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Winter Barley, A New Factor in Missouri Agriculture

W. C. ETHERIDGE, C. A. HELM, AND E. MARION BROWN

Fig. 1.—Winter barley is a new and highly valuable pasture crop in Missouri agriculture. The crop shown here was grazed 60 calendar days in the dry fall of 1933, and 49 calendar days in the dry spring of 1934. The picture was taken near the end of the spring grazing period.

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Winter Barley, A New Factor in Missouri Agriculture

W. C. ETHERIDGE, C. A. HELM, AND E. MARION BROWN*

Winter barley, long known locally in southern Missouri, is now recognized as a valuable crop for the whole State. It has rapidly increased from less than 4000 acres in 1924-25 to more than 200,000 acres in 1934-35. This expansion has progressed as the merits of the plant have been made known to farmers and is reasonably expected to continue.

Tests and farm observations of winter barley were begun by the Missouri Agricultural Experiment Station in 1921. They first were of a minor form but in recent years they have been broadened and intensified. This bulletin will report the information gained by these studies and will explain the usefulness of the winter barley crop in Missouri agriculture.

THE MERITS OF WINTER BARLEY

Winter barley gives an abundant and nutritious pasturage as well as good yields of excellent grain. Perhaps it is not equaled by any other crop for such a dual purpose.

It fits well in rotations with other crops and is a particularly favorable nurse for legumes and grasses. It makes a thrifty use of soil fertility and is one of the most efficient cover crops for the control of soil erosion during the fall and winter. It can profitably take the place of corn on land medium in fertility.

Winter barley is much the earliest of Missouri grain crops to ripen. The favorite varieties are ready for harvesting in late May or the first days of June, about two weeks ahead of rye, three weeks ahead of spring barley, three to four weeks ahead of wheat, and four to five weeks ahead of oats.

Thus winter barley escapes much of the damage by chinch bugs and spring drought that may be fully inflicted upon later grain crops. Because the barley crop is harvested so early, the growth of any legume or grass previously sown therein is greatly favored; or, if there is no intersown growth, the land is left free at a timely period for sowing a full season crop of soybean hay. Bar-

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ley grain is ready for use in early summer when the supply of other grains, especially corn, is low and the price high.

Winter barley may be produced by nearly the same standard methods used in growing a crop of wheat. It may be considered as safe a crop as either wheat or oats, if it is correctly handled, and if its partial avoidance of chinch bugs and spring drought is taken into account over a long period.

Fig. 2.—Winter barley should be harvested in the stage of early ripeness, shown by the erect and slightly green heads at the right in the picture. The drooping over-ripe heads at the left will shatter badly in harvesting. Heads on both sides are of Missouri Early Beardless, a new and important variety of winter barley developed by the Missouri Agricultural Experiment Station.

WINTER BARLEY PASTURE

Winter barley in Missouri is generally the best pasture crop among the grains. It exceeds the other grains in earliness and size of fall growth and vigorously renews itself under grazing. It therefore can furnish a more abundant pasturage for a longer fall period and still develop a spring growth for either pasturage or grain. Wheat sown very early for pasture and grazed as long and as heavily as barley sown at the same time, would be so weakened by this intensive use and by injury from the Hessian fly that it would succumb to cold weather and reach spring with a poor stand. Wheat estimated wholly as a pasture crop is inferior to barley for fall pasture but equal or superior for spring pasture. Probably it cannot match barley in total pasture yields. Moreover

a consideration of the high cash value of the wheat grain will generally persuade the grower against a maximum grazing of his wheat crop. Rye is less productive than barley on medium to good land if both crops are given an early start in a normal season; but rye is preferred to barley on poor land, particularly if the sowing is very late and the season dry.

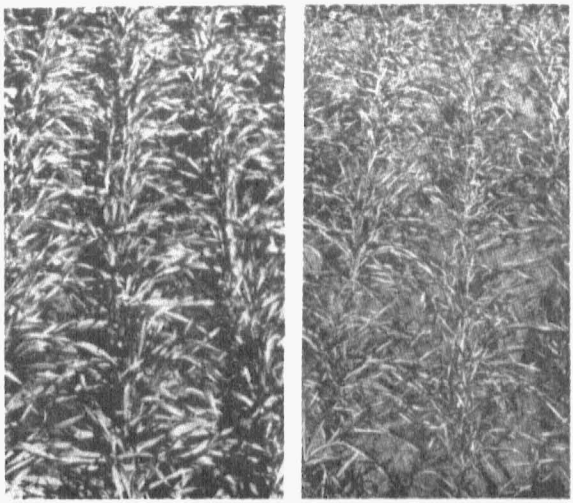

Fig. 3.—The picture shows a 24-day growth of winter barley (left) and wheat (right) both sown October 3, 1934. At this stage the barley had produced several times as much foliage as the wheat sown at the same time, nearby on the same kind of land. The advantage of winter barley as a pasture crop is mainly in its rapid and abundant fall growth. (See Fig. 4.)

Winter barley in the fall and early spring stages of its growth has the high palatability and nutritive quality of good young grass. The average composition of barley pasturage through the period October 10 to November 7, is shown in comparison with representative analyses of young bluegrass and young alfalfa, in Table 1. A striking feature of the barley composition is a good content of protein in relation to such a high proportion of water. The water content, however, decreases as the plants advance in age. The abundant growth is eagerly eaten by grazing animals. The plentiful production of feed by winter barley pasture is well illustrated by the following records of experimental and practical cases.

Table 1.—Chemical analysis of barley pasturage, bluegrass and alfalfa

	Water %	Ash %	Crude protein %	Fat %	Crude fiber %	Nitrogen-free extract %
Barley (6-10 weeks growth)	84.9	2.3	4.0	0.5	2.6	5.7
*Bluegrass (before heading)	76.2	2.7	5.3	1.3	5.2	9.3
*Alfalfa (before bloom)	80.1	2.3	4.7	0.8	4.2	7.9

*From Henry and Morrison.

