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WINTER EMMER.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., August 24, 1911.

SIR: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript entitled "Winter Emmer," prepared by Mr. Mark Alfred Carleton, Cerealist in Charge of the Office of Grain Investigations.

In recent years the cultivation of emmer in the United States has come to be of considerable importance. Heretofore almost the entire bulk of the crop has been made up of spring varieties. In localities where spring grain is not well adapted there is always need of fall-sown varieties. The accompanying paper will therefore be of value to farmers in such districts.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

[A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.]

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WINTER EMMER.

INTRODUCTION.

Emmer has been grown to a considerable extent as a profitable field crop in portions of this country for 15 to 20 years and was known to northwestern farmers probably as early as 1875 or 1880. In recent years its cultivation has greatly increased and it is now found worthy of a place in statistics. There are both spring and winter varieties, but the emmer crop of the United States heretofore has been almost entirely spring sown. This paper treats of winter emmer and the importance of using winter varieties for certain conditions and in certain districts. The general description of emmer, its history, etc., are applicable equally to spring or winter varieties.

USE OF INCORRECT NAMES FOR EMMER.

It is again necessary to protest strongly against the use of incorrect names for emmer, as writers who are supposed to be well informed still persist in using them. The most common word thus wrongly used is "speltz," which does not even exist as a legitimate word in any language. What is meant is the German word "spelz," which is spelled differently and which is translated "spelt" in English. True spelt, however, differs as much from emmer as pears differ from apples. The difference between emmer and spelt is shown in the accompanying illustrations (figs. 1, 2, and 3). The third specimen (*c*) in figure 1 is Black Winter emmer.

CHARACTERISTICS OF EMMER.

Emmer is a species of wheat, known botanically as *Triticum dicoccum* (*T. amyleum*). The plants of this species are pithy or hollow, with an inner wall of pith; leaves sometimes rather broad and usually velvety hairy; heads almost always bearded, very compact, and much flattened at the 2-rowed sides. The appearance in the field is quite different from that of spelt. The spikelets (that is, the unhulled grains as they come from the thrasher), however, look considerably like those of spelt, but differ principally in the presence always of a short, pointed pedicel. (Fig. 2.) This pedicel, which is really a portion of the rachis (stem) of the head, if attached at all

to the spelt spikelets, is always very blunt and much thicker. Usually, however, its pedicel does not remain attached to the base of the spelt spikelet after thrashing; instead, each spikelet carries on its inner face the pedicel belonging to the next spikelet above. (Fig. 3.) Besides, the emmer spikelets are flattened on the inner side and not arched as in spelt, so that they do not stand out from the rachis as the spelt spikelets do, but lie close to it and to one another, forming a solidly compact head. The spikelets of spelt, on the other hand, are placed far apart and, being arched on the inner side, stand out from the rachis, forming a very loose head. The spikelets of emmer are usually two grained, one grain being located a little higher than the

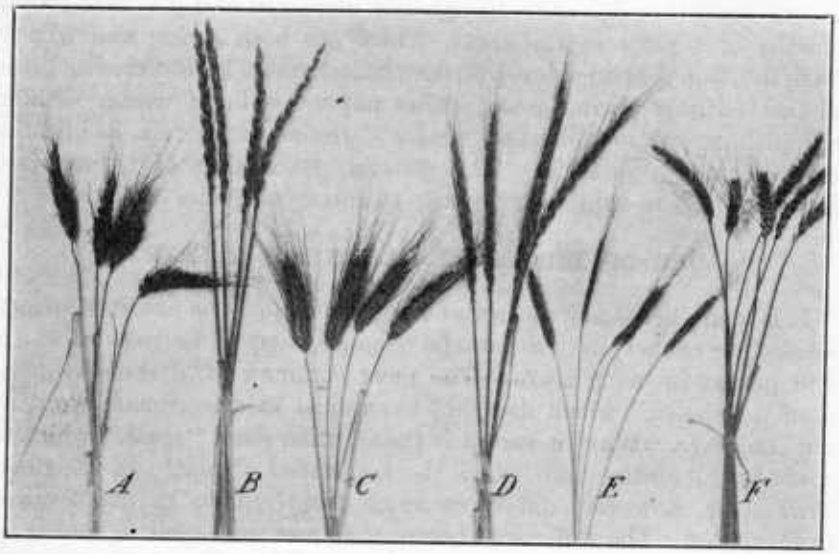

FIG. 1.—Heads of German emmers and spelts: *A*, Black Winter emmer with compound heads; *B*, white beardless spelt; *C*, Black Winter emmer; *D*, black bearded spelt; *E*, double einkorn; *F*, spring emmer.

other. The outer chaff is boat shaped, keeled, and toothed at the apex. The grain is somewhat similar to that of spelt, but is usually harder, more compressed at the sides, and redder. Emmer is a more hardy plant than spelt in every way. Almost all varieties of emmer are considerably resistant to drought, and certain varieties are very resistant to rust. Moreover, emmer is a crop adapted to general conditions, more so than other cereals, and will withstand to a considerable degree the effects of wet weather in humid climates. (Fig. 4.) Fall-sown varieties are also quite winter hardy. Emmer will produce a fair crop under almost any condition of soil and climate, but thrives best in a dry prairie region with hot summers, where it gives excellent yields.

DISTRIBUTION OF EMMER.

The origin of emmer as a cultivated plant dates back to prehistoric times, without much question. It was probably derived from einkorn (*Triticum monococcum*), a still simpler form of wheat, which apparently originated in southeastern Europe and which has very narrow, compressed heads, with usually but one grain to the spikelet.

