the farmer besides producing his own manure becomes his own manufacturer and this means the profitable employment of farm labor during the winter season. In conclusion, it means the building up and reclaiming of much worn out land.

WORK CONTEMPLATED FOR 1901.

It is claimed that some of the varieties of wheat introduced this year from other states will not give as good results a second year. In other words, that when brought to the climate of Tennessee they will degenerate in producing power. In order to test this question this Department will import new seed of a number of the varieties grown and test them with the seeds produced this year on our home plats. In addition, an experi-

WINTER BARLEY.

ment is being planned whereby the influence of changing seeds from heavy to light soils will be studied. It is proposed to select the type soils of Tennessee, grow wheat on the University farm and send it out to be tested on these different soils and then bring it back to the original soil. It is generally believed that seed taken from heavy soils to light soils gives much better results and this experiment is designed to test the accuracy of the statement.

The experiments with winter wheat will be continued this year on an enlarged scale. The fertilizer test will be made more comprehensive, while seed selection and various cultural tests will constitute new lines of work.

SUMMARY OF RESULTS FOR 1900.

1. The results secured on small plats are relatively correct when compared with field trials.

2. The early and thorough preparation of wheat land is of the utmost

importance, as this insures a deep and friable seed bed and an ample supply of moisture for germination.

3. Fulcaster made the highest yield per acre with 41.66 bushels; followed closely by Early Gennessee Giant with 41.35; and Improved Fulcaster with 40.25. In addition, Niger, Fultz and Poole averaged more than forty bushels per acre.

4. Considering the weight per measured bushel, Velvet Chaff heads the list with 61½ pounds. Fultz, Poole, Harvest King and Deitz Amber were all equal to or above the "standard," though yielding more than thirty-nine bushels per acre.

5. The best milling varieties of wheat are Fulcaster, Niger, Mediterranean, Improved Fulcaster and Deitz Amber; while the poorest milling varieties are White Golden Cross, Early Gennessee Giant and Fultz.

6. The weakest strawed variety was Egyptian, and the stiffest strawed, Early Gennessee Giant.

7. In general appearance, Fulcaster was unsurpassed.

8. Such varieties as Buck Wood's Hybrid, etc., should not be used by our farmers until they have been given further trials at the Station.

9. The best results from the use of twenty-two combinations of fertilizers as made were secured with ten tons of barnyard manure which increased the yield over no fertilizer 11.72 bushels.

10. Barnyard manure used at the rate of five tons per acre increased the yield over no fertilizer 7.71 bushels, at a cost of 26 cents per bushel. The results emphasize the fact that more stock should be kept and the manure saved and returned to the soil.

11. A complete HOME-MIXED fertilizer used at the rate of fifty pounds nitrate of soda, 100 pounds Tennessee acid phosphate and twenty-five pounds muriate of potash increased the yield over no fertilizer 8.07 bushels, at a cost of 27 cents per bushel.

12. A ready mixed commercial fertilizer as sold on the local market and used at the rate of 150, 300 and 450 pounds per acre proved unsatisfactory.

13. Commercial fertilizers do not influence soil texture favorably and by their continued use alone the soil may be exhausted. The humus of barnyard manure improves the texture of the soil and aids in the disintegration of useful plant food.

14. Nitrogen is chiefly stored in the leaves of the cowpea plant, and not in the nodules on the roots as many suppose.

15. The best time for seeding wheat is between the 1st and 15th of October.

16. There was a gain of 2.13 bushels per acre from sowing in wide as compared with narrow rows and cultivating with the Breeds weeder.

17. The rate of seeding made but little difference in the yield of wheat, though as a rule it would be safer to use two bushels per acre.

18. The results of growing winter cereals for grain are very satisfactory. Common Gray Winter oat yielded 39.31 bushels; Excelsior Winter rye 51.78 bushels; and winter barley 56.66 bushels per acre. In this way grain can be provided for the winter feeding of farm stock at home.

19. The question of seed selection is of vital importance to the farmer. Use only good pure seeds of such varieties of wheat as the millers want, and which are guaranteed true to name.

20. These results should be regarded as suggestive and tentative as they constitute but one season's work.