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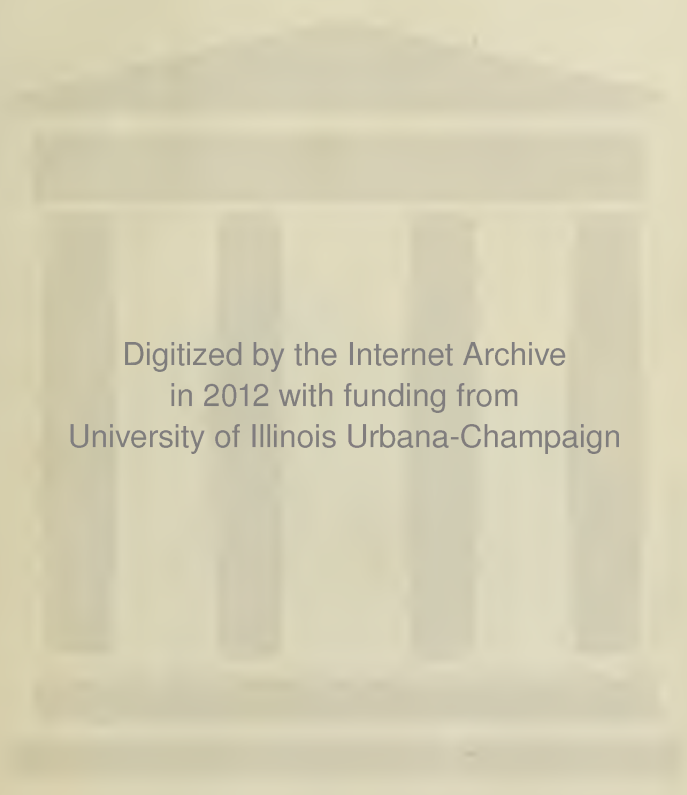
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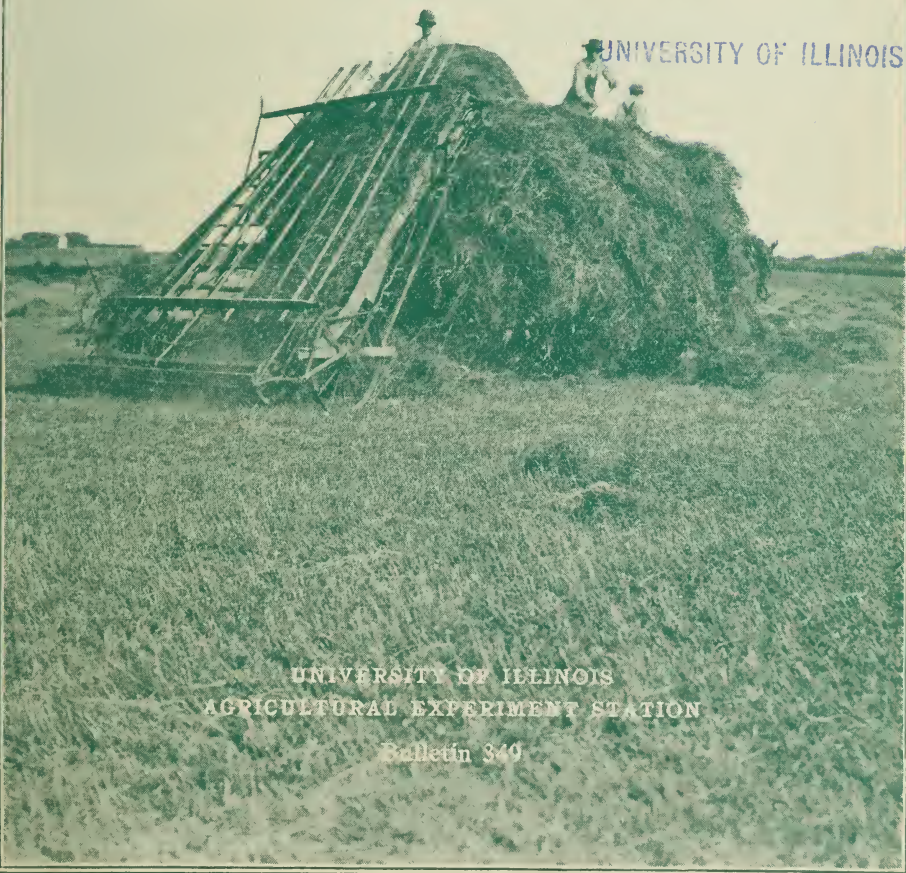
Growing Alfalfa in Illinois

By W. L. BURLISON, O. H. SEARS,
and J. C. HACKLEMAN

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Bulletin 349

Alfalfa Facts for Illinois Farmers

ONE of the most productive hays available for Illinois farmers and an excellent feed for all classes of Illinois livestock, alfalfa has no superior among the hay crops. Its production could well be increased to provide for a large part of the legume shortage in this state. Variety and cultural investigations warrant the following statements with respect to the growing of this crop.

1. Variegated alfalfas, such as Baltic, Grimm, and Hardigan, exhibit greater winter-hardiness under Illinois conditions than common alfalfas. In the north-central and northern portions of the state these types are preferable where it is desired to maintain an alfalfa meadow for several years. In central and southern Illinois common alfalfas, especially those of northern and northwestern origin, seem sufficiently winter-hardy to warrant their use, especially in short rotations of two or three years. (Pages 426-431)

2. Imported seed (except from Canada) and seed grown in southwestern United States is not recommended for Illinois. (Pages 426-431)

3. Spring seeding of alfalfa has given best results in northern Illinois and is gaining favor down state. (Pages 431, 433)

4. Cultivation does not rejuvenate an alfalfa meadow nor does it atone for lack of seed-bed preparation. In starting an alfalfa meadow a first-class seed bed, on a soil adapted to alfalfa, is essential to success. (Page 433)

5. Three alfalfa diseases are of importance in Illinois. Bacterial wilt has destroyed fields in many counties. Leaf spot and yellows are frequently present but not so deadly and their attacks are more or less seasonal and irregular. (Pages 444-447)

6. The character of the soil is one of the most important factors in alfalfa production in Illinois. Some Illinois soils are naturally adapted to this crop; others may be made suitable by soil treatment; still others are entirely unadapted to it. (Pages 415-416)

7. Where alfalfa is to be grown for the first time, careful attention must be given to thoro inoculation. Most Illinois soils lack the bacteria that form nodules on and fix nitrogen in the alfalfa plant. (Pages 417-420)

8. To sow alfalfa seed on sour soils is to invite failure. Limestone applications to sweeten sour soil should be based on the needs of each individual field. Farm manure has a pronounced beneficial effect on alfalfa yields and is especially valuable in giving a vigorous start to a new seeding. Phosphorus can be used with profit on many soils. The need for this element, as for limestone, should be determined for each individual field. (Pages 420-426)

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GROWING ALFALFA IN ILLINOIS

By W. L. BURLISON, O. H. SEARS, AND J. C. HACKLEMAN*

ALFAFA is an outstandingly profitable crop in Illinois. This is the conclusion reached by investigators in the Department of Farm Organization and Management⁷ at this Station after studying for sixteen years the cost of producing various farm crops. Over these sixteen years alfalfa proved to be the most profitable hay crop in central Illinois, its larger yield per acre giving it a distinct advantage over other hays. It also showed a larger profit than corn, wheat, or any other grain crop.

Experimental evidence and field observations indicate that from the standpoint of soil fertility approximately 25 percent of the cultivated land of a farm should be in legumes. The proven value of legumes as a feed for livestock and their importance in making possible a good seasonal distribution of labor⁷ are further reasons for maintaining them on at least one-fourth of the land.

While the legume acreage in Illinois has been greatly increased during the past ten years, few counties are producing half the legumes which good practices would seem to justify. In 1920 the U. S. Census reported 27,294,533 acres of improved land in farms in Illinois. Of this area 3,069,000^b acres were seeded in legumes in 1927, or one acre in every 8.8. If one acre in every four of cultivated land were to be devoted to legumes, the 1927 acreage would need to be increased about 222 percent. (The alfalfa acreage, like the acreage of soybeans and sweet clover, has been substantially increased in Illinois during the past ten years, but production is not yet sufficient to meet the needs of the state. According to conservative estimate about 200,000 tons were shipped into Illinois in 1928 despite the fact that about 478,000 tons were harvested.

Alfalfa was early recognized as a valuable crop for Illinois agriculture. More than a quarter of a century ago investigations were started at the University of Illinois, under the direction of the late Dr. Cyril G. Hopkins, to solve the many problems encountered in the production of this crop under Illinois conditions. The work has been continued with special emphasis on soil treatment and on the finding of adapted varieties and strains. The information gleaned from these experiments is reported in this bulletin, and it is hoped that the wide dissemination of these facts will help to overcome the chief hazards in alfalfa production in this state.

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^bIncluding the acreage of timothy and clover, clover alone, alfalfa, sweet clover, annual legumes cut for hay, soybeans for seed and cowpeas for seed.