FIG. 2.—Emmer spikelets, showing short and pointed pedicel attached to base.

Emmer seems to have been found first in Switzerland and is grown in that country at present. It is also grown in Servia, Germany, Russia, Spain, and Abyssinia, and to some extent in France and Italy. A rather large quantity of emmer of excellent quality is produced in Russia each year. All our best seed of spring emmer is obtained from that country, and when grown in our northwestern plains yields a grain entirely equal in quality to that of the original. The average annual production of emmer in Russia is about 10,000,000 bushels. The climate of the upper Volga region seems admirably suited for the growth of this cereal. The varieties grown there are almost wholly of the white-chaff group. In north Caucasus a considerable quantity of red-chaff emmer is produced. Emmer is also grown in Germany to a considerable extent, as is true spelt, hence the two cereals have been much confused, and it is partly for that reason, probably, that there has been such a confusion of names in other countries, into which both emmer and spelt have been introduced from Germany. Several varieties of emmer are grown in Servia, including an excellent white-chaff sort. Often the

FIG. 3.—Spelt spikelets, mostly without pedicel attached to base, but usually with the pedicel of the next spikelet attached to face.

heads in the Servian varieties are rather small. The annual production of emmer in Servia is considerable. Varieties of the white, smooth, bearded group are mostly grown in Germany, Switzerland, France, and Italy. In Abyssinia several interesting varieties are grown at altitudes of 5,000 to 9,000 feet. Judging from certain statements in official reports, the inference is that emmer is also grown in northern India, Tibet, and portions of China, but it has not yet been introduced from those regions into this country.

CULTIVATION OF EMMER IN THE UNITED STATES.

In a previous bulletin, the writer[1] entered into a general discussion of emmer, referring especially to spring varieties. Certain tests of

FIG. 4.—Black Winter emmer (G. I. No. 2337) at the Maryland Agricultural Experiment Station, June 21, 1906.

spring emmer made by different farmers are mentioned, as well as trials at agricultural experiment stations. The results of these trials are summed up briefly on page 11 of the bulletin cited, as follows:

From the trials so far made of emmer, both at the experiment stations and on farms, as well as the plat experiments of this Department, one may draw the following conclusions with respect to its success in cultivation in this country: (1) It is most successful in the Great Plains region, particularly the northern portion, in the Palouse country, and in northern portions of the irrigated districts; (2) in other parts of the country, however, it will often compare well with other crops, and is especially able to escape

[1] Carleton, M. A. Emmer: A Grain for the Semiarid Regions. Farmers' Bulletin 139, U.S. Dept. of Agriculture, 1901.

damage from continued wet weather at harvest time; (3) it stands up well in the field; (4) it is usually very resistant to the attacks of leaf rust,[1] smuts, and other fungi; (5) it is very resistant to drought; (6) in districts where it is otherwise adapted it gives excellent yields; (7) true winter varieties, of which there are not many, resist rather hard winters.

As already stated, emmer, though resistant to drought, and having been introduced more especially for use in semiarid districts, is also fairly well adapted to humid areas; in fact, it is a general-purpose crop with reference to climate and soil. However, in the humid areas and in other districts where the winters are not severe, winter grains are always much more profitable than spring grains where the former can be grown, as they give much better yields and by ripening early often escape the effects of rust, and they also appear to escape attacks of some insects, and may also furnish fall and winter pasturage. It was therefore desirable to introduce and test winter varieties of emmer if these could be obtained.

INTRODUCTION OF WINTER EMMER.

It was known to the writer for some time that winter emmer existed in southern European countries all the way from Spain eastward to Servia. One variety in particular, the Black Winter emmer, has been for many years advertised by a seed firm in Paris, and small samples received from that firm at different times have been planted in the nursery rows of our experimental plats. It was decided to obtain more seed and give this variety a thorough trial. Therefore, in August, 1904, 36 kilos, or about 79 pounds, of seed of Black Winter emmer were obtained from the seed firm mentioned and planted that fall. From the resulting crop the seed was increased from year to year (figs. 4 and 5) and finally distributed under G. I. No. 2337, to experiment stations and a number of farmers throughout the country. The results of all trials made since that time to date have been generally good, though there have been occasional disappointments.

Several varieties of winter emmer are grown in southern Europe. Aside from minor characters these varieties differ from the spring emmers in having a considerably larger head, particularly broader, and a larger and stiffer stem. The leaves and chaff are velvety, that is, covered with many small hairs. There is a good root development and the habit of growth of the plant is that possessed by all winter cereals. The velvety character of the plant, as well as other peculiarities in the structure of the leaves and stem, probably accounts for the fact that this crop is resistant to the effects of wet seasons in the humid areas and also resistant to drought.

[1] A few varieties have been found to rust considerably in certain instances.

ADAPTATION OF WINTER EMMER IN THE UNITED STATES.

Trials of winter emmer have been conducted on experiment farms and quite a number have also been made by farmers.

TRIALS ON EXPERIMENT FARMS.