A 24-acre field at the Missouri Agricultural Experiment Station*, sown to winter barley in late August, 1934, was heavily pastured by 33 cows and 3 calves from October 10 to November 21. Also 16 stocker calves grazed this field during the period December 18 to April 9, whenever the ground was not too wet. From May 11 to June 1, a herd of 27 cows and 7 yearling heifers grazed there continuously. Also 11 mares and 3 fillies were on this pasture all or part of the time from May 6 to June 1. Thus

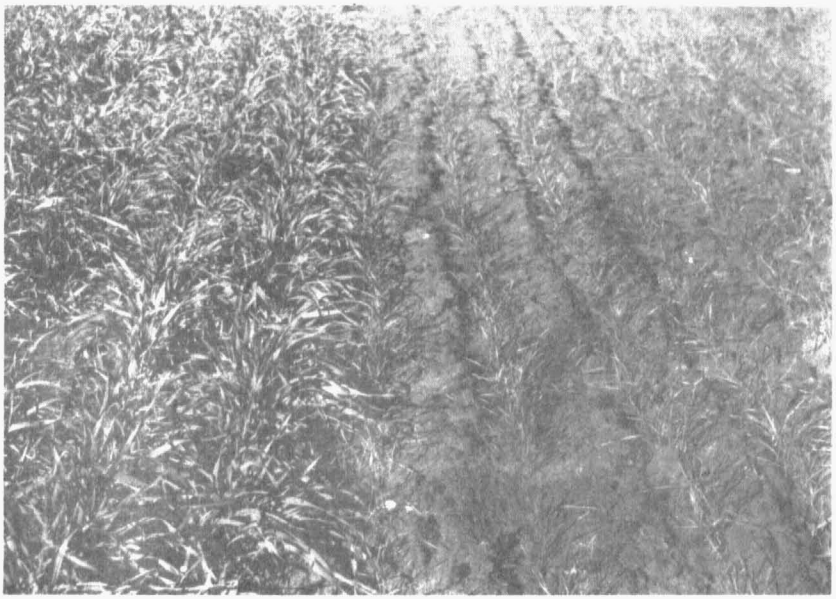

Fig. 4.—Winter barley (left) sown in early September, within the time limits of sowing barley pasture, is shown to have made many times the fall growth of wheat (right) sown on the fly-free date in early October. The picture was taken in late October. On account of frequent heavy damage from the Hessian fly, wheat cannot safely be sown as early as barley for pasture purposes. This fact puts wheat under a disadvantage as a fall pasture crop. But even though the two crops are sown at the same time, barley far outgrows wheat in the fall. (See Fig. 3.)

the pasture furnished 1334 animal unit days of grazing in the fall of 1934 and 894 animal unit days in the spring of 1935—a total of 2228 animal unit days, or 92.8 such days per acre. (An animal unit day is counted as one day of grazing for one cow or horse). The land is rolling Putnam silt loam, scarcely medium in fertility, producing an average of 20 to 25 bushels of corn per acre. It was treated with 200 pounds of 4-12-4 fertilizer per

*From the records of the Department of Animal Husbandry, Missouri Agricultural Experiment Station.

acre, and the weather, both fall and spring, was remarkably favorable for growth. The pasture was not overgrazed to furnish the total number of unit days here reported.

For three spring seasons, 1933 to 1935*, grazing records have been kept on both winter barley and wheat sown in October on lespedeza sod after the lespedeza had ripened seed. This time of sowing is too late to permit the grain crops to produce a great amount of fall pasturage. Spring grazing began in April and extended through May into June, in the normal season of 1933 and the wet season of 1935, but in the exceedingly dry season of 1934 it ended in late May. After the barley and wheat were finished the volunteer lespedeza in each pasture was grazed until early October. The soil type here was Putnam silt loam, below medium in productivity, not fertilized nor limed. The results of grazing the two crops are summarized in Table 2.

Table 2.—Spring pasture yields of winter barley and wheat, expressed in calendar days and animal unit grazing days per acre.

Crop	1933		1934		1935		Average	
	Calendar days	Unit days	Calendar days	Unit days	Calendar days	Unit days	Calendar days	Unit days
Winter barley	47	48	32	22	45	47	41	39
Wheat	47	32	48	26	52	49	49	36

A 10-acre field on Sni-A-Bar Farms** was sown to winter barley on September 1, 1933. A thin stand was obtained. Intensive grazing began October 4 and continued through November 7 for 600 animal unit days. It was resumed through the period April 7 to April 21 for 490 animal unit days. Thus the 10-acre field furnished a total of 1090 unit days of grazing, or 109 unit days per acre. (See Fig. 10.) The soil here is Wabash clay loam, a highly fertile type. Other conditions for growth, however, were extremely unfavorable, as the total fall and spring season was the driest known in the locality.

An interesting record of winter barley pasture comes from Mr. Elmer Adams, a dairy farmer of Blue Springs, Missouri, and is presented here in his figures. A 25-acre field sown August 10,

*From the cooperative records of the Department of Animal Husbandry and Field Crops.

**From the cooperative records of the Missouri Agricultural Experiment Station, the United States Department of Agriculture, and Sni-A-Bar Farms.

1933, was intensively pastured by the Adams dairy herd through 34 days in the fall and 34 days in the spring for a total of 4886 animal unit days of grazing, or 195 animal unit days per acre. Mr. Adams shows (1) that during the whole period of grazing the barley pasture furnished more than one-fourth of the total feed then consumed by his cows, and (2) that in terms of the value of commercial feed saved, this pasture was worth $15.60 per acre. The Adams farm is located on the fertile Summit silt loam, but the fall and spring droughts of 1933-34 held the growth of barley there to a comparatively low standard.

The foregoing cases are not exceptional and are selected only because they can be described in accurately measured terms. Hundreds of farmers have reported high returns from winter barley as a pasture crop. It is an essential part of the all-year pasture system described in Circular 186, recenty pulblished by the Missouri Agricultural Experiment Station.

MANAGEMENT OF WINTER BARLEY PASTURE

Winter barley to give its largest and best distributed yield of pasturage, should be sown at the rate of two bushels per acre right after the August or early September rains. In normal seasons it may be used from late September or early October until early December, although if the season is unusually favorable and the land very productive, grazing may begin 3 weeks from the date of sowing. Spring grazing, beginning March 15 to April 1, may run well into May. Thus the combined fall and spring grazing periods of this crop may amount to as much as 100 to 125 calendar days. (See Fig. 1.)

The length of the pasture period as well as the intensity of grazing winter barley requires regulation for the best yields of either pasturage or grain. It is important to begin grazing long before the plants have begun to joint, for the jointed plants will neither renew growth if eaten down nor live through the winter if left ungrazed. Also there may be some smothering in a tall rank growth which goes ungrazed into winter, even though it has not reached the jointing stage. It is equally important, however, that the stand be not grazed to the ground, for this treatment will so weaken the plants that large numbers will die during the winter. Therefore the fall grazing of barley should be well balanced between under-grazing and over-grazing. The growth must be kept down to prevent either jointing or smothering, but not so low as to starve the plants. Probably the max-

imum pasturage for both fall and spring will be obtained if fall grazing begins when the stand is 4 or 5 inches tall and proceeds until winter at a rate that will evenly consume the growth and finally leave enough (about 3 inches) to stand cold weather.

Fall grazing, if not carried to the point of destruction, will not materially reduce the spring yield of grain; it may even increase the grain by keeping down a rank early growth that might otherwise reach the jointing stage or become infected with disease. (See Fig. 5.) Spring grazing, however, should be regulated according to the immediate need for pasturage and the future need for threshed grain. If the greater necessity is for pasturage the crop may be grazed out completely; if grain is the main requirement the spring growth must be spared from heavy grazing, or in a dry season from any grazing, in order that it may develop a grain yield. Certainly the grower cannot have heavy spring pasturage and a good yield of grain from the same crop. In normal spring seasons even light grazing will reduce the grain yield.

The profits from (1) grazing out the spring growth of winter barley or (2) saving it to mature a crop of grain, cannot be accurately compared. Their net difference will fluctuate with the nature of the season, the need of the grower for pasture or grain, the cost of harvesting and threshing the grain, and the prices of other feeds that could be substituted for the barley pasturage in early spring or the barley grain in early summer. In case the feed requirements of a farm demand heavy grain pasturage in both fall and spring, and a supply of threshed barley in early summer, the necessity can be met by (1) the usual heavy grazing of barley in the fall, and (2) the fall-sowing of a small acreage of wheat to be saved for heavy spring grazing. Thus the barley would be relieved from any spring use and allowed to produce its maximum yield of grain.

WINTER BARLEY AS A GRAIN CROP

Winter barley is an excellent grain crop in Missouri by reason of its good yields, early maturity, high nutritive value, ability to grow well on medium land, and easy rotation with other crops.

Under farm conditions in Missouri, winter barley yields of grain commonly range from 15 bushels to 50 bushels per acre. Experimental yields have ranged within these figures and even

higher, but they have been concerned mainly with broad comparisons of varieties, including the elimination of less important kinds, and so have not established average levels of production. Nor have standards been set for high yields of this grain by the best practical farming, under different grades of natural fertility and through a varied range of seasons. Such experimental data as have been collected, together with numerous farm observations and reports, are the basis for a reasonable expectancy of 30 bushels of barley per acre on land capable of yielding 25 to 30 bushels of corn in normal seasons.

Fig. 5.—The crop of Missouri Early Beardless winter barley shown here was produced on average 45-bushel corn land, on the farm of Mr. C. H. E. Walther, near Boonville. The stand had been pastured moderately in late fall and through the winter of 1934-35 and the spring until May 1 of 1935. Both seasons were unusually favorable for growth. The crop ripened in the last of May and yielded 40 bushels per acre.

In the fairly good season of 1932-33, a group of eight varieties grown at Columbia, on land medium in fertility but without fertilizer treatment, yielded from 18 to 38 bushels per acre, averaging 30 bushels for all varieties. In the very dry spring of 1934, preceded by an unusually dry fall, a piece of poor land that will scarcely produce an average of 20 bushels of corn, gave an acre yield of 31 bushels of barley. The crop was aided by 150 pounds per acre of 4-16-4 fertilizer. The chinch bug invasion in that season was perhaps the most destructive ever known here, but the fertilized crop of winter barley, by reason of its early maturity, mainly escaped this damage. An extremely early variety of wheat, grown beside the barley and receiving an equal treatment

of fertilizer, but ripening about two weeks later, suffered heavily from chinch bugs.

Earliness, in ripening spring grain and in producing fall pasturage, is an important quality of winter barley. The first advantage is in the partial escape of the grain crop from the chinch bugs. Barley in general is highly susceptible to the chinch bug and this insect will congregate heavily in a barley field, but the earliest winter varieties, ripening in late May or early June before the insect attacks has reached its peak, will suffer less injury than the later growing grains—spring barley, wheat, or oats. Therefore, in this section where the chinch bug is a partner with spring drought in heavy damage to spring grain crops, earliness generally insures a good yield. Also an early replenishment of the feed grain supply, by the quick maturity and timely threshing of the winter barley crop, is an important matter to the livestock feeder.

The Missouri Agricultural Experiment Station is trying to develop varieties of winter barley that will ripen even earlier than the established kinds. A successful beginning has been made with the fortunate discovery of Missouri Early Beardless.* This variety in 1934, one of the hottest and driest spring seasons on record at Columbia, was harvested here on May 23; in 1935, one of the coolest and wettest spring seasons on record here, it was ready to harvest on June 1, although harvesting was then prevented and the crop, except a small remnant, ultimately lost by continued rains. From this consistency in early maturity under such an extreme difference in seasonal conditions, Missouri Early Beardless may be expected to ripen in central Missouri within a 10-day period covering late May and the first few days of June.

The methods for the production of barley grain scarcely differ from those used in growing a good crop of wheat. Good preparation of the seed bed, as for wheat, is especially important. This may be accomplished by early summer plowing and occasional disking or harrowing to keep down the weeds until the time of sowing; or by spring plowing and the production of a soybean hay crop, which will leave the land in a good condition requiring little or no further fitting for the barley.

Where the natural available fertility is not sufficient to develop the full vigor of the barley plant, the yield is increased, the

*This is a hooded variety but actually having no beard it is called "beardless" for practical reasons.

quality of the grain improved, and the maturity hastened, by suitable fertilizer treatments. A test of fertilizers for barley on the more important soils in Missouri has not been made, but the requirements of the plant for readily available soil nutrients are considered to be generally similar to those of wheat. If there is an important difference between the two plants in this respect, barley is likely the more responsive to fertilizer. Therefore, in fertilizing a barley grain crop it is safe to apply *fully* the treatment recommended for wheat under local conditions. (See Missouri Agricultural Extension Circular 315, for the rules of fertilizing wheat on the leading soil groups of Missouri.)

The best time for sowing a crop of winter barley intended for grain is the subject of a double consideration. If a maximum yield of grain is the only objective, it is more likely to be reached by sowing in late September or early October, the actual date to be set according to the section of the State and the nature of the season; if fall pasturage is required from the crop, in addition to the spring grain yield, late August or early September sowing is necessary to best serve both purposes. The grower must decide in relation to his needs whether he will sow at one time or the other.

Probably the best general rate of seeding for the production of grain only is 6 pecks per acre. For the production of both heavy fall pasturage and spring grain by the same crop, an 8-peck rate is preferred.

Barley grain is an excellent feed for livestock but it must be crushed or ground to make its full value available. Processed in this way, barley grain is from 85 to 90 per cent as valuable for feed as shelled corn, the variation depending upon the comparative grades of the barley and corn, the class of livestock to which the grain is fed, and the supplements used with it. Barley contains more protein than corn but is low in calcium and these facts must be considered in selecting supplementary feeds.

WINTER BARLEY AS A SUBSTITUTE FOR CORN

One of the larger problems of Missouri agriculture is to find a better use for land in a low stage of fertility than in growing the meagre crops of corn that now occupy more than half of our total corn acreage. Our corn crop, under government control, covers approximately five million acres. The more productive part of this land, roughly estimated at two million acres, gives average yields above 30 bushels; the next two million acres pro-

duce an average of 20 to 30 bushels; but the scanty output of the remaining million acres falls below the 20-bushel mark.

There is no profit in growing 20 to 30 bushels of corn to the acre, unless prices are very high. The acre production of less than 20 bushels can find no profit at any price within reasonable limits. Moreover, the continued cultivation of corn on land grading from 30 bushels downward to less than 20 bushels, rapidly reduces the small store of fertility, subjects the soil to destructive erosion, and therefore year after year increases the difficulty of making a living on the whole farm, even with advancing prices for farm products.

Land below the productive grade of 20 bushels of corn to the acre, if it is to be kept in staple crops, should not grow corn at all, nor any kind of grain, but should be turned to pastures and forages. Even pastures and forages on such land will not bring a high return, but when their low cost, steady yields, and beneficial effect upon the soil itself are counted, these crops will be found far ahead of corn or other grains in net value per acre.

On land capable of producing 20 to 30 bushels of corn, the lighter grains should be widely substituted for the corn crop, to supplement the feed supply from the large acreage of pastures and forages grown there.

Winter barley should replace corn on all but the very best of the 20 to 30 bushel corn land. (See Fig. 6.) The crop seems suitable for this purpose. It is much better than wheat or oats for corn replacement, because of its larger returns in total feed units from the combined yields of pasturage and grain. With good treatment, barley on such land probably will surpass corn in the average acre yields of grain alone, over a long period in which the corn crop many times will suffer great damage from chinch bugs or drought. Barley grain, as has been said, is nearly the equal of corn in feed value. Add to the grain yield the very important fall pasturage, and the winter barley crop in total output will easily exceed corn as a productive unit on this kind of land. And by the time each crop has been consumed, barley will have cost less than corn, unit for unit of feed produced and utilized. Actual figures on the production costs of barley have not been gathered in Missouri. They doubtless are similar to the cost figures for wheat. A 9-year survey (1921-29) found the average acre cost of wheat in Missouri to be $17.69 and of corn $19.88.* Assuming the wheat cost figures to apply accurately

*From the records of the Department of Agricultural Economics, Missouri Agricultural Experiment Station.

to winter barley, and then comparing barley with corn on a cost basis of total feed units produced, the difference between the two crops would be even greater.

Going further with this comparison of winter barley and corn on 20 to 30 bushel corn land, barley is far superior to corn in its soil relations. Barley draws moderately on soil fertility; corn rapidly consumes soil fertility. Barley is among the best of all crops for the prevention of soil erosion, its dense spreading growth giving good protection against early fall rains; but the corn crop, by reason of its loosening cultivation, breaks down the resistance of the soil to erosion, gives but little coverage during the winter, and so in net result hastens and multiplies erosion losses.

Winter barley, maturing so early, can here be a part of a valuable 1-year rotation with soybeans or Korean lespedeza, or it can come between soybeans and lespedeza in a 2-year or 3-year rotation. In longer rotations it of course may occupy a position similar to that of wheat. Corn, however, is not well adapted here to double-cropping; nor even to short rotations on mediocre land which cannot stand the strain imposed by the frequent and exhaustive growth of the corn crop.

The efficiency of winter barley in annual and other short rotations is one of the advantages of the crop. The principal benefits from such rotations are (1) an abundant and well distributed production of feed at a low unit cost, (2) a favorable effect upon soil fertility, and (3) a practical control of soil erosion. Some of the best of these short systems of cropping are here discussed.

BARLEY-SOYBEANS ROTATION

In this rotation the early maturity and harvesting of winter barley, if followed by early threshing or stacking, will leave the land free for the sowing of a soybean hay crop by the 10th to the 20th of June. The barley ground will not be as dry and hard as the land left by wheat or oats, for the barley crop will have been harvested three or four weeks earlier than the other grains. Therefore, thorough disking and harrowing will usually prepare a good seedbed for the soybeans, though plowing may sometimes be necessary. Also the barley ground, containing more moisture than ground after wheat or oats, will cause a quicker germination of the soybean seed and a more rapid early growth of the crop.

Fig. 6.—This crop of winter barley, grown at Green Ridge Experiment Field, Pettis County, Missouri, on average 25-bushel corn land, was harvested May 28, 1935, and yielded 40 bushels per acre. The field is ready to be prepared for soybeans, as soon as the barley is taken off. The soil here is Oswego silt loam, a very extensive type in the level prairie region of Southwest Missouri.

Fig. 7.—The soybean hay crop shown here was sown July 2 and photographed July 25. It will have plenty of time in which to make a good growth of hay and to be harvested for this purpose before the date when barley should be sown on the same land.

The soybeans should be sown as a hay crop, drilling or broad casting the seed at the rate of one bushel per acre. A hay crop instead of a seed crop of soybeans is an essential point in the

barley-soybean succession. There are two reasons for this: (1) there will be enough time (60-90 days) between the removal of one barley crop and the sowing of the next to grow the soybeans to a good stage for hay, but not enough time to ripen the seed; and (2) the soybean crop sown thick for hay will aid in the control of soil erosion, but if sown in open rows and cultivated it will cause soil erosion.

The soybean hay will be harvested at some time between the middle of August and early September. The soil is then left so loose and mellow that it usually will not require any preparation as a seedbed for barley. In fact, any mechanical treatment of the soybean ground that goes much deeper than harrowing is likely to be detrimental to the barley because it will dry out the soil and promote erosion.

The barley, in order to give its full service as fall pasture and its full protection against soil erosion, should be sown just as soon as the soybean hay crop is removed from the land. In normal seasons the barley can be seeded in the last week of August or the first week of September.

Fig. 8.—This picture, taken on September 20, gives a close view of winter barley sown on August 25. Soil erosion could scarcely occur in such a thick spreading growth, and the crop is ready for a long period of fall grazing.

The barley-soybean rotation, if smartly managed, will seldom be broken by an adversity of the season, and it can be made highly efficient in the annual production of feed per acre. In abnormal seasons the soybeans may not be sown following barley before the first of July; also the barley following the soybeans may not be sown until the middle of September. The later dates, however, are still within the seasonal limits of planting. By a conservative estimate the fall pasturage from winter barley (60-75 days), the yield of barley grain (20-30 bu.), and the soybean hay crop (1-1½ tons), all added together will double in total feed value the average corn crop that may be produced on 20 to 30 bushel corn land. This estimate takes into account the comparatively steady yields of barley and soybeans, and the frequent damage to corn from chinch bugs and drought.

In total acre cost of production, both crops in the barley-soybean rotation would not greatly exceed the single crop of corn. Taking again the figures of $17.69 and $19.88 as the respective average acre costs of barley and corn, there would go with the barley figure the acre cost of $9.00 for the soybean hay, making a total of $26.69 per acre for the barley-soybean succession. The latter figure, however, is a maximum and in average actual cases would be reduced by at least $2.00 per acre, because the land for barley after soybeans would never be plowed and the land for soybeans after barley would seldom be plowed, but usually only disked and harrowed, whereas the base figure on the cost of wheat ($17.69), as used for barley, includes the item of plowing. Let us say then in round figures for easy comparison that the average yearly acre cost of barley-soybeans would be $25.00 and of corn $20.00. These figures are high, but they include all items of cost—land with interest and taxes, depreciation on all production equipment, labor, seed, and every other accountable item that enters into the crops.

And so we have in the barley-soybean succession a producing unit that on 20 to 30 bushel corn land may be expected to double the corn crop in the annual output of feed, while exceeding corn in cost by only one-fourth. This comparison of course is in round numbers, but it probably will vary about equally for both sides in the case.

What would be the comparative effect of these crop units on the continuing productivity of the land An accurate analysis of this question is not possible because of the many variable conditions involved, but a practical estimate can be made. Let us

begin with the acre yield of 25 bushels of corn, and the acre yield of 30 bushels of barley followed by 1½ tons of soybean hay. These yields are perhaps nearer the maximum than the actual average on 20 to 30 bushel corn land, but they are suitable for this comparison.

The 25-bushel crop of corn uses in growth about two-thirds as much nitrogen and phosphorus as is used by both crops in the barley-soybean succession, and its related erosion loss of these nutrients, under average conditions of fertility and slope, is double the erosion loss connected with the production of the barley and soybeans.* Briefly, the production of the corn may be calculated to use and cause to be lost an approximate total of 115 lbs. of nitrogen and 27 lbs. of phosphorus per acre; and the barley-soybean production may use and cause to be lost a total of 91 lbs. nitrogen and 23 lbs. of phosphorus per acre. The comparison so far is definitely in favor of the latter crops.

What may be done in each case to lessen the removal of soil fertility? The acre application of 150 to 200 pounds of superphosphate to either the corn or the barley, together with the return to the land of corn stalks or barley straw and a quantity of manure equivalent to that produced by feeding the crop, would give back a quota of phosphorus exceeding that taken out by either crop in growth. These treatments, however, could but partly refurnish the quantity of nitrogen used by either corn or barley, and could not approach the restoration of the nitrogen and phosphorus lost by erosion. There is no further practical way of immediate replenishment for the heavy inroads of corn production; but there is still another important means of restoring the fertility used and lost in the production of the barley-soybean unit. If the manure from the soybean hay is applied to the land it will return a substantial part of the nitrogen and some of the phosphorus taken out of the soil by the growth of this crop, together with a large quantity of nitrogen taken from the air. This replenishment of nitrogen by the soybeans, together with the nitrogen in the manure from feeding the barley, will maintain the original nitrogen content of the soil and is a vital point in the favorable relation of the barley-soybean unit to soil fertility.

Thus it is possible in the production and home use of the barley-soybean feed unit, on land not subject to serious erosion,

*The estimates here of soil nutrients used by the crops and lost by erosion, are furnished by the Department of Soils, Missouri Agricultural Experiment Station.

to reach a practical maintenance of soil fertility. The essential practices to this end are (1) the use of superphosphate on the barley, a treatment invariably found profitable; (2) the quick turn from barley to soybeans and from soybeans to barley, so that the land may be kept almost continually covered to prevent erosion; and (3) the careful feeding of both crops and the thrifty handling of the manure.

Altogether the barley-soybean rotation, grown and handled as here outlined, is an excellent substitute for corn, and by every logical reason of good yields of feed well distributed through the year, a low unit cost of production, and a conserving effect on soil fertility, it should be widely practiced on 20 to 30 bushel corn land. It will require good management for the best returns, but that is a part of smart farming.

SOYBEANS-BARLEY-LESPEDEZA ROTATION

The 1-year rotation of soybeans and barley may be extended to a 2-year or 3-year rotation of soybeans-barley-lespedeza by adding Korean lespedeza and allowing it to run either one or two seasons. The soybeans and barley would be produced and used as outlined in the discussion of the barley-soybean succession. In late winter or early spring lespedeza would be sown in the barley at 15 to 20 pounds of seed to the acre. Barley being harvested in late May or early June would give the land to lespedeza for approximately four months to complete the crop seasons in a 2-year rotation. Lespedeza is much more useful after winter barley than after wheat or a matured crop in oats in full stand, because of its larger early growth and longer pasture period allowed by the earlier harvesting of the barley crop. By October 15, the lespedeza stand, though heavily grazed since June, will have ripened an abundance of seed for its natural reseeding.

From this point the rotation may proceed in any of the several ways that follow:

(1) The lespedeza sod may be plowed during late winter and returned to soybeans by May 15. The purpose of early plowing is to bury the lespedeza seed and save it from spring germination and the destruction that would result from late plowing for the soybeans in that season. If the 2-year rotation of soybeans, barley and lespedeza is continued through several courses, repeated winter plowing will so stock the ground with lespedeza seed that the crop will volunteer in the barley every year. Plowing may then be done at the usual time in the spring.

(2) The lespedeza sod instead of being winter plowed may be allowed to produce a volunteer crop of lespedeza for another season of pasture to complete a 3-year rotation.

(3) In October when the lespedeza seed have ripened sufficiently for natural reseeding and volunteering in spring grain, the sod may be thoroughly disked, harrowed, and sown to winter barley or wheat.

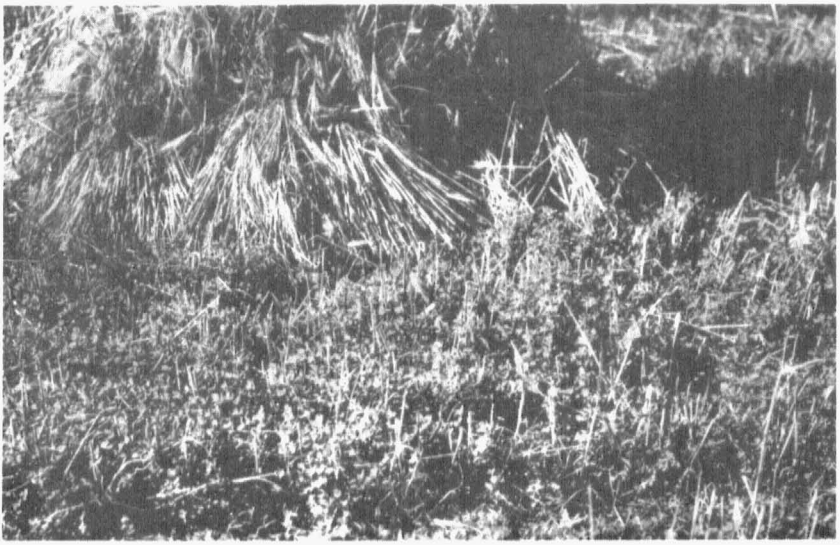

Fig. 9.—A close view on July 5 of Korean lespedeza in the stubble of winter barley harvested on June 3. The dense growth has for some time been ready for the beginning of grazing that will continue through summer and into early fall. This is a first-year stand of lespedeza. It was sown in the barley January, 1935.

(4) Or the lespedeza sod may stand until late winter or early spring of its second year and then instead of being plowed for soybeans it may be disked for oats. If the oats crop is sown early, at 4 to 6 pecks per acre, and harvested early for hay, it will aid rather than injure the lespedeza, because it will prevent a growth of spring weeds that definitely would lessen the seasonal value of the lespedeza stand. Therefore a short period oats crop on the second-year lespedeza sod, is a serviceable and valuable part of the 3-year soybeans-barley-lespedeza rotation.

Let us now review the annual products of this 3-year rotation of soybeans, winter barley, and Korean lespedeza with its adjunct of oats. In the *first year* there will be a crop of soybean hay followed by 60-75 days of abundant fall pasturage from win-

ter barley sown on the same land after the bean hay is harvested. In the *second year* a crop of barley grain will be followed by lespedeza pasture for three or four months. In the *third year* a crop of oats cut early for hay will be followed by a heavier stand of lespedeza than grew in the year before. On the more productive soils and in favorable seasons an oats crop that had been sown at a moderate rate could be allowed to mature a normal crop of grain, without reducing the pasture or hay value of the lespedeza during the remainder of the season. The products of any of these years would far exceed in total feed value the average crop of corn that may be grown on 20 to 30 bushel corn land.

Fig. 10.—Compare in this picture the thin undeveloped stand of red clover in wheat stubble at the left, with the thick strong stand in winter barley stubble at the right. The wheat produced nearly twice as much straw, but not more than two-thirds as much grain, as the barley. The line beween the two grain crops is plainly marked by the difference in their stands of clover in early July. Now look at Figures 11 and 12.

The total acre cost of producing this rotation for the whole 3-year period would not be more than half the acre cost of growing three crops of corn. On a basis of the unit cost of feed produced, the soybeans-barley-lespedeza account would be much less than half that of corn.

This 3-year rotation would be highly favorable to soil fertility. Erosion would be greatly reduced, and if a quick turn is made from soybeans to barley, so that the land is not left uncovered for a considerable period in early fall, a serious loss through

erosion could scarcely occur. (See Fig. 8.) For the whole 3-year period the total removal of soil nutrients by the growth of crops would be comparatively small and easily restored. Nitrogren in particular would be not only restored but increased by its large return in the manure from the soybean hay and lespedeza pasture, with a small amount coming back also in the manure from barley and oats. Phosphorus would be only partly restored by the various manures, but the original level of this nutrient in the soil would be maintained or increased by the application to the barley crop of 150 to 200 lbs. of superphosphate per acre.

Briefly then, this 3-year rotation of soybeans, barley, and lespedeza, because of its thrifty use of soil nutrients in growth, its high efficiency in the control of erosion, its production of feed crops that under the rules of good farming are practically sure to be home fed and returned to the land as manure, and its profitable use of superphosphate, offers an easy and almost certain means for the rapid and steady improvement of the soil.

WINTER BARLEY ON FERTILE LAND

Soils yielding 40 bushels or more of corn per acre may produce greater annual cash or feed returns in corn than could be expected were barley substituted. But it must be realized that unless corn is grown in a rotation suited to the resources of the soil, the continued cultivation of the crop, even on the better land, will rapidly consume soil nutrients and cause extensive erosion. A more conservative use for a part of this land may be found in the production of winter barley as a combination pasture and grain crop, thus lessening the need for a large corn acreage. (See Fig. 5.) Or where the normal acreage of corn is desired, winter barley may replace a part or all of the oats or wheat in the rotation, serving as a better nurse crop for clover or grass than either of these grains. (See Figs. 10, 11, 12.) On such land barley of course will give much greater returns than on marginal corn land.

WINTER BARLEY AN EXCELLENT NURSE CROP

Winter barley, with its short straw and early maturity, is much the best of all the grain crops as a nurse for new seedings of legumes and grasses. The growth of barley straw, especially if the crop is fall pastured, probably will not exceed two-thirds of the straw growth in wheat or oats, and the grain normally ripens in late May or early June. Thus the barley crop makes a lighter and shorter draft than the other grains upon soil moisture and

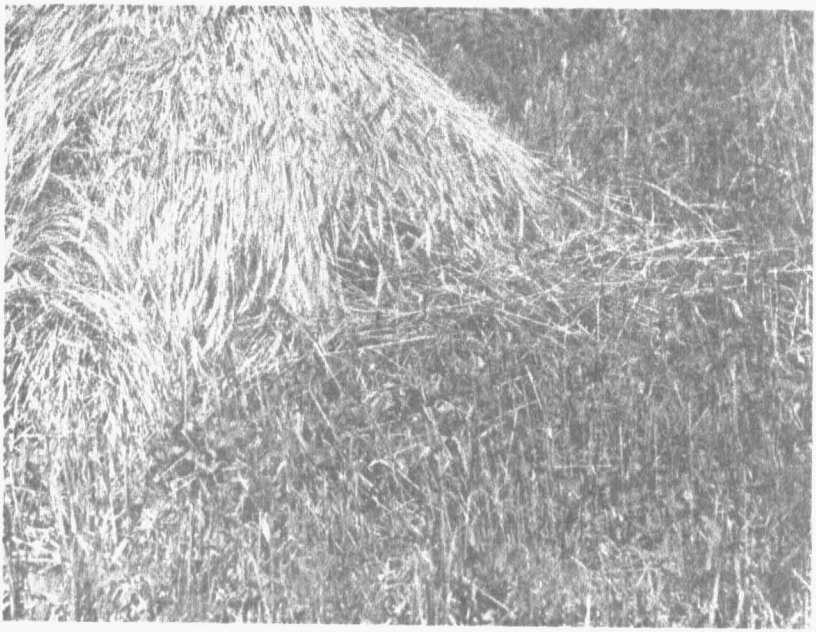

Fig. 11.—A close view of red clover in the wheat stubble shown at the left in Figure 10. The wheat was mature on July 5. Compare the ordinary stand of clover here with the large vigorous growth in barley stubble, Figure 12.

Fig. 12.—A close view of red clover in the winter barley stubble shown at the right in Fig. 10. The barley ripened in the last of May. Compare this excellent growth of clover with the growth shown in Figure 11.

available fertility, thereby at an early stage relieving the intersown legume or grass from the retarding effect of competition by the larger plants for moisture, soil nutrients and light. The result is a comparatively quick and strong development of the legume or grass. It is not uncommon to observe in experiment fields and in farm practice, at an early stage in winter barley stubble, the marked superiority of red clover, sweet clover, alfalfa, lespedeza, or timothy, in comparison with the less thrifty growth of any of these plants in the stubble of wheat or oats. A similar advantage of course is given the young intersown plants by the very early varieties of wheat and oats, though it is not so great as that which results from the earlier maturity and smaller production of straw by winter barley. This favorable effect of winter barley upon the success of the legume or grass sown in it, is one of the important features of the crop.

WINTERKILLING OF BARLEY

Winter barley, like all other fall sown crops, is subject to serious losses from winterkilling. In our observations the general winter damage to the barley stand has been increased by unwise management in grazing and the special weakness of certain varieties. In some places barley seems to stand winter as well as wheat. At Columbia, in central Missouri, winter barley, under good cultural treatment, for the last fifteen years has practically equaled wheat in winter resistance. The land here may be rated no better than average 25-bushel corn land, without special quality for barley, except fairly good drainage; nor have the productive methods been above those which an efficient farmer would practice. At the Bottomland Experiment Field, Lincoln County, about 50 miles north of St. Louis, all varieties of winter barley came through the winter of 1934-35 in excellent condition. Kentucky No. 1 was remarkable in both winter hardiness and yield. The soil on this experiment field is an extremely heavy Wabash clay, commonly called *gumbo*. In southern Missouri also, barley is generally the equal of wheat in survival of the winter season.

In other places, however, the success of barley in experimental plantings has been less uniform. At Sni-A-Bar Farms, Jackson County, slightly north of a central Missouri latitude, winter injury to a number of barley varieties was somewhat greater than to wheat, and was more extensive in the excessively wet, mild winter of 1934-35 than in the extremely dry, cold winter of 1933-34. In the latter season a field of barley there was heavily pas-

tured in both fall and spring, but the late spring stand showed but little reduction in density. (See Fig. 1.) The soil on which the varieties were grown at Sni-A-Bar is a heavy type, very fertile but inclined to drain slowly. At the Soil Erosion Experiment Station, Bethany, north Missouri, 8 varieties sown in 1933-34 and 1934-35, on 30 to 40 bushel corn land, showed survivals of only 40% to 80% of their stands. Missouri Early Beardless, however, came into spring with 90% to 100% of stand, and Kentucky No. 2 with 80% to 90%.

The unusual character of these two winters at Bethany is worthy of special note. The winter of 1933-34 was exceedingly dry, and although there was much mild weather, several sub-zero temperatures were recorded. In the last of February, almost at the initial stages of spring growth, there was a drop of 15° below zero. The winter of 1934-35 was excessively wet, and generally mild, although a few periods of severe cold occurred. The degree to which the barley varieties were killed, however, was very similar in the two widely different winter seasons.

These facts from the records of the Soil Erosion Experiment Station, indicate (1) a wide difference in the ability of barley varieties to withstand winter, (2) the remarkable hardiness of Kentucky No. 2 and Missouri Early Beardless through a wide range of temperature, winter drought and moisture, and (3) the special effect of varietal resistance in determining the winter survival of barley in north Missouri.

Varietal resistance to winterkilling in barley of course may change with different combinations of weather and soil. Thus a variety exceptionally winter hardy under one set of conditions may be found very susceptible to winter under another set. A thorough test of varieties for winter hardiness on all of the great number of soil types in Missouri through a long range of variable seasons, would require a very long time. From dealing with conditions as they have been met, however, we can say that the Kentucky bearded types and Missouri Early Beardless are the hardiest varieties yet found for Missouri. It is quite possible that other varieties excelling these may be discovered or developed by plant breeding.

The experience of farmers with the resistance of barley to winterkilling has been variable but in most cases satisfactory. In the fall of 1934 there was a great increase in winter barley acreage, the crop being sown mainly for fall pasturage as the quickest supplement to a feed supply diminished by drought.

The supply of genuine winter barley seed was limited. The demand for this seed could not be filled. Many farmers tried winter barley, who had never before sown it or even seen it as a growing crop. A large majority of these new growers were satisfied, some of them praising their barley in high terms; but others lost their crop by winterkilling. More than 2300 individuals have reported to us their experience with the barley crop sown last fall. In these reports the cases of loss were invariably associated with one or more of the following conditions: (1) the unknowing purchase and seeding of spring barley instead of winter barley; (2) the seeding of poor varieties of winter barley; (3) delay in grazing, until the barley had jointed, after which stage it was naturally certain to be winterkilled; and (4) over-grazing until the stand had been eaten to the ground and could offer little resistance to cold. These unfortunate experiences, though costly to the growers who suffered them, may serve to warn future growers against similar mistakes.

Good practices in production can greatly strengthen the barley crop against winterkilling in Missouri. They may be summarized: (1) sow only the seed of a known good winter variety; (2) locate the crop on well drained land; (3) prepare the seedbed well or follow soybeans harvested early for hay; (4) use about the same good fertilizer treatment that would be given wheat, if the barley is being sown for a high yield of grain; and (5) begin grazing when the plants are 4 or 5 inches tall, and keep down the growth but do not graze it to the ground. Within limits the date of sowing also will influence winterkilling. The crop from which a long fall supply of pasturage or a succession of fall pasturage and spring grain is to be obtained, should be sown in the middle of August to early September. A crop intended primarily for grain, with little or no grazing expected, should not be sown until late September or early October.

It is believed that if these practices are followed winterkilling will seldom prevent the successful production of winter barley in the southern three-fourths of Missouri. The crop has not been extensively grown in the counties near the Iowa line, and therefore the fact of its general resistance to winterkilling in that latitude has not been fully established. The high resistance of Missouri Early Beardless and Kentucky No. 2, at Bethany, indicate a degree of winter hardiness in these varieties that may in farm practice be found satisfactory for the conditions of the northern counties.

BARLEY DISEASES*

Covered smut and loose smut are the most serious diseases that attack barley in Missouri. Covered smut may be recognized in mature barley heads, where the grains have been replaced by a black mass of smut spores covered by a white or gray membrane. Many of the smut masses go through the thresher unbroken. The spores are carried from one crop to the next on the outside of the seed. Therefore the disease may be practically eliminated by the use of chemical seed treatments described later.

Loose smut appears when the barley is in bloom. The black, dusty smut-heads are not covered by a membrane and the smut is soon rained off or blown away, leaving only the naked stalk. Immersion of the seed in hot water has long been considered the necessary remedy for loose smut, since the smut fungus was believed always to be inside the seed where it could not be reached by chemicals. It has recently been learned, however, that there are two kinds of loose smut. They are very similar in appearance, but one type penetrates and remains alive *inside* the seed, and the other adheres to the *outside* of the seed in the same fashion as covered smut. The latter type therefore may be prevented by the same chemical treatments that control covered smut.

In experiments at Columbia this year, with home grown seed of the variety Tennessee Winter No. 5, all loose smut on this seed was of the type controllable by chemical treatments. The plots sown with untreated seed were found to contain about thirteen per cent of smutted heads. Of these about half were of covered smut and half of loose smut. Chemical treatments of the seed prevented both smuts, reducing the total percentage of infected plants to one-tenth of one per cent. Whether loose smut on other varieties can be controlled by chemical treatments is not yet known. There is a possibility that Tennessee Winter No. 5 in other sections or in other seasons may become infected with the kind of loose smut which cannot be controlled by seed disinfection.

Seed treatment is profitable as a certain preventive of covered smut. The possibility that it may prove effective in eliminating at least a part of the loose smut infection increases its value. The cost is so small that every bushel of barley planted in Missouri should be treated.

*The information on barley diseases in this section was furnished by Dr. C. M. Tucker, plant pathologist for the Missouri Agricultural Experiment Station.

One of the best chemical materials for treating barley seed is a dust sold under the trade name *Ceresan.* It is to be mixed with the seed at the rate of one-half ounce per bushel of seed. Twenty-four hours after treatment the seed is ready for planting. The treatment may be applied at any time, however, as a long delay between treatment and planting does not injure the seed nor lessen the effect of the treatment. The familiar formaldehyde treatments are also effective. Dust containing formaldehyde are now available. These dusts are used at the rate of three ounces per bushel of seed, and are satisfactory if they are fresh and if applied according to instructions. Barley seed should be fanned to remove smut balls and weak seed, before the application of any of these treatments.

Another barley disease occasionally found in Missouri is *barley stripe.* Long, narrow, dark brown stripes appear on the leaves, which split and turn brown. Diseased plants usually die before heading. The fungus that causes barley stripe is borne on the seed and is destroyed by the seed treatments described for the prevention of covered smut.

Winter barley sown in August or early September often suffers in the fall from a disease known as *brown spot.* The leaves become yellow and show many brown spots or blotches. Infection is often general over the field, causing a yellow, sickly appearance. Grazing to keep the growth down during the fall prevents the conspicuous yellowing and browning of the plants. The disease has not reappeared in the spring sufficiently to interfere with grain development even in fields where there was heavy fall infection. Seed treatments have not been found effective in preventing brown spot.