PLACE OF ALFALFA IN ILLINOIS AGRICULTURE

A Valuable Pasture and Hay Crop

For a number of years the University of Illinois has been studying the feeding value of alfalfa. The results of this work have shown in all cases the outstanding value of this legume for all classes of livestock when fed with oat straw or timothy hay since these carbonaceous roughages, available on many farms, do not form a satisfactory ration when combined with the farm grains.

For Hogs. "Alfalfa furnishes more feed per acre for hogs than any other forage crop. It is palatable and highly nutritious and after the first season it will stand continuous pasturing. The best method seems to be to remove the first cutting each year before the field is pastured. Hogs may then be left in the field until late in the fall, if it is not pastured too closely. . . . An acre will carry from twelve to eighteen shotes, depending upon their size and the grain ration which is used."⁹⁶

For Beef Cattle. "Corn and alfalfa hay make an ideal ration for fattening cattle. These feeds can be grown successfully on almost every corn-belt farm, they are easily stored and fed, and a ration of them is well enough balanced for all practical purposes Three acres of corn and one acre of alfalfa produce 8 percent more beef at 9 percent less cost than the same area planted wholly in corn."⁹⁷

For Dairy Cattle. "An advantage of alfalfa is that it gives larger yields of total digestible nutrients to the acre than do any of the other hay crops, either legume or non-legume. This is partly on account of its greater tonnage, but the great superiority of this crop in particular and of legumes in general over non-legume crops as feeds for milk production is in their higher content of digestible protein When a legume hay is used as the sole roughage, or when it forms a large part of the roughage, a much smaller amount of high-protein concentrates is necessary to balance the grain ration than when a non-legume hay is used."⁹⁸

For Sheep. "Shelled corn and alfalfa hay have come to be considered a standard ration for fattening western lambs. . . . In these experiments shelled corn and alfalfa hay proved somewhat superior to shelled corn and soybean hay for fattening western lambs, the former ration resulting in slightly greater total gains and in lower feed consumption for 100 pounds of gain. In both rations the amounts of corn required for 100 pounds of gain were practically equal, but the hay required was about 20 percent greater with soybean hay than with alfalfa hay."⁹⁹

For Horses. "For the roughage part of the ration, no common feeds are likely to prove more desirable than *good quality* legume hays. Clover and alfalfa in particular may be grown with the assurance that they may be fed both safely and economically to farm work animals. Wherever they are produced in the corn belt, they may safely be made the basic roughages for horses and mules."⁹⁹

"Experiments have shown that the production of purebred draft fillies in Illinois, or where conditions are similar, will be most satisfactory when good pastures and legume roughages form the basis of their rations. Sound, good quality legume hay, such as alfalfa, may constitute from one-half to two-thirds of the roughage fed; the remainder to consist of carbonaceous roughages such as oat hay, oat straw, or perhaps timothy hay or corn stover."¹⁰⁰

One of the Best Soil Builders

The foregoing statements of the value of alfalfa as a feed for livestock do not tell the whole story of the value of this legume on Illinois farms. The full worth of alfalfa in the cropping system is not limited to its value as a cash crop or as a forage crop, but includes also its effect upon the soil, a fact that is sometimes overlooked. Being a legume, it has the power to secure nitrogen, the most expensive and elusive plant-food element, from the supply in the air; and a portion of this acquired nitrogen, under favorable circumstances, will be left behind in the soil for subsequent crops.

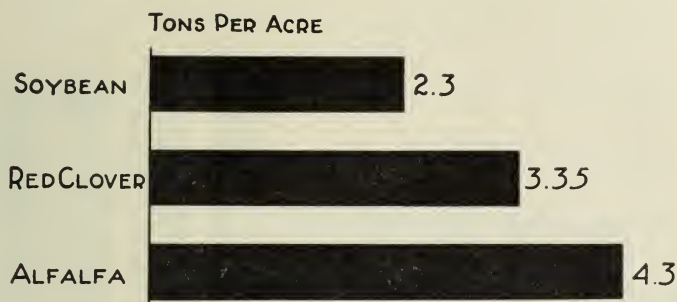


FIG. 1.—GROWN ALONE OR IN A GRASS MIXTURE, ALFALFA PRODUCES LARGE YIELDS OF HAY OF HIGH QUALITY

The combination of quality and quantity makes alfalfa a high-profit crop. These hay yields of soybeans, red clover, and alfalfa were secured at Urbana on land to which manure, limestone, phosphorus, and potash had been applied.

The extent to which any legume will add to the supply of soil nitrogen, however, depends upon the degree of inoculation, the growth habits of the plant, and the way in which the crop is utilized. It is obvious that sparsely inoculated legumes will not be able to secure as much nitrogen from the air as will legumes which show abundant nodulation, since the bacteria within the nodules are responsible for the addition of air nitrogen. Furthermore, even those legumes that are abundantly supplied with nodules secure only 60 to 75 percent of their nitrogen requirements from the air;⁴ the remainder is supplied by the soil. Assuming that the crops are utilized in the same manner, the legume whose roots make up a relatively large proportion of the total growth may be expected to leave a larger amount of nitrogen in the soil than one that has a comparatively small proportion of roots to tops. Alfalfa is a good example of a legume having a relatively large root system and so being especially valuable for soil-building purposes. Results obtained at this Station indicate, however, that where three cuttings are removed in one season, approximately three times as much nitrogen is removed in the hay as is left in the

roots.⁸ Obviously, in a cropping system in which the hay is continually removed and no manure returned, the nitrogen content of the soil will not be increased and the supply of soil minerals will be gradually depleted. Swanson and Latshaw²⁷ found this to be the case in Kansas. They determined the nitrogen content of land that had grown alfalfa for twenty to thirty years and compared it with virgin land. They concluded that the continuous growing of alfalfa may not increase the nitrogen content of the soil.

Where alfalfa is grown and fed on the farm and the manure carefully returned to the land, or where it is grown for one or two years and then a good growth plowed under as a green-manure crop, it may be expected to add to the nitrogen content of the soil.

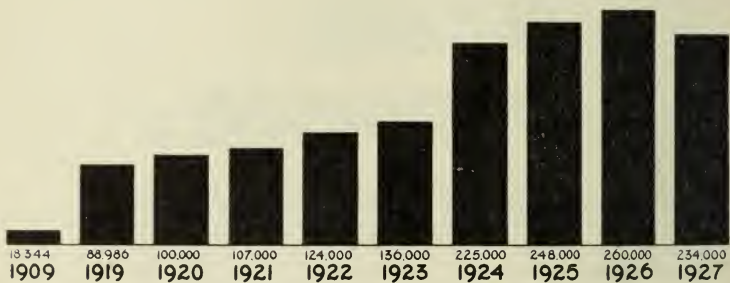


FIG. 2.—INCREASE IN ALFALFA ACREAGE IN ILLINOIS

There is a place for even more acres of this profitable crop. Many more farms in Illinois should include alfalfa in the rotation.

Even when soil conditions or cropping practices are such that the total nitrogen content of the soil is not increased by the growing of alfalfa, a beneficial effect upon the crop following alfalfa usually is noted. This increase in the immediate crop-producing capacity of the soil is probably due to the rapid transformation of the nitrogenous material of the alfalfa residues into a form of nitrogen that can be taken up readily by the following crop.

In pointing out the merits of alfalfa for soil improvement purposes the authors do not mean to imply that alfalfa is the only legume suitable for this purpose or that it is necessarily the best crop to employ under all circumstances. Sweet clover, red clover, and soybeans, as well as many other legumes, may function in this capacity.

Alfalfa in the Rotation

Because of these observed benefits to the soil from growing alfalfa, and the fact that alfalfa seed has been less costly than red clover during recent years, there is a growing tendency to make alfalfa an integral part of the crop rotation in Illinois. When used as a biennial

legume, either alone or in a clover-alfalfa mixture, it is likely to be of greatest value to the crops that follow it. Thus it is possible to remove a profitable hay crop and subsequently plow under a second or third crop as a green manure.

Following are a few suggested rotations that may serve as models or outlines to be modified according to special circumstances.

1. Corn, wheat or oats or barley, alfalfa: 3-year rotation
2. Corn, corn, oats or barley or wheat, alfalfa: 4-year rotation
3. Corn, corn, oats or barley or wheat, alfalfa, wheat (sweet-clover catch crop): 5-year rotation
4. Corn, oats or barley or wheat, alfalfa, corn, soybeans, wheat (sweet-clover catch crop): 6-year rotation

In each of these rotations it is often advisable to seed an alfalfa-clover mixture rather than to depend upon a straight alfalfa seeding.

Alfalfa may also be employed in a rotation where it is allowed to stand for several years—three, four, five, or six, depending upon the rotation used.

On the ordinary farm when alfalfa is produced primarily for home consumption and a limited acreage is needed, it may be used profitably as a part of the minor rotation rather than in the main rotation, particularly if it is desired to allow the alfalfa to occupy a given field for several years.