While emmer has been grown for one or two years in a number of places, the grain-experiment farms controlled wholly or in part by

FIG. 5.—Field of Black Winter emmer (G. I. No. 2337) at the United States Experiment Farm, Channing, Tex., June 14, 1906.

the United States Department of Agriculture have not been running a sufficient length of time to permit tests to extend over any considerable number of years. The only very extensive series are the trials made at the Amarillo (Tex.) Experiment Farm and on the cooperative experiment farm conducted until recently at McPherson, Kans. Even at the Amarillo Experiment Farm the series covered only three years, viz, 1906 to 1908, inclusive. The yields for these three years were as follows:

TABLE I.— *Yields of winter emmer at the Amarillo Experiment Farm, 1906–1908, inclusive.*

G. I. No.	Yield (in bushels).				
	1906	1907	1908	Average.	
				3 years.	2 years.
2337	42.07	32.25	23.30	32.54	
2483		50.37	17.29		33.83

At the McPherson (Kans.) Cooperative Experiment Farm tests with winter emmer were made covering the five years from 1905 to 1909, inclusive, with results as follows:

	Bushels.
1905	18.75
1906	53.33
1907	31.10
1908	77.00
1909	47.20
Average for 5 years	45.47

Mr. V. L. Cory, in direct charge of the experiments at McPherson, in a recent report comments as follows on emmer as grown on this farm:

Neither einkorn nor spring emmer, so far as tested, is of value. On the other hand, our results demonstrate the value of winter emmer. It is resistant to cold and drought, coming through the severely cold and dry winter last year (1909) with a survival of 50 per cent and giving a yield of 47 bushels per acre.

With this grain there is a certainty of producing a fair crop that does not exist in either barley or oats. In bushels per acre it yields more than any other of the small grains, and in pounds per acre it is only outyielded by wheat, which can not be considered as a feeding crop. Again, emmer is scarcely susceptible to leaf rust and not at all to the smuts, and is not readily damaged by harvest rains. If not harvested at early ripening, stem rust usually attacks the plants, but too late to cause much damage.

Emmer and spelt are used for feeding to live stock and compare favorably with oats and barley for that purpose. The large yields produced by these two winter cereals indicate that these grains may be of considerable value in central Kansas for furnishing stock feed.

Before beginning operations at the Amarillo (Tex.) Experiment Farm, investigations had been conducted for three years at Channing, Tex., and during two of these years, 1905 and 1906, Black Winter emmer (G. I. 2337) was grown, giving yields of 47.10 bushels per acre in 1905 and 31.10 bushels in 1906 (fig. 5), or an average for the two years of 39.10 bushels. Concerning this crop at Channing, Mr. A. H. Leidigh, then superintendent of the experiments, commented as follows in a report for the year 1906:

The Black Winter emmer (G. I. No. 2337), also of foreign origin, while not making as striking a showing in 1906 as in 1905, is undoubtedly a valuable introduction and would have shown a higher yield if it could have been cut at the proper time the past season.

In the cooperative grain experiments conducted at Nephi, Utah, between this Bureau and the Utah experiment station, Black Winter emmer has been grown three years with the following yields: 1908, 41.33 bushels; 1909, 42.49 bushels; 1910, 32 bushels. The average for the three years was 38.6 bushels. The weight per bushel has been so far about 30 pounds. In Circular No. 61 of the Bureau of Plant Industry, entitled "Dry-Land Grains in the Great Basin," pages 15–16, the author, F. D. Farrell, comments as follows on this crop:

> Its ability to resist drought has been satisfactorily demonstrated and at Nephi it has proved extremely hardy. * * * The hardiness and drought resistance of Black Winter emmer and its high yield and excellent feeding qualities make it a particularly desirable grain for dry-land farmers who wish to raise their own stock feed.

Black Winter emmer was grown in cooperative experiments conducted with the State experiment station in California during four seasons, 1906 to 1909, inclusive. These experiments were in duplicate at Modesto and Yuba City. The Yuba City experiments in 1908 were transferred to Davis. The yields of the winter emmer at Modesto were as follows: 1906, 13 bushels; 1907, failure; 1908, failure; 1909, 35.3 bushels. Counting the total failures the average for the four seasons was 12.7 bushels per acre. The results at Yuba City and Davis were: 1906, 13.7 bushels; 1907, 24 bushels; 1908, 12.6 bushels; 1909, 52 bushels. The average yield for the four years was 25.6 bushels per acre. The results were therefore fair at Davis and Yuba City, but unprofitable at Modesto.

As previously stated, winter emmer has been tested at several of the State experiment stations, but in no case has there been any considerable number of trials. The few tests that have been made at stations south of the fortieth parallel have as a rule given satisfactory results. No doubt a considerable number of instances with positive results would have been obtained in experiment-station trials if more attention had been given to its distribution in southern latitudes. The idea at first was that winter emmer would be adapted to withstand winters rather more severe than appears to be the case. On looking up the matter more recently it appears that in all tests of winter emmer in European countries it has been found that, although a winter crop, it will not withstand as severe cold as some of the hardier common winter wheats.

TRIALS BY FARMERS.

Winter emmer has not yet been given a very wide distribution. Nevertheless, a number of farmers have had opportunity to grow it, and wherever careful attention has been given and the winters are not particularly severe results have usually been good.

Mr. George W. Oster, of Osterburg, Pa., grew winter emmer in 1908–9 and obtained a yield of 45 bushels per acre. No rust, smut, or insects of any kind affected the crop.

Mr. R. T. Bennett, of Wadesboro, N. C., obtained a yield of about 25 bushels per acre in 1907, when wheat on the same farm yielded 12 bushels per acre. In that locality, of course, winter emmer is winter proof. Mr. Bennett made the comment that "stock prefer the emmer to oats and no weather is too frosty for it."

Mr. A. L. Dunlap, of Lupton, Mich., obtained a yield of 12 bushels per acre in 1910, when the preceding fall from seeding time until winter was very dry. He states that the crop is "very good; better than oats." It weighed 40 pounds per bushel.

Mr. D. L. Davis, of Zenia, Cal., grew winter emmer during the year 1909–10, sowing broadcast at the rate of 70 pounds per acre. A yield of 31 bushels per acre was obtained. Mr. Davis remarks in a report that "it is a great drought resister. It stood the drought equal to rye. It is the surest crop I have found in eight years' trial of grain here. The straw is soft. It fills well, stands up good, and yields better than barley or rye." In February, 1911, Mr. Davis wrote in response to an inquiry from this office: "I have sold every bit of the emmer. I have not even a sample on hand. The people come for 25 miles for seed."

As showing the adaptation of this crop to dry districts it is interesting to report that Mr. S. A. Figart, of Johnson, Stanton County, Kans., in the extreme southwestern part of the State, obtained a yield of 60 bushels per acre in the summer of 1907 from a seeding of only half a bushel per acre. The crop was drilled and was no doubt given good attention in other respects. The same season the other crops of Mr. Figart yielded as follows: Corn, 30 bushels; wheat, 5 bushels; white spelt (true spelt, not emmer), 15 bushels. It should be remarked that a crop of this kind giving such yields is of the greatest importance in this district, where the conditions are such that stock raising must be practiced to a large extent, and emmer has already proved to be an excellent stock feed, easily taking the place of barley, rye, or oats.

EXPERIENCE WITH BLACK WINTER EMMER ON A WYOMING FARM.

The most interesting trial of winter emmer, outside of those conducted on the Federal and State experiment farms, is that on a farm at Worland, Wyo., by Prof. B. C. Buffum, who was formerly director of the State agricultural experiment station at Laramie, Wyo. Having had much experience in experiments with grains as well as other crops, an account of his results with this cereal will be read with much interest.

In the summer of 1907 Prof. Buffum obtained about 2 quarts of Black Winter emmer from the Office of Grain Investigations of this Department and has recently reported his results with this crop, as follows: Portions of this seed were planted at intervals during August

and September on sagebrush bottom land which had been prepared in July; the soil being then dry and loose, the land was thoroughly irrigated before planting. The crop from the earliest planting was 5 to 7 inches in height at the beginning of winter. In the spring of 1908 it was found that only 72 plants had survived, the rest having been winterkilled. Among the survivors were a few which seemed to be of a different type, with large, coarse-growing straw and very large, composite heads which were different in appearance and

FIG. 6.—Increase plat of Improved Winter emmer, 1909. Rows 2½ feet apart and plants about 4 inches apart in the row; yield at the rate of 42½ bushels per acre. Photographed at Worland, Wyo.

of darker color than the ordinary ones. These particular plants were used by Prof. Buffum as the basis for an improved strain of winter emmer. He reports that in the three seasons since 1908 none of it has winterkilled, so far as observed, and that it has come true to the type selected. In the fall of 1908 he planted about four-fifths of an acre of bench land to this strain of emmer. The seed was dropped by hand in rows 2½ feet apart, with only a single seed in a place so far as possible. In 1909 this four-fifths acre (fig. 6)

yielded 34 bushels of seed weighing between 34 and 36 pounds per bushel.

In the fall of 1909 a 10-acre field was sown to this seed. Earlier in the season the field had been sown to Canada peas, but a lack of water and the hot summer prevented the peas from making any profitable growth. A volunteer crop of spring barley and spelt came up and these and the few peas were cut for hay. The ground was then plowed, irrigated, and, in September, sown to the emmer, which made a small growth before freezing weather commenced. The rate of seeding was from 30 to 34 pounds per acre. In the spring

FIG. 7.—Side view of a 10-acre increase field of Improved Winter emmer. The estimated yield of this portion of field was 140 or 150 bushels per acre. The actual yield of the 10 acres was 691 bushels. Photographed at Worland, Wyo.

of 1910 the plants on this field looked thin and scattered, but apparently none had been winterkilled. During the third irrigation of the field a break in the canal left the crop without further water for 26 days. The field yielded 691 bushels, or at the rate of 69.1 bushels per acre. (Fig. 7.) The crop of 1911 was also good, but the actual yields are not yet known.

The most important feature of Prof. Buffum's report is that with reference to winterkilling. As stated, in the spring of 1908 it was found that only 72 plants had survived the winter from the sowing of 2 quarts of the original seed. This natural selection has apparently resulted in the production of a much hardier strain. In the three following crops of 1909 to 1911 little or no winterkilling has occurred.

This strain of winter emmer, therefore, after a trial of three years without winterkilling probably completely establishes winter emmer as a winter-hardy crop in intermountain districts as far north as northern Wyoming, especially as the winter of 1909–10 was unusually severe. As also stated in the report, the 72 plants surviving in the spring of 1908 showed considerable variation in the form of head, some of them being composite. Only about a dozen plants having large composite heads were selected and planted that fall, and from these plants have resulted all the crops since grown. Because of this selection of a comparatively pure strain unusually hardy it is now called the improved winter emmer. From the dozen selected plants of the 1908 crop were produced 34 bushels in 1909 and 710 bushels in 1910, while the present crop (1911), at this date unthrashed, is estimated at about 20,000 bushels. This is an unusual record and somewhat similar to that achieved by David Jones with the Swedish Select oat.[1] It will now be important to test this strain in the Northern States east of the Rocky Mountains, and the results of such tests will be awaited with much interest

VALUE OF WINTER EMMER AS A FIELD CROP.

Winter emmer will be found of much value in a field-cropping system in several ways. Since it is used for stock feeding in the same way as oats or barley, it will be of much use in localities where those crops do not give good results. In a number of the Central, Southern, and Eastern States, where oats do not do so well as in the North and where winter oats would not be hardy, there is considerable demand for a winter cereal to be used as stock feed. This crop should exactly fill that demand. It will ripen earlier than oats, yield better, and may furnish a considerable quantity of fall and winter pasturage when the ground is in condition for turning stock into the field with safety. It will withstand extremes of climate much better than any other cereal. For a large part of the United States, therefore, it may be considered a general-purpose crop so far as climate is concerned, but it will not withstand the winter in the Northern States east of the Rocky Mountains.

In the Rocky Mountain and Pacific coast region winter emmer will be particularly valuable as a stock feed in dry farming, for the reason that often the drought is too great for ordinary crops of oats and barley, but not sufficient to prevent the production of a fair crop of emmer. It can, therefore, be used as a parallel crop to winter wheat, the emmer being grown for stock feeding and the winter wheat for sale. The best results with winter emmer so far have been obtained in intermountain districts.

[1] Carleton, M. A. Ten Years' Experience with the Swedish Select Oat. Bulletin 182, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910 pp. 29–30.

USES OF WINTER EMMER.

In Germany, Russia, and other southeastern countries of Europe emmer is often used as human food. In Russia such use is chiefly in the form of breakfast foods. In other countries it is used to a considerable extent in bread making. In the United States emmer is not yet used for human food, but it may be so used before many years, as it is known to furnish an excellent breakfast food.

A number of experiments in the use of emmer for feeding to stock have been made already at several of the experiment stations with various results. Emmer has usually been found, however, a fairly good food, though in some cases barley or oats appear to be better. To decide accurately between emmer and the other crops, however, one must consider the greater possibility of obtaining a crop of emmer in the drier districts. Several bulletins on the feeding value of emmer have been published by the South Dakota Agricultural Experiment Station, the first results having been published in 1901. In these first experiments it was found that emmer was worth about two-thirds as much per bushel as barley for feeding to fattening lambs as a single-grain ration and that about twice the profit can be realized from fattening sheep on barley as can be obtained from feeding upon emmer under the same conditions, where the expense of caring for the sheep is disregarded.[1] A further conclusion is that emmer is not a proper food for fattening lambs as a single-grain ration.

In 1906 further results were published from this station[2] on the use of proso, or Russian millet, and emmer for feeding calves in comparison with corn and oats. In this instance emmer produced good results as compared with corn. The lot of calves fattened on emmer did not produce as much average daily gain as the lot fattened on corn, but the difference was not great, and during the pasturing period the lot fed on emmer gained 112 pounds more than the lot fed on corn. It required only 5.16 pounds of emmer during this pasturing period to produce a pound of gain, compared with 7.03 pounds of corn. An important feature is that the lot fed on emmer did not consume as much hay per pound of gain as did other lots, showing that the chaff of emmer is a good substitute for hay.

In Bulletins Nos. 81 and 86 of the South Dakota station, results were published, showing that it requires more pounds of emmer to produce a pound of gain, either in butter fat (in feeding to dairy cattle) or in flesh (in fattening range lambs).

In another publication from the South Dakota station in 1907 it was found, among other things, that a pound of corn is equal to 1¼

[1] Chilcott, E. C., and Thornber, W. T. Speltz vs. Barley—A Comparison of the Food Value of Speltz and Barley as a Single-Grain Ration for Fattening Sheep. Bulletin 71, South Dakota Agricultural Experiment Station, 1901, p. 88.

[2] Wilson, James W., and Skinner, H. G. Speltz and Millet for the Production of Baby Beef. Bulletin 97, South Dakota Agricultural Experiment Station, 1906.

pounds of emmer for steer feeding and that where the corn and emmer were mixed half and half by weight the relation was about the same, with a small gain in favor of the mixture.[1] It was also found to be a detriment to feed ground emmer instead of the whole kernel, the palatability of the food appearing to be thus decreased.

In a publication from the Wyoming station in 1909[2] on emmer feeding, using for feeds emmer, barley, and alfalfa, it was found among other things that 27 per cent less alfalfa and 28 per cent less grain were required in a feed for lambs when barley replaced emmer in a ration.

The Colorado station gives an account[3] of interesting trials showing good results from feeding emmer. Of five lots of lambs fed different combinations of food, a lot fed with emmer and alfalfa gave the most profit. The cost per pound of gain of feeding each of the first lots and the resulting profit in each case were as follows:

TABLE II.—*Cost and profit in feeding lambs with different feeds.*

Lot.	Feed.	Cost.	Profit.
		Cents.	
1	Corn and alfalfa	5.25	$1.65
2	Emmer and alfalfa	4.28	3.04
3	Barley and alfalfa	4.95	2.02
4	Wheat, barley, and alfalfa	4.68	2.30
5	Wheat, emmer, and alfalfa	5.93	.52

It is seen in feeding with the various combinations of cereals, some results are favorable and some are unfavorable to the use of emmer. As before remarked, the adaptability of emmer in the drier districts must be taken into consideration together with the greater quantity of grain per acre that may be produced in these districts by growing this crop.

PRODUCTION OF EMMER IN POUNDS OF GRAIN PER ACRE AS COMPARED WITH OTHER CEREALS.

It is important to know, if possible, the amount of grain per acre by weight that emmer will furnish compared with other cereals that may be used in stock feeding in order to determine which crop it is most profitable to grow for that purpose when quality is also taken into consideration. The North Dakota station[4] presents a tabular

[1] Wilson, James W., and Skinner, H. G. Bulletins of the South Dakota Agricultural Experiment Station: No. 81, Feeding Dairy Cows, II, 1903, pp. 27–40; No. 86, Fattening Range Lambs, 1904, pp. 1–16; No. 100, The Feeding Value of Speltz in Beef and Pork Production, 1907, pp. 119–128.

[2] Faville, A. D. Lamb Feeding for 1908–9. Bulletin 81, Wyoming Agricultural Experiment Station, 1909, p. 8.

[3] Buffum, B. C., and Griffith, C. J. Lamb Feeding Experiments. Bulletin 75, Colorado Experiment Station, 1902, pp. 21–27.

[4] Shepperd, J. H., and Churchill, O. O. Cereal Crop Experiments. Bulletin 75, North Dakota Agricultural Experiment Station, 1907, p. 312.

statement of yields for eight years in pounds per acre of emmer, barley, oats, common wheat, and durum wheat, here reproduced as follows:

TABLE III.—*Comparative yields in pounds per acre of emmer, barley, oats, and wheat for eight years at Fargo, N. Dak.*

Kind of grain.	1898	1899	1900	1901	1902	1903	1904	1906	Average.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Emmer	2,338	2,291	980	2,518	2,469	2,101	1,976	890	1,945
Barley	2,336	2,360	844	1,946	2,780	2,079	1,704	840	1,877
Oats	2,400	2,436	1,058	1,933	1,988	2,378	2,054	1,610	1,969
Wheat	2,212	1,552	1,379	1,719	1,590	2,694	984	1,560	1,711
Durum wheat	.....	1,948	1,167	1,997	1,943	2,833	1,410	1,500	1,835

It is seen that in acre yield emmer exceeded all other cereals except oats, which exceeded emmer only slightly.

At the Dickinson, N. Dak., substation[1] the average acre yield in pounds of four cereals for the years 1907–1909 was as follows: Emmer, 1,893; barley, 2,011; oats, 2,321; and wheat, 1,871. Here emmer yielded more than wheat but considerably less than either oats or barley, oats standing highest of all.

The fact should be considered that these results at both stations were obtained while using spring emmer in the comparison. As in all other cases where winter grains are compared with spring grains, winter emmer would no doubt give much better yields.

CHEMICAL ANALYSES.

Below are given a few analyses of emmer, of the chaff and the kernel separately, and also of the two ground together.

TABLE IV.—*Analyses of emmer.*

Determination.	Kernels and chaff.	Kernels alone.	Chaff alone.	Straw.
1. By Prof. James H. Shepard, of the South Dakota Agricultural Experiment Station:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Water	10.17	10.86	8.12	.....
Ash	2.95	1.46	7.45	.....
Ether extract	2.46	2.76	1.48	.....
Crude fiber	11.45	2.26	39.02	.....
Crude protein	11.57	14.64	2.39	.....
Nitrogen-free extract	61.39	68.02	41.54	.....
Total nitrogen	1.84	2.34	.38	.....
Albuminoid nitrogen	1.42	1.79	.30	.....
2. By Prof. E. F. Ladd, of the North Dakota Agricultural Experiment Station:*				
Water	8.88	10.03	4.62	.....
Ash	4.33	1.84	13.58	.....
Fat	2.55	2.80	1.64	.....
Protein	9.81	11.69	2.81	.....
Crude fiber	10.09	2.94	36.68	.....
Carbohydrates	64.34	70.70	40.67	.....

* Shepperd, J. H., and Ten Eyck, A. M. Crop Report for 1898. Variety Tests; Thickness and Depth of Planting Grain, Forage, and Root Crops. Bulletin 39, North Dakota Agricultural Experiment Station, 1899, p. 436.

[1] Waldron, L. R. Second Annual Report of the Dickinson Subexperiment Station, for the year 1909, p. 34.

TABLE IV.—*Analyses of emmer*—Continued.

Determination.	Kernels and chaff.	Kernels alone.	Chaff alone.	Straw.
3. By Dr. H. W. Wiley, Chief, Bureau of Chemistry, United States Department of Agriculture (samples furnished by the Bureau of Plant Industry):				
(1) 2789—*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Water	9.05	10.88	8.89	.....
Ash	3.33	1.53	7.77	.....
Fat	2.10	2.13	.60	.....
Albuminoids	13.69	14.88	4.50	.....
Amido bodies	.....	2.10	.38	.....
Total nitrogenous bodies	13.69	16.98	4.88	.....
Moist gluten	.....	41.02	.....	.....
Dry gluten	.....	14.77	.....	.....
Crude fiber	8.37	1.69	30.70	.....
Pentosans, lignins, organic acid, etc	20.43	18.56	39.66	.....
Starch	43.03	48.23	7.50	.....
(2) 2959—*				
Water	8.57	10.06	6.77	.....
Ash	2.83	1.25	7.16	.....
Fat	1.50	2.11	.71	.....
Albuminoids	13.00	14.88	3.50	.....
Amido bodies	.43	1.36	.21	.....
Total nitrogenous bodies	13.43	16.24	3.71	.....
Moist gluten	.....	37.85	.....	.....
Dry gluten	.....	13.26	.....	.....
Crude fiber	7.83	1.73	31.52	.....
Pentosans, lignins, organic acid, etc	18.69	16.47	41.32	.....
Starch	47.15	52.14	8.81	.....
4. Kernels and chaff carefully separated by hand, weighed and analyzed—kernel, 72.2 per cent; chaff, 27.8 per cent:†	*Spikelets.*‡			
Water, air dry	6.95	8.00	4.22	4.61
Ash—				
Air dry	4.85	2.15	11.85	9.06
Water free	5.21	2.34	12.37	9.50
Ether extract—				
Air dry	1.59	1.80	1.05	1.37
Water free	1.71	1.96	1.10	1.44
Crude fiber—				
Air dry	12.32	1.86	39.50	42.64
Water free	13.24	2.02	41.24	44.70
Crude protein—				
Air dry	10.04	12.68	3.16	2.14
Water free	10.79	13.78	3.30	2.24
Nitrogen-free extract—				
Air dry	64.25	73.51	40.22	40.18
Water free	69.05	79.90	41.99	42.12

* Numbers used by the Office of Foreign Seed and Plant Introduction.
† Unpublished analyses reported March, 1911, by Prof. Henry G. Knight, University of Wyoming, received through Prof. B. C. Buffum.
‡ Calculated from the analyses of kernels and chaff.

The first three analyses are of spring emmer. The fourth one, by Prof. Knight, is an analysis of the improved winter emmer, developed by Prof. Buffum, which has already been discussed.

One interesting feature of the above analyses is the considerable quantity of crude protein found in emmer. It would be considered a rather "heavy" or concentrated food if fed without the hulls. However, the presence of the hull, or chaff, counteracts this heaviness and appears to make it all the better, the hull furnishing the quantity of roughage necessary to make it a complete food.

Dr. J. S. Chamberlain, formerly of the Office of Grain Investigations, in 1909 published a bulletin on the feeding value of cereals, and in the investigations therein reported emmer and einkorn were

included with the other cereals.[1] Table V, taken from page 43 of that bulletin, gives the pounds of digestible nutrients per 100 pounds of dry matter in emmer, einkorn, and oats.

TABLE V.—*Digestible nutrients in oats, emmer, and einkorn.*

[Pounds per hundred pounds of dry matter.]

Cereals.	Protein.	Fat.	Crude fiber.	Carbohydrate.	Production value—gain in flesh.	Nutritive ratio.
Oats	10.73	3.59	3.17	51.04	17.86	5.8
Emmer	9.96	1.36	4.98	52.06	17.20	6.0
Einkorn	11.00	1.55	5.96	48.04	16.81	5.2

The author comments as follows:

With the less common grains, emmer and einkorn, it is seen that while the protein in emmer is somewhat lower, the production value and nutritive ratio are nearly the same as that of oats. Einkorn, owing to higher crude fiber, falls below the other two in production value and nutritive ratio. It is plain, however, that both of these grains belong in the oat class rather than in the wheat class. * * * The hulled emmer would, if fed as such, be as much like wheat, however, as it is like oats when fed with the hulls. * * * The average protein content of emmer is nearly 1 per cent lower than that of oats, yet there are 108 samples out of 242 of United States oats which have a protein content less than the average of the emmer, and 7 samples of emmer out of 25 have a higher protein content than the average of the oats. * * * For feeding purposes, then, the less common cereals, emmer and einkorn, when used with the hulls may be considered as belonging with oats in the group of high protein, muscle, or energy-producing foods and nearly equal to the latter in intrinsic food value.

CULTIVATION OF WINTER EMMER.

The preparation of the land, seeding, and subsequent management of the winter-emmer crop are practically the same as that required for rye and winter wheat and have been discussed in different publications of the Department of Agriculture. As the crop is well adapted as a winter cereal to intermountain districts of the West where dry farming is practiced, the first requisite, of course, is to have the land thoroughly prepared for the conservation of moisture. It may be sown either on summer fallow or follow a cultivated crop. If following an uncultivated crop, the ground should be plowed rather deeply as soon as possible after the latter crop is removed and thereafter often surface cultivated, particularly after rains, to conserve as much moisture as possible for the emmer. Seeding should be done only with the drill. It should be sown about the same time as winter wheat, the date ranging from about August 20 to October 1. In the drier districts the rate of seeding should be about the same as for barley—that is, from 4 to 6 pecks per acre.

[1] Chamberlain, Joseph S. The Feeding Value of Cereals, as Calculated from Chemical Analyses. Bulletin 120, Bureau of Chemistry, U. S. Dept. of Agriculture, 1909, pp. 30–32, 43–45, 47, 55–56.

In the Eastern and Southern States, where the rainfall is greater, it is nevertheless often rather dry near seeding time. Much the same treatment of the soil should, therefore, be practiced as in the Western States, except that the need of conserving moisture will not usually be so great. Also, in the humid areas it is possible to follow a cultivated crop with emmer and it is never necessary to sow it on summer fallow. The crop may take the place of winter wheat or winter barley in systems of rotation.

USE OF WINTER EMMER IN WHEAT BREEDING.

Emmer is really a subspecies of wheat, and in actual experience it has been found that it can be readily crossed artificially with the

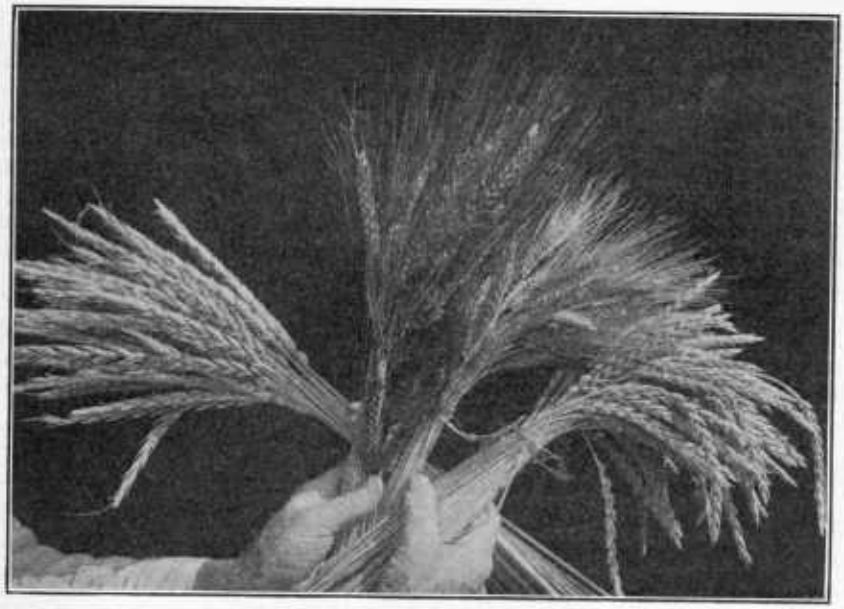

FIG. 8.—Two bundles of bearded grain, showing the black-glumed and white-glumed types of the sporting emmer, and two bundles of beardless grain, showing two hybrids which came true to the selection in the second generation. Photographed at Worland, Wyo.

common wheats. It is probably true that many natural crosses occur where emmer is sown near ordinary wheat, which would account for a number of cases of unusual mixtures that have been found in wheat fields near where emmer has been grown. Varieties of spring emmer have already been used by this department and by experiment stations in producing hybrids for the purpose of adding rust resistance to ordinary wheats. The use of winter emmer would have an added value for this purpose in winter-wheat districts, since emmer itself is to a considerable degree winter hardy. The winter emmer appears also to be even more resistant to rust than most of the spring varieties.

There is a tendency in the winter emmer, when placed under unusually stimulating conditions, to produce compound or branched heads. This is particularly likely to occur when it is transported from a certain locality to another where the soil conditions and climate are particularly favorable. This tendency to produce compound heads appears to be characteristic of all winter-emmer varieties. There are red-chaff winter emmers and white winter emmers, as well as the black variety. Each of these has a corresponding compound form, such as the Red Winter compound emmer, the Black Winter compound emmer, etc. Only one other group of wheats, the poulards, is known to have this peculiarity of compounding its heads. This tendency to produce compound heads and the probability that all emmers often produce natural crosses with wheat probably account largely for the numerous sports obtained in connection with the development of the improved winter emmer already discussed. (Fig. 8.)

It is seen, therefore, that there is considerable opportunity of producing valuable results in wheat breeding by the use of the many varieties of emmer, if we include both the spring and the winter forms, and no doubt in the future much of the actual improvement of the wheats of this country will be accomplished in that way.

SUMMARY.

Emmer has been known as a profitable crop in parts of the United States for 15 to 20 years. Both winter and spring varieties are grown, but the spring varieties have been most commonly planted.

There is an increasingly strong demand for a drought-resistant winter feeding crop in many parts of the country. This paper discusses the superior value of winter varieties for certain conditions.

Emmer is commonly but incorrectly called spelt or "speltz." True spelt is a distinct crop. Emmer has stouter, compact, and usually bearded spikes which on breaking up in thrashing leave a short, pointed pedicel attached to each spikelet. Spelt spikes are more slender and loose, both bearded and beardless, and, in breaking up, the pedicel usually does not remain attached to the base of the spikelet.

All varieties of emmer are considerably resistant to drought and certain varieties are very resistant to rust. They are also considerably resistant to the effects of wet weather in humid climates, though best adapted to rather dry regions with hot summers.

Emmers are cultivated throughout southern Europe and to some extent in east-central Africa. They are very largely grown in Russia.

Black Winter emmer was first introduced from France by the Department of Agriculture in 1904, and the seed has been increased and distributed as rapidly as possible since that date.

It has been tested on many of the Departmental experiment farms with good results. A 5-year test at McPherson, Kans., gave an average acre yield of 45.5 bushels, the highest yield obtained being 77 bushels in 1908. Five crops grown in the Panhandle of Texas averaged about 35 bushels per acre.

Many cooperating farmers in the Western States report yields ranging from 25 to 60 bushels per acre. A seed-breeding farm in Wyoming has been selecting a strain of this Black Winter emmer with special reference to winter resistance. In 1909 this variety yielded at the rate of 42.5 bushels per acre and in 1910 a 10-acre field yielded at the rate of 69.1 bushels per acre. Both crops were grown under irrigation.

Emmer withstands extremes of climate much better than any other cereal and is well adapted for use as a general-purpose crop.

Winter emmer is likely to prove of value as a feeding crop in a number of the Central, Southern, and Eastern States where oats are not profitably grown. It will ripen earlier and yield better than oats and may furnish fall and winter pasturage also.

In the Rocky Mountain and Pacific Coast States winter emmer will be particularly valuable as a stock feed under dry farming. The best results, so far, have been obtained in intermountain districts. It will probably not be winter resistant in the Northern States east of the Rocky Mountains.

In Europe emmer is often used as human food, in Russia chiefly in the form of a breakfast food, and in the other countries to a considerable extent in bread making.

In the United States it has been and is likely to be most used for stock feeding. In a considerable number of feeding tests conducted at different stations emmer has been found nearly, if not quite, equal to barley and oats for sheep and cattle.

In deciding the value of emmer not only its comparative feeding value but its comparative productiveness and certainty in western dry-farmed areas must be taken into account.

Since the emmer kernel does not become separated from the chaff in thrashing, emmer is more comparable to oats and barley than to wheat as a feeding grain.

The preparation of the land, the seeding, and subsequent management of the winter emmer crop are practically the same as required for rye and winter wheat.

Emmer is really a subspecies of wheat and can be readily crossed with wheat by artificial means. It is being used in this way for the purpose of adding rust resistance to wheat hybrids.

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