SOIL NEEDS OF ALFALFA

Where May Alfalfa Be Grown?

The successful growing of alfalfa in Illinois depends very largely on soil conditions. Altho the climatic differences between the extreme northern part of the state and the extreme southern part are quite pronounced, soil differences are more important than the climate in determining the yields of alfalfa in Illinois. In general, inoculation, the absence of acidity, and good drainage are the most important soil conditions affecting the growth of alfalfa in this state. Adequate inoculation may be secured fairly easily, and soil acidity may be corrected by the systematic use of limestone. The drainage problem, however, is less easily solved, and it is largely for this reason that some areas of the state are unsuited to the production of alfalfa.

Sixteen soil groups are now recognized in Illinois, each of which includes two or more related soil types (Fig. 3). From the standpoint of alfalfa production, these 16 groups may be considered under four general heads.^a

1. *Soils Naturally Adapted to Alfalfa* (Groups 2, 6, and 11). Considered in a broad way, the soils of these groups are naturally adapted to the growing of alfalfa. Within each group, however, are

^aMaterial supplied by R. S. Smith, Chief in Soil Survey Mapping.

types that are exceptions to this general rule. In Group 2 are soils which, because of topographic position and poor drainage, are not naturally adapted to alfalfa. Group 6 includes areas where the impervious subsoil is too near the surface for good alfalfa production. In all three groups the soils, with a few exceptions, need a light application of limestone in order to grow alfalfa successfully.

2. *Soils Requiring a Medium Application of Limestone to Produce Fair to Good Alfalfa* (Groups 1, 3, 4, 9, 14). The soils in these five groups all require a medium application of limestone to produce alfalfa. Groups 1 and 9 contain some areas too low and flat to be suitable for alfalfa.

3. *Soils Requiring Heavy Application of Limestone to Produce Fair Alfalfa and Fertilizer Treatment in Addition to Produce Good Alfalfa* (Groups 8 and 16). The soils of Group 8 are not well adapted to alfalfa but they may be made to produce fair crops by the application of limestone and may further be improved for this purpose by the application of other fertilizing materials, particularly one of the phosphates. In Group 16 the soils for the most part are unsuited to alfalfa because of hilly topography. Thruout these regions, however, areas occur that may be used for this crop after limestone has been applied and, preferably, after other fertilizer treatment.

4. *Soils on Which the Growing of Alfalfa Should Seldom Be Attempted* (Groups 5, 7, 12, 13, 15). An impervious subsoil renders Groups 5 and 7 unfit for alfalfa production, while danger of overflow eliminates Groups 12 and 13. In each of these groups, however, there are areas suited to this crop, and in Group 13 there are areas naturally adapted to it. Group 15 also contains soils suitable for alfalfa, altho the group as a whole is not adapted to the crop.

Alfalfa a Heavy Feeder

Since alfalfa makes a very rapid and large growth and is rich in the essential plant-food elements, it requires a comparatively large quantity of plant-food material in a relatively short period. The soil must therefore be well supplied with these elements in forms readily available to the plant if large yields are to be obtained. The amount of plant-food nutrients removed from the soil by corn, oats, wheat, and alfalfa when grown on Illinois corn-belt soil, are shown in Table 1. These data are based on the average yields obtained on nine experiment fields located in the central and northern parts of the state.

Based on the analysis of average hay, the average acre yield of alfalfa on these fields contains nearly as much nitrogen and three times as much calcium as the corresponding corn, oats, and wheat crops combined. In these figures no account is taken of the quantity of these ele-

Provisional Soil Map of

ILLINOIS

University of Illinois Agricultural Experiment Station

September, 1928

Revision June, 1929

O S Smith E A Norton

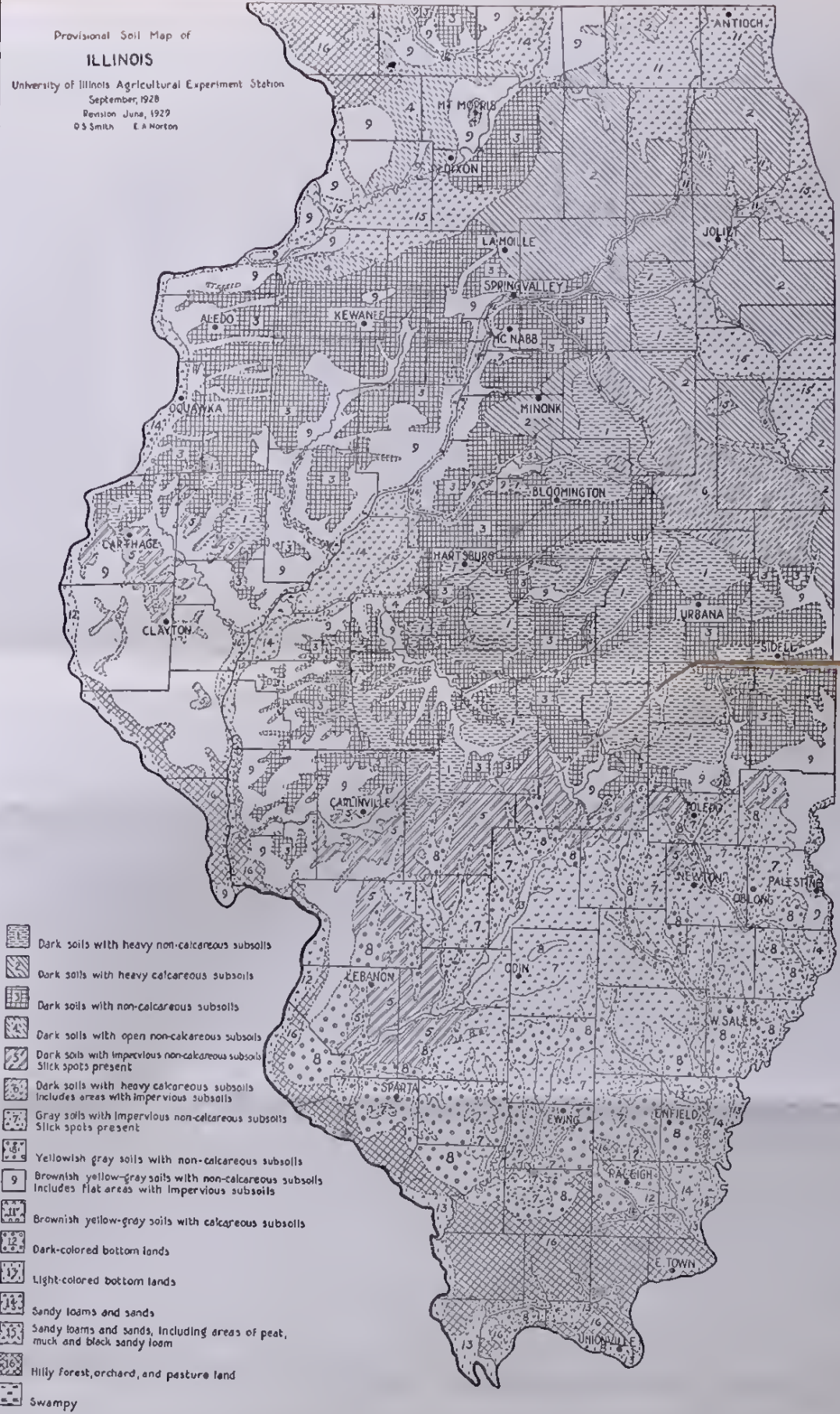


FIG. 3.—SIXTEEN SOIL GROUPS ARE NOW RECOGNIZED IN ILLINOIS

types that are exceptions to this general rule. In Group 2 are soils



TABLE 1.—PLANT-FOOD ELEMENTS REMOVED BY CROPPING ON DARK-COLORED ILLINOIS CORN-BELT SOILS

(Figures are based on data obtained on nine experiment fields located in central and northern parts of Illinois)

Kind	Crops		Plant-food elements removed annually per acre				
	Number	Yield	Nitrogen	Phosphorus	Potassium	Calcium	CaCO ₃ ^a
		<i>bu.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>	<i>lbs.</i>
Corn.....	85	65.1	96.35	14.97	46.22	14.32	35.80
Wheat.....	61	33.8	64.89	10.82	39.21	7.10	17.75
Oats.....	92	59.6	57.81	9.54	40.53	10.13	25.33
Total.....	..	....	219.05	35.33	125.96	31.55	78.88
Alfalfa.....	115	(4.1 tons)	205.00	18.45	98.40	88.97	222.43

^aCalcium carbonate equivalent to calcium.

ments contained in the roots, and when the whole plant is considered, it is obvious that the alfalfa requirements are in excess of the combined demands of the non-legume crops mentioned above. It is not surprising, therefore, that the nitrogen and limestone problems are of fundamental importance in planning for the growth of the alfalfa crop.

Inoculation Important

Even the rich prairie soils of Illinois do not furnish sufficient nitrogen in available form for maximum crop yields. Owing primarily to the absence of alfalfa nodule bacteria in the soils of Illinois, alfalfa was an unsuccessful crop in the state for many years.

TABLE 2.—INFLUENCE OF INOCULATION ON ALFALFA YIELDS¹³
(Yields given in pounds of air-dry hay per acre)

Soil treatment	Yield ^a
	<i>lbs.</i>
None.....	1 313
Inoculation.....	2 563
Lime.....	1 438
Lime and inoculation.....	2 875
Lime and phosphate.....	1 938
Lime, phosphate, and inoculation.....	3 625

^aOne cutting only.

Nitrogen may be supplied in farm manures, but ordinarily a sufficient quantity of this material is not available to produce maximum alfalfa yields. Furthermore, a considerable portion of the manure produced on the farm may be used more effectively upon other crops in the rotation, for the alfalfa plant, if supplied with suitable legume bacteria, can secure a large portion of its nitrogen from the inexhaustible supply of the atmosphere. However, unless the roots of the

plants have numerous tubercles or nodules containing these nitrogen-fixing bacteria, the crop is dependent upon the soil supply of nitrogen for its growth and development.

Inoculation Increases Yields. The effect of inoculation upon alfalfa production is well illustrated by the data in Table 2, taken from Bulletin 76 of this Station.¹³ In commenting on the results of this trial, Dr. Cyril G. Hopkins said:¹⁴ "The effect of the inoculation became very apparent, all of the inoculated soil producing a much more vigorous growth than occurred on uninoculated soil, and the more vigorous growth was accompanied by a dark green healthy looking color in the growing alfalfa, while the plants on uninoculated soil took on a pale green color indicative of an insufficient supply of nitrogen."

The inoculated plots, it will be noticed, yielded about twice as much hay as the uninoculated plots, and neither limestone nor phosphate applications were a substitute for inoculation (Fig. 4).

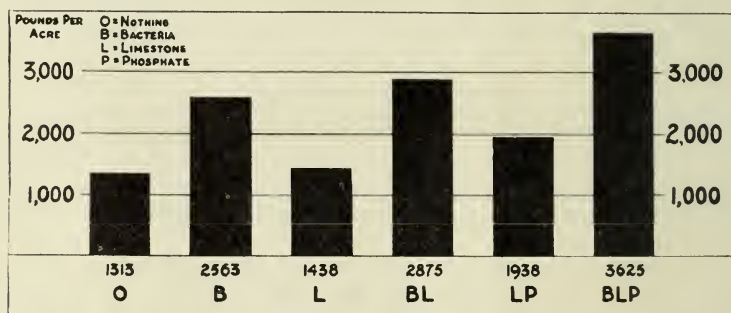


FIG. 4.—LIMESTONE AND PHOSPHATE ARE NOT SUBSTITUTES FOR INOCULATION

If not inoculated, alfalfa is a failure even on limed land. Unless sweet clover or alfalfa has been grown successfully on the land, suitable nodule bacteria should be applied before planting the seed. Note difference in hay yields when bacteria (B) were supplied.

Inoculation Improves Quality of Hay. While inoculation is indispensable for maximum yields of alfalfa, it has another important effect; it improves the quality of the hay by increasing its protein content. Some indication of the advantage of inoculation, from the protein standpoint, is suggested by the data in Table 3, which is compiled from experimental data secured at five different experiment stations.

It is chiefly the high protein content of alfalfa that makes it one of the most valuable hays for milk and meat production. In these tests inoculation increased the protein content an average of 3.52 percent, which is equivalent to a gain of 70 pounds of protein per

TABLE 3.—GAIN IN PROTEIN CONTENT OF ALFALFA HAY DUE TO INOCULATION
(From experimental data secured at five experiment stations)

Location	Percent protein		Gain for inoculation	
	Inoculated	Uninoculated	Percent	Pounds per ton
Ontario.....	17.8	15.6	2.2	44
Illinois.....	16.8	12.3	4.5	90
Minnesota.....	21.6	19.7	1.9	38
Nebraska.....	15.1	9.1	6.0	120
Wisconsin.....	28.8	23.8	3.0	60
Average.....	19.6	16.1	3.52	70.4

ton of crop, an amount equivalent to the protein in a half-ton of timothy. When both increase in yield and increase in proportion of protein are considered, the total increase in the amount of protein



FIG. 5.—THE FEEDING VALUE OF ALFALFA IS IMPROVED BY INOCULATION

Uninoculated alfalfa produced 321 pounds of protein per ton while inoculated alfalfa produced 392 pounds.

per acre to be credited to inoculation is 164 percent, or 314.67 pounds, an amount as great as that contained in 2 tons of timothy hay (Fig. 5).

Is Inoculation Always Necessary?

There are some fields where it is not necessary to inoculate the seed or the soil before sowing alfalfa. The same bacteria that produce nodules on the sweet-clover plant will also form tubercles on alfalfa. Fields that have recently grown good crops of sweet clover are therefore ordinarily well supplied with nitrogen-fixing bacteria capable of growth on the roots of the alfalfa plant, and do not need to be especially inoculated. It is partly for this reason that some successful alfalfa growers have adopted the practice of seeding a sweet-clover crop ahead of alfalfa.

If the field on which alfalfa is to be seeded has not grown a satisfactory crop of alfalfa or sweet clover recently, it is highly important that thoro inoculation be made.

Methods of Inoculation

When the value of inoculating legumes was first recognized, the bacteria were carried to new fields by direct transfer of soil. Inoculated soil was spread upon the field, 400 to 600 pounds being applied to each acre. The splendid results secured by many farmers showed that this was a very effective method. However, there are some objections to it. The cost of hauling such a large quantity of soil is considerable and there is a possibility of scattering weed seed and spreading plant diseases. The latter point is particularly important in the case of a disease such as alfalfa wilt.

More recently several modifications of the soil method have been used. One of these, sometimes called the "muddy water" method, consists in adding to a measured quantity of well-inoculated soil an equal amount of water. Stirring the soil for approximately five minutes breaks up the lumps of soil and permits the bacteria to be washed into the muddy water. The soil is allowed to settle for another five minutes and the trash is removed from the surface of the liquid. One pint of this muddy water is sprinkled over each bushel of seed. The seed are stirred until every one is moistened; then they are allowed to dry in the shade and are sown at once. (Drying may be hastened by sprinkling some of the dry soil on the seed and stirring again.) It is important that the soil be obtained from a field in which alfalfa or sweet clover has shown abundant nodule development; the mere fact that one of these crops grew in a field does not insure that the soil will give satisfactory inoculation. Preferably, the soil should be taken from around the roots of well-inoculated plants.

Recently it has been found possible to grow legume bacteria in the laboratory. These organisms can be transferred to the proper legume seed very successfully. The development of this method has now reached the stage where nodule bacteria may be obtained from a number of commercial laboratories at a cost ranging from 25 cents to one dollar for a quantity sufficiently large to inoculate one bushel of seed.

Alfalfa Requires a "Sweet" Soil

Altho inoculation of alfalfa is essential for success, this practice alone will not insure satisfactory yields. Most soils in the central and northern parts of the state and practically all of the upland soils of southern Illinois require the application of limestone for profitable alfalfa production. Even on soils that will grow red clover very satisfactorily, alfalfa often fails to do well unless the soil is limed. No common crop plant except sweet clover has such a high lime requirement as alfalfa. The high calcium needs of the plant and the fact that alfalfa nodule bacteria are unable to survive in very acid soil are factors which contribute to this high lime requirement.

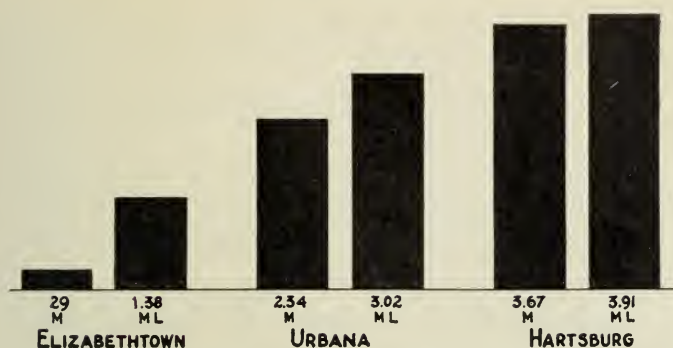


FIG. 6.—THE RESPONSE OF ALFALFA TO LIMESTONE DEPENDS ON THE SOIL

On the very acid soils at Elizabethtown alfalfa is a failure unless limestone is applied. On the sweet soils represented by the Hartsburg field, little is to be gained from liming. A test for acidity as described in Circular 346 will show where applications of limestone are needed.

The amount of limestone required for satisfactory results varies greatly. In Soil Groups 2, 6, and 11, previously discussed, applications of one to two tons to the acre will usually suffice; whereas in Groups 8 and 16 as much as four or five tons may be required. The lime requirement varies, however, within a soil group and in fact commonly varies from place to place within a given field. Obviously, the amount that should be used can be determined only by a systematic test of the area upon which alfalfa is to be seeded. For complete instructions in this matter, the reader is referred to Circular 346 of this Station, "Test Your Soil for Acidity."¹⁸

On many soils alfalfa is practically a failure unless limestone applications are made. The results secured on three soil experiment fields in southern Illinois (Table 4) illustrate this fact. Besides the low yields of alfalfa on the unlimed plots (.29 ton per acre on the Elizabethtown field, .60 ton at Unionville, and .79 ton at Sparta), the hay is poor in quality, a large portion consisting of weeds. While the yields are not high on the limed land they are improved both in quality and in quantity by the limestone applications. It is evident that the growing of alfalfa should not be contemplated on the dis-

TABLE 4.—EFFECT OF LIMESTONE ON YIELDS OF ALFALFA ON VERY ACID SOILS IN SOUTHERN ILLINOIS
(Yields given in tons per acre)

Location	Number of crops	Yields per acre		Increase for limestone
		Limed	Unlimed	
Elizabethtown.....	3	1.38	.29	1.12
Sparta.....	4	1.95	.79	1.16
Unionville.....	9	2.27	.60	1.67

tinety sour soils such as are represented by these fields, without a previous application of limestone.

Sour Sandy Soils Respond to Liming

The application of liming materials to the acid sandy soils of the state may be expected to show benefits similar to those shown on the light-colored silt loam soils of southern Illinois, according to the results obtained on the Oquawka experiment field in Henderson county (Table 5).

The increase from limestone on this sand soil has been practically the same as that obtained on the very acid soils in the experiments reported in Table 4. Two tons of limestone applied every four years has increased the alfalfa yields 85 percent over the yields from the manure plot. In the grain system limestone has given even more striking results.

TABLE 5.—INFLUENCE OF VARIOUS SOIL TREATMENTS ON ALFALFA YIELDS ON SAND SOIL: OQUAWKA FIELD, HENDERSON COUNTY, ILLINOIS
(Figures indicate tons of alfalfa per acre)

	0	Livestock system			0	Grain system				0
		M	ML	MLP		R	RL	RLP	RLPK	
Average of 11 years.....	.56	1.43	2.64	2.73	.95	1.02	2.41	2.43	2.48	.72

The soil treatment in this and following tables is designated by the following symbols:

- 0 = None
- R = Residues (residues from crops, and legumes used as green manure)
- M = Manure
- MP = Manure and rock phosphate
- RP = Residues and rock phosphate
- ML = Manure and limestone
- RL = Residues and limestone
- MLP = Manure, limestone, and rock phosphate
- RLP = Residues, limestone, and rock phosphate
- RLPK = Residues, limestone, rock phosphate, and potassium (usually in the form of kainit)

On many other soils where alfalfa is not a complete failure without the use of liming materials, applications of limestone have a very pronounced beneficial effect. Even on the fertile soils of the corn belt, the use of limestone has been profitable. As an average of 99 crops grown on eight different experiment fields located on the dark-colored soils of the corn belt, the lined soils have returned 1,080 pounds more alfalfa per acre per year than the corresponding unlined plots (Table 6). The gain due to liming varies from 6.5 percent on the Hartsburg field to 101 percent on the Pana field. While the darker soils of the central and northern portions of the state do not respond so uniformly to limestone treatment as do the lighter colored soils of the southern section, yet a large proportion of the dark soils give a profitable return upon the addition of liming materials.

Because of the prevailing acidity in Illinois soils it seems desirable, even with the best soils, to ascertain the lime requirement of

every field on which an attempt is to be made to grow this crop. The correction of acidity creates a more favorable condition for the nodule bacteria and provides a more suitable medium for the development of the root system of the alfalfa plant.

TABLE 6.—INFLUENCE OF SOIL TREATMENT ON ALFALFA YIELDS ON DARK-COLORED ILLINOIS SOILS
(Figures indicate tons of alfalfa per acre)

Field	Number of crops	0	M	ML	MLP
Dixon.....	18	3.14	3.79	4.12	3.95
Hartsburg.....	10	3.47	3.67	3.91	4.18
Joliet.....	7	.84	1.13	1.72	2.64
LaMoille.....	11	2.12	2.25	2.57	2.44
Mt. Morris.....	19	2.33	3.06	3.87	3.96
Pana.....	4	1.46	1.65	3.32	3.46
Sidell.....	14	2.30	2.46	2.77	3.28
Urbana.....	16	2.29	2.34	3.02	4.16
Average.....	..	2.42	2.77	3.31	3.63

The need for lime is apparently as great in the livestock system of farming as in the grain system, if we may judge by the results secured on five Illinois fields located at Hartsburg, Joliet, Pana,



FIG. 7.—ALFALFA DOES NOT FLOURISH ON SOUR SOILS

On soils which produce fair to good red clover, alfalfa frequently fails completely unless the soil is limed. The above plots show the advantage of lime in growing alfalfa at Urbana.

Sidell, and Urbana, that afford a comparison of the two systems (Table 7). The effect of adding lime to one of plots on the Urbana field is shown in Fig. 7.

TABLE 7.—COMPARISON OF ALFALFA YIELDS IN LIVESTOCK AND GRAIN SYSTEMS OF FARMING ON DARK-COLORED ILLINOIS SOILS
(Figures indicate tons of alfalfa per acre)

Field	Number of years	Livestock system			Grain system				0
		M	ML	MLP	R	RL	RLP	RLPK	
Hartsburg.....	10	3.67	3.91	4.18	3.77	3.44	4.03	4.15	3.19
Johet.....	7	1.13	1.72	2.04	.82	3.31	2.75	2.91	1.04
Pana.....	4	1.65	3.32	3.46	1.84	3.18	3.65	3.79	2.02
Sidell.....	14	2.46	2.77	3.28	2.06	2.51	3.10	3.44	2.04
Urbana.....	16	2.34	3.02	4.16	2.37	2.78	3.96	4.27	....
Average.....	..	2.41	2.97	3.66	2.31	2.66	3.55	3.80	2.16

Manure Helps to Secure a Stand

The value of farm manure for soil improvement is generally recognized. On soils that are in a low state of productivity, farm manure is of special benefit to the alfalfa crop. In the experiments reported in Table 6 on dark-colored Illinois soils, an average increase of 700 pounds (.35 ton) of alfalfa per acre per year has resulted from its use. At Dixon and Mt. Morris in particular, a decided gain in yields has been obtained by applying manure. This benefit

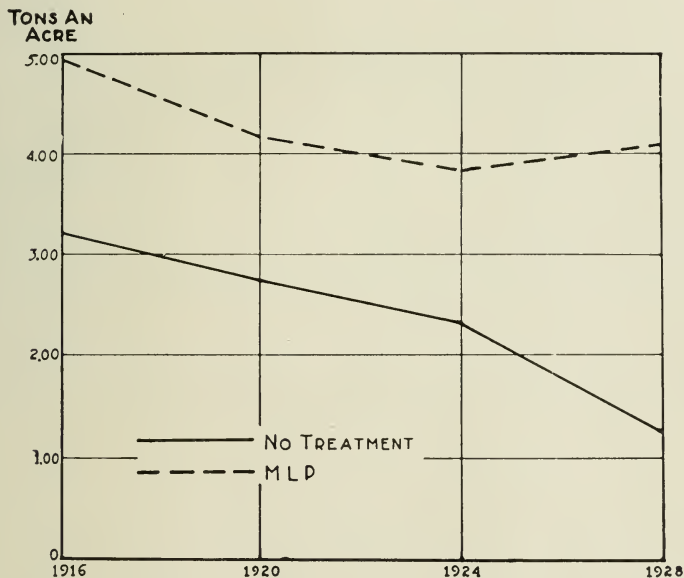


FIG. 8.—SUITABLE SOIL TREATMENT CHECKS DECLINING ALFALFA YIELDS

On untreated land at Urbana the yield of alfalfa has declined steadily during the last twelve years, but on land treated with manure, limestone, and phosphorus the decline has been arrested.

no doubt is due largely to the minerals which the manure supplies and to the tendency of manure to raise the general productive level of the soil. Manure is especially valuable for the readily available plant-food material which it furnishes while the plant is still too small to secure an abundant supply of nutrients from the soil minerals and the atmosphere, thus helping the plant to get established.

On sandy soils in particular, an application of manure, and of lime if it is needed, goes a long way in establishing a good alfalfa field (Table 5). It is important to remember, however, that even on this soil, which is very low in organic matter, manure will not take the place of limestone. In the tests reported in Table 7 on the dark-colored Illinois soils manure alone increased the yield 300 pounds (.15

ton) an acre, whereas a combination of manure and limestone resulted in an increase nearly five times as large. Altho these data do not prove the fact, it is probable that limestone is valuable in creating a favorable environment for the plant and in increasing the effectiveness of the manure.

Response to Phosphate Variable

Unlike limestone, the use of phosphate on Illinois soils has not been consistent in its effect upon the alfalfa crop. At Joliet, Sidell, and Urbana a very distinct improvement in the yields has been secured thru the use of rock phosphate, while on the other fields where comparison is possible, the gains due to phosphate applications have been negligible (Tables 6 and 7). Either phosphorus is not the limiting element on all the soils of the state or it has not been used in an effective way; there are reasons to believe that both conditions are responsible for this lack of response to phosphate applications.

That soils with similar phosphorus content vary in their response to phosphate fertilization has become recognized in comparatively recent years. It is only within the past year, however, that a method has been available that makes it possible for a farmer to determine the needs of individual fields for this important element of plant food. This method, developed at the Illinois Station, is described in Bulletin 337, "A Field Test for Available Phosphorus in Soils."³

Sulfur Not Needed on Illinois Soils

Altho sulfur is one of the essential elements for the growth of plants, the supply of this element under Illinois conditions appears to be adequate for the growing of alfalfa. Notwithstanding the fact that remarkable increases in alfalfa yields have been secured in some western states by the application of sulfur-containing fertilizers, no increased yield has been secured at this Station from the use of sulfates.¹ The natural supply of sulfur in Illinois soils and the additions that occur thru rainfall appear to meet the needs of large alfalfa crops.

BEHAVIOR OF ALFALFA VARIETIES

While attention to soil factors is essential for satisfactory alfalfa production, the meeting of soil requirements does not in itself guarantee a successful crop. Types and varieties and regional strains of alfalfa differ markedly in yield under Illinois conditions, and it is just as essential to get an adapted strain in the case of this crop as it is to choose the proper variety of corn. In order to determine the best types and strains for Illinois several variety trials have been

TABLE 8.—DEKALB FIELD, NORTHERN ILLINOIS: COMPARATIVE YIELDS OF ALFALFA VARIETIES, AVERAGE OF SPRING AND FALL SEEDINGS (Tons per acre)

Variety	1918	1919	1920	1921	1922	1923	1924	1925	Average
Common.....	1.68	2.50	2.93	2.68	3.29	4.19	3.09	2.91	2.91
South Dakota No. 12.....	2.00	2.84	4.07	4.67	4.32	4.42	3.13	3.64	3.64
Turkestan.....	1.52	1.78	2.73	2.82	3.42	4.00	2.99	3.48	2.84
Baltic.....	.....	3.16	5.52	4.69	4.95	4.70	3.38	4.28	4.38
Common from northern South Dakota.....	3.37	2.31	3.63	3.35	3.25	3.37	1.95	1.63	2.86
Grimm.....	3.59	2.89	4.07	3.40	3.96	4.29	2.16	2.86	3.40

TABLE 9.—URBANA FIELD, CENTRAL ILLINOIS: YIELDS OF VARIETIES OF ALFALFA IN NORTHWEST ROTATION^a (Total tons per acre from three cuttings each year)

Variety	1924	1925	Average
South Dakota No. 12.....	3.94	4.99	4.47
Grimm.....	3.86	4.66	4.26
Cossack.....	3.64	4.64	4.14
Kansas (common).....	3.87	4.67	4.27
Idaho (common).....	3.70	4.61	4.16
Argentine (common).....	3.22	2.74	2.98

^aFigures for 1926, 1927, and 1928 are not reported because during those years the plots were all seriously injured by alfalfa wilt. There is also some question as to the accuracy of the field weight for one cutting in 1927.

conducted at DeKalb in northern Illinois, at Urbana in central Illinois, and on several other experiment fields over the state.

In all these variety trials the soil was prepared just as a good farmer would prepare his land for alfalfa. For spring seeding about 15 to 18 pounds of seed were drilled in during the last week in May or early in June, and the fall seeding was done in August. Except where time of cutting was a part of the experiment, the alfalfa was cut at the one-tenth-bloom stage.

On the DeKalb field, where alfalfa has been grown on dark-colored silt loam soil having a calcareous subsoil, limestone is not required for satisfactory yields. At Urbana the major variety tests were made on a rich, dark-colored soil that had received 2,000 pounds of rock phosphate, $\frac{1}{2}$ ton of limestone, and a heavy coating of farm manure each four years since about 1906, when the field was established. The rotation at Urbana consists of corn, soybeans, potatoes, and alfalfa; alfalfa remaining on the same field for six years while the other crops are moved around twice. On one series (No. 300) in 1924 the alfalfa was seeded in the spring, and in the other years the seeding was done during the last two weeks of August.

At DeKalb, Baltic, Grimm, and South Dakota 12 have produced very satisfactory yields, while common and Turkestan strains have been unsatisfactory (Table 8).

The results at Urbana suggest that South Dakota 12, Grimm,

TABLE 10.—AVERAGE ESTIMATED^a STAND OF ALFALFA SEEDED ON UNIVERSITY PLOTS AT URBANA, ^bAUGUST, 1926
(Percentage of full stand)

Plot No.	Variety	Source of seed	S. P. I. No. or identification	Stand Nov. 24, 1926, before first winter	Stand June 23, 1927, after first winter	Stand May 19, 1928, after second winter
1.	South Dakota No. 12	South Dakota.	Certified seed.	83	84	72
2.	Canadian variegated	Canada.	Canada government seal.	72	83	65
3.	Argentine (common)	U. S. D. A.	2536	65	69	16
4.	Arizona	U. S. D. A.	2273	70	47	10
5.	Hardigan	Michigan	Certified seed.	56	78	73
6.	South African	U. S. D. A.	2502	51	36	7
7.	California	California.	Seed company verification.	71	77	26
8.	Cossack	South Dakota.	Certified seed.	57	75	72
9.	Provence	U. S. D. A.	34886	8	9	6
10.	Kansas (common)	U. S. D. A.	581	62	66	48
11.	Baltic	U. S. D. A.	1870	51	73	68
12.	Italian (common)	U. S. D. A.	2123	51	37	3
13.	Dakota (common)	U. S. D. A.	552	60	61	52
14.	Grimm	South Dakota.	Certified seed.	53	71	48
15.	Peruvian	U. S. D. A.	600	74	6	1
16.	Nebraska (common)	Nebraska.	Nebraska Experiment Station.	57	55	40
17.	Canadian variegated	U. S. D. A.	2472	70	67	61
18.	Spanish	U. S. D. A.	7101	50	36	10
19.	Montana (common)	Montana.	Montana Experiment Station.	77	83	72
20.	Grimm	U. S. D. A.	565	74	88	78
21.	Utah (common)	U. S. D. A.	2624	75	79	62
22.	Kansas (common)	Kansas.	Kansas Experiment Station.	63	82	59

NOTE.—Plots 11 to 16 inclusive in the second series, and 5 to 9 and 17 to 22 in the third series, were washed out and otherwise so badly damaged by the heavy rains in the fall of 1926 and 1927 that they were not included in the averages.

^aAverage stands as estimated by three persons on duplicate and in some cases triplicate plots. ^bThese plots were located immediately north and south of the Stadium Drive.

Cossack, Kansas common, and Idaho common are well adapted to central Illinois. The Argentine strain has not given satisfactory yields (Table 9).

Winter Resistance of Alfalfa Varieties and Strains

The variegated strains of alfalfa, according to tests at the Illinois Station as well as others reported herein, appear to be the hardiest under Illinois conditions, followed by northern and northwestern-grown common, then western-grown common, then by the nonhardy alfalfas of southwestern United States, and finally by the imported alfalfa seed of Mediterranean, South American, and South African origin.

The above statements are based on the results of three years' tests at Urbana reported in Table 10 and further summarized in Table 11. The tests included 22 strains, 16 of which were native and 6 imported.

TABLE 11.—AVERAGE ESTIMATED STANDS OF DIFFERENT TYPES AND REGIONAL STRAINS OF ALFALFA SUMMARIZED FROM TABLE 10
(Percentage of full stand)

Source of seed	Type	November 1926	June 1927	May 1928
Imported.....	Common	50	32	7
Southwest U. S.....	Common	70	62	18
West and northwest U. S.....	Common	68	73	58
Northern U. S. and Canada.....	Variegated	62	76	61

The 16 native lots included six of the hardy or variegated types. Of the remaining 10, at least two were recognized as unadapted to Illinois, being nonhardy strains produced in southwestern United States.

While these tests have not covered as long a period as is desirable, the results nevertheless suggest something regarding the adaptation of different strains of alfalfa seed to Illinois conditions.

The 22 varieties and regional strains were seeded in triplicate in August, 1926, on one-fortieth acre plots, at the rate of 15 pounds of germinable seed to the acre. A few of the imported lots were of low vitality but sufficient seed was used on each plot to make the total amount of vital seed practically equal. These lots all came up to a good stand, little or no difference being noted until after the rains subsided late in October or early in November. Most of the imported and a few of the native lots proved quite susceptible to water injury. Marked differences in stand were noted in November just prior to the first severe freezes.

The imported alfalfas and the southwestern common alfalfa in the fall of the first year made more growth than the others and

showed little or no evidence of preparing for winter. On the other hand, the variegated strains, together with South Dakota No. 12, Dakota common, Montana common, and some of the other lots, made comparatively little growth in the fall, apparently expending their energies in building up root reserves to carry thru the winter.

The variegated types made substantial gain in appearance of stand during the first winter. This probably is explained by the condition just mentioned. The southwestern and the imported lots developed into large, vigorous plants which gave the appearance of good stands in the fall of the first year, but in the following spring difference in growth among these types largely disappeared.

The soil where these plots were seeded is a dark, productive loam, probably somewhat more fertile than the average corn-belt soil, having had several applications of barnyard manure during the previous ten years. Two tons of limestone per acre—an amount sufficient to correct the acidity—was applied prior to seeding the plots. All plots were thoroly inoculated by the soil-transfer method, the inoculated soil being worked into the surface before seeding. The drainage of these plots had proved fairly satisfactory under average seasonal conditions prevailing during the preceding seasons, but owing to the excessively wet fall and spring of 1926 and 1927, and the heavy rains in the fall of 1927, the plots were covered on several occasions with one to two feet of water, thus giving an additional opportunity to study the resistance of the different varieties to flooded soil conditions.

The results from a series of cooperative plots located in Hancock, DeKalb, Rock Island, and Will counties (Table 12) confirm those reported in Table 11, the imported alfalfa being decidedly inferior to the native common and much less winter-resistant than the variegated types.

TABLE 12.—PERFORMANCE OF ALFALFA TYPES AND STRAINS IN FOUR REPRESENTATIVE ILLINOIS AREAS^a: AVERAGE STAND IN SPRING OF SECOND YEAR
(Figures represent estimated percentage of full stand)

Variety	Hancock county		DeKalb county	Rock Island county		Will county
	Plot 1	Plot 2		Plot 1	Plot 2	
Idaho (common).....	74	26 ^b	95	85	70	....
Utah (common).....	65	23 ^b	....	..	70 ^d	....
Argentine (common)....	16	15 ^b	75	..	..	40
Kansas (common).....	60	30 ^b	90	..	..	60
South Dakota No. 12...	70	42 ^b	90	80	60 ^{d,e}	77.5
Grimm (Montana).....	95	73	....	..	..	....
Canadian variegated....	95	72	....	65 ^c	88 ^d	67.5
Grimm (Idaho).....	80	73	87.5	95	80	77.5
Hardigan.....	75	73	....	..	..	....
Ladak.....	..	..	....	88	40 ^d	....
Montana (common)....	..	..	....	83	..	65

^aWith the exception of those in Will county, the above plots were seeded in 1928 and the records of stand were taken in April and May, 1929. Will county was seeded in April, 1926. ^bExcessive rains washed plots badly. ^cInjured by heavy growth of nurse crop and later by foxtail. ^dNurse crop lodged injuring young plants. ^ePlot in dead furrow which was filled with water for long periods.

Alfalfa is a perennial which, under the most favorable conditions, remains productive for many years. In Illinois, however, the average alfalfa meadow reaches its best production during the second and third years, then wanes, and seldom is sufficiently productive after the fourth or fifth year to be allowed to stand. Most Illinois meadows, according to observations made during the past few years and the experience reported by Illinois farmers, fail at four years. This means that it is necessary to reseed approximately 25 percent of the existing acreage each year in order to maintain present production.

This premature death of alfalfa in Illinois meadows and the gradual thinning of stands until they become so weak and unproductive as to be unprofitable frequently is a complex problem. It seldom is possible to single out any one cause for the failure since several important factors—inadequate drainage, poor soil, lack of inoculation, poor and improper cultural practices, diseases, and the use of unadapted varieties—all contribute to alfalfa losses. The weakening of the plants during the growing season frequently is not noted, and it is only when growth fails to start in the spring that the farmer realizes something is wrong. Winterkilling usually is the immediate cause of such failures, tho one or all of the factors just enumerated may be the primary cause.

The tests reported here, as well as observations thru the state, point to the use of unadapted varieties as one of the important causes of failures during the past few years. With an average importation of more than 6 million pounds of seed yearly during the past ten years, the relative value of the imported lots, as well as some idea of the adaptation of the various native lots, becomes a matter of increasing importance.

SEEDING, CULTIVATING, AND CUTTING

A Good Seed Bed Essential

Many failures of alfalfa are directly traceable to a poor seed bed. The bed must be plowed well, approximately two weeks in advance of seeding; it must be disked and then harrowed until it is firm "like a garden." This applies particularly to summer seeding, where moisture may become a limiting factor. As some one has said, the alfalfa seed bed should feel like "a thick rug when walking over the field." In preparing a first-class seed bed most of the weeds will be killed; this is very desirable since weeds are real enemies of alfalfa.

Spring Seeding Gaining Favor

In order to compare returns from alfalfa seeded in the spring and fall, experiments at DeKalb were conducted in 1919. The spring

TABLE 13.—DEKALB FIELD, NORTHERN ILLINOIS: AVERAGE YIELD OF ALFALFA VARIETIES AND STRAINS,
 SPRING AND FALL SEEDED, 1919-1925
 (Tons per acre)

Variety	1919	1920	1921	1922	1923	1924	1925	Average yield
Common.....	Spring.....	2.93	3.74	3.27	4.25	2.98	3.17	3.26
	Fall.....	.....	1.62	3.31	4.14	3.20	2.66	2.99
South Dakota No. 12.....	Spring.....	3.20	4.06	5.01	4.52	3.31	3.39	3.99
	Fall.....	2.48	4.08	4.33	4.13	2.96	3.89	3.75
Turkistan.....	Spring.....	2.39	4.20	3.74	3.54	3.16	3.93	3.64
	Fall.....	1.18	1.26	1.90	3.30	2.82	3.03	2.42
Baltic.....	Spring.....	3.06	5.62	4.23	4.97	3.49	4.62	4.45
	Fall.....	3.27	5.43	5.16	4.93	3.28	3.94	4.32
Common from northern South Da- kota.....	Spring.....	3.43	5.11	4.20	4.81	2.51	2.54	3.97
	Fall.....	1.19	2.16	2.51	1.70	1.39	.72	1.61
Grimm.....	Spring.....	3.26	4.35	3.91	4.68	2.45	3.32	3.78
	Fall.....	2.53	3.79	2.90	3.24	1.88	2.41	2.98

seeding was done during the last days of May or very early in June, while the fall seeding was done during the last days of August or very early in September.

Spring seeding gave the best results with each variety (Table 13). It would seem then that spring seeding for northern Illinois is more desirable than late summer or fall sowing. In central and southern Illinois the seeding of alfalfa during the last two weeks in August has been a common practice, tho spring seeding is more frequent now than formerly.

Cultivating Does Not Pay

Much has been said regarding the desirability of cultivating alfalfa after the crop has been seeded. In earlier years the practice was to cultivate with the common disk harrow. Later special alfalfa cultivators were placed on the market.

TABLE 14.—YIELDS OF ALFALFA SECURED FROM DIFFERENT METHODS OF CULTIVATION
(Tons per acre)

Kind of cultivation	1919	1920	1921	1922	1923	Average
Spring-tooth harrow.	4.00	4.71	4.00	4.27	4.19	4.23
Alfalfa cultivator.	4.16	4.47	4.21	3.61	3.85	4.06
No cultivation.	4.36	4.92 ^a	4.31 ^a	4.12 ^a	4.54	4.45

^aIncludes a small fourth cutting.

In order to determine the value of different cultural practices, a set of experiments was conducted on the Urbana field that included cultivation with the spring-tooth harrow and with the alfalfa cultivator. A check plot was left uncultivated. On the cultivated plots the crop was cultivated after each of the three cuttings. The plots *not* cultivated gave a slightly better yield than the cultivated areas (Table 14), and it would therefore seem that there is no justification for cultivating this crop. Some feeders have complained that the hay from cultivated alfalfa fields is dusty and less desirable, particularly for horses.

When to Cut Alfalfa

Illinois experiments extending over a number of years seem to indicate a slight advantage for cutting alfalfa at the one-tenth-bloom stage, tho there is very little difference between the yields obtained at this stage and at full bloom (Table 15).

The Wisconsin and Kansas Stations have also been investigating this problem. Moore and Graber¹⁹ of Wisconsin draw the following conclusions:

"Two crops of alfalfa cut as near the full-bloom stage as possible without making the hay too coarse, will over a period of years yield considerably more

TABLE 15.—URBANA FIELD, CENTRAL ILLINOIS: ALFALFA YIELDS IN CUTTING EXPERIMENTS IN THE NORTHWEST ROTATION
(Tons per acre)

Stage of cutting	1919	1920	1921	1922	1923	1924	1925	Average
First shoots.....	3.87	4.51	3.86	4.08	4.19	3.39	4.09	4.00
1/10 bloom.....	4.86	4.52	4.26	4.11	4.33	3.94	4.99	4.43
Full bloom.....	3.95	4.84	4.46	3.31	4.08	4.63	4.88	4.31

hay than three crops cut in the early bud or tenth bloom stages. It is true that the later alfalfa is cut, the coarser and poorer will be the quality of hay, but early cutting weakens and thins out the alfalfa, retards the root growth, lowers the yield and permits the ready entrance of bluegrass."

Throckmorton and Salmon²⁸ of Kansas say:

"The old rule to begin cutting when the field is about one-tenth in bloom is reasonably safe if the same field or the same portion of the field is not cut in the tenth-bloom stage every year. If it is, the stand is likely to be thinned out after the second or third year, and the alfalfa will be replaced by weeds and grass.

"Very recent experiments indicate that fields may occasionally be cut as early as the bud stage without material injury, providing it is not repeated too frequently. This suggests that it may be possible to cut the first or the first and second crops of the season very early and thus avoid the very rank growth that is characteristic of the first crop, and then give the plants an opportunity to recuperate by allowing the later crops of the season to reach full bloom before they are cut."

The best stage for cutting alfalfa would thus seem to depend very largely on the season and the locality.

ALFALFA VARIETIES AND STRAINS

Alfalfa, a relatively new crop, especially in the humid regions of the Mississippi Valley, has been generally considered a rather stable, uniform, one-variety field crop. As the acreage increased and additional observers began to study the crop, distinct differences in the performance of various lots of alfalfa became apparent. Wide variations were noted in the adaptability of different lots of seed to the peculiar conditions prevailing in the Mississippi Valley. Effort to find strains adapted to special conditions or localities has resulted in the introduction on the American seed market of a number of more or less generally recognized types or varieties.

The increase in the alfalfa acreage in many of the countries of the Old World as well as in the Western Hemisphere has brought into commercial importance many new strains or types which until relatively recently were comparatively unrecognized.

Alfalfas can probably best be grouped into five great classes or types. These groups listed in the probable order of their acreage

in the United States are: (1) common; (2) variegated, the most common strain of which is Grimm; (3) Turkestan; (4) nonhardy; and (5) yellow-flowered. Each group contains numerous strains which, for the most part, are indistinguishable from other members of the group, but which generally are designated by their origin.

Common Alfalfas

Common, or purple-flowered, alfalfa is widely grown thruout central and western United States. Much of the seed of this type found on the American market is thought to "have a common lineage, being descended from stock introduced into California during the early history of that state."¹¹ Our native seed is usually designated by such names as Kansas, Oklahoma, Colorado, Idaho, Utah, Montana, South Dakota, North Dakota, Minnesota, Michigan, etc., these names merely indicating the probable origin of the seed. In addition to these names, which suggest native-grown seed, imported common alfalfa is also to be found on the market now, as Argentine, Italian, French, German, etc. Most of the imported alfalfa is of the common, or purple-flowered, strain.

Regional Strains. While there is little noticeable difference in the external appearance of the strains of common alfalfa, there is a distinct difference in their winter-hardiness. As a rule, northern-grown strains seem to be more dependable under severe winter conditions than strains of a more southern origin. Experiments conducted at the Iowa Station¹⁶ indicate that, "seed from Utah, Mexico, and Oklahoma is of much lower value than that from the Dakotas, Nebraska, and Kansas" under Iowa conditions.

Strains that come from the same general region and appear similar frequently react very differently. In northern Illinois two strains of common alfalfa from South Dakota, during the years 1918 to 1924, showed marked variation in their winter resistance and yielding power. During the same period, common alfalfa from the Middle West proved less cold-resistant and a poorer producer than either of the South Dakota strains.

Alfalfa is an open-fertilized plant. This perhaps partially accounts for so many apparently different strains in the same group. In every field of common alfalfa many variations in the character of the plants can be readily noted. Some plants may be tall, erect, exhibit quick recovery after cutting, and frequently are crowned higher than others. The lower-crowned strains are likely to be shorter, may even be almost decumbent, and will recover slowly from clipping. As a rule these low, or submerged crowns, are associated with hardiness, while smaller, more exposed crowns are found in alfalfas that are sensitive to winter injury. As such mixed strains are moved northward only the hardier plants are likely to persist; when moved southward, the

more tender, earlier, more erect, and quicker-maturing plants would probably soon predominate.

There is very little evidence of any uniform difference in the character of plants of different strains of common alfalfa. The difference in hardiness probably is due to natural or selective acclimatization, that is, to the survival of the fittest. The chief difference in the typical northern common alfalfa and the typical plant produced from southern seed appears to be in the character of the root system. Garver¹² reporting in Bulletin 1087 of the U. S. Department of Agriculture states, in commenting on the characters of the root system of the northern strain, ". . . root systems of this alfalfa are fairly uniform and intermediate between the root system characteristic of southern-grown common alfalfa and that of the hardier varieties, such as Turkestan and Grimm. The tap-root is quite distinct and branch roots are most prominent at 1½ to 4 inches below the crown. This is somewhat nearer the surface than is characteristic of the southern-grown strains and almost identical with the Turkestan and Grimm."

The names applied to the different lots of commercial alfalfa seed are not necessarily an indication that any such process of natural selection has gone on. There seems little question, however, but that alfalfa that has been grown for a number of generations under severe winter conditions will be more hardy than a strain not so tried.

Imported Strains. The rapid expansion of the alfalfa acreage in non-seed-producing sections of the United States has annually created an active market demand for seed. This demand could not be fully met by native seed. Imported seed has therefore found its way on to the American market in increasing quantities since the close of the World War, until last year. The annual importation fluctuates inversely with the carry-over in this country and with seed production in the important seed-producing areas.

The greatest quantity of alfalfa seed imported into the United States during any one year was reported for the fiscal year ending June 30, 1920. Of the 18,831,000 pounds imported that year 9,151,900 pounds, or 48.5 percent, came from Italy; 3,569,900 pounds, or 18.9 percent, from Turkestan; and 2,439,300 pounds, or 12.9 percent, from Argentine. Since the average Italian crop does not permit the exporting of any such quantity as indicated above, it seems probable that a large proportion of the Italian importation originated in some other country, probably in Turkestan. Since 1920 importations have not reached the above figures, being slightly less than one million pounds in 1921, 7,259,100 pounds in 1922, 8,784,000 pounds in 1923, 12,818,400 pounds in 1924, and 4,782,500 pounds to June 30, 1925. During each of the years 1921 to 1924 Argentina consigned more alfalfa seed to the United States than to any other country. This would seem to in-

dicates that South American seed is likely to continue to occupy an important place in the alfalfa seed supply of the United States.

Imported alfalfa seed is not so satisfactory as native-grown. The fact that until recently but little attention was given to the origin of alfalfa seed and the additional fact that much of the alfalfa seed sold was wholly or in part imported—largely Turkestan seed—probably accounts for a portion of the alfalfa failures and consequent disappointments of Illinois and other corn-belt farmers. Blended foreign and native alfalfa seed may cause as much loss as all-imported seed. Farmers who are purchasing alfalfa seed therefore should demand seed that is all of native origin.

Argentine. Found on the American market for a number of years, Argentine is rapidly becoming of increasing importance to Illinois farmers because of the likelihood of being able to get it in the local markets. There is no apparent difference between the seed of this strain and many of the strains of native common alfalfa. Certain strains of Argentine seem to be quick growers, recovering readily after being cut and at the end of two or three weeks appearing more vigorous than other strains. Argentine is of somewhat southern type and is more likely to have the high, or exposed, crowns than are the northern-grown native sorts. Wherever tested out under Illinois conditions, Argentine strains have been much more susceptible than native strains to winter injury.

Chile. A strain imported from Chile, which is very similar to that from Argentine, is found frequently on the American market. Seed from this source is not likely to be of any more value than the average Argentine seed just described.

Italian. Italian is a southern European strain which prior to 1920 was one of the most important foreigners on the American market. This strain has been compared with northern European strains and with regional strains from the United States by several experiment stations. In all tests in the corn belt the Italian, like all other strains produced in mild climates, proved less resistant, and therefore less desirable, than strains from farther north.

Provence. Much of the alfalfa seed imported from France which finds its way into the commercial trade of the United States is carried under the trade name "Provence." Not all seed carried under this name, however, is true Provence. The true Provence comes from southern and southwestern France. This is another regional strain of common alfalfa which, Oakley says, "differs so slightly in general appearance from the common regional strain from Kansas that one can scarcely be distinguished from the other."²¹ The true Provence alfalfa reacts much the same as other strains produced under mild climatic conditions in that it is likely to winterkill easily, will start growth quite early in the spring, and recovers relatively quickly after cutting. Oakley says further: "While the true Provence strain is an excellent one for sections in which severe winters do not occur, it is not commercially important in this country. Very little seed of it is offered on our markets, and a considerable portion of that offered as Provence is not true to name. On account of the uncertainty of securing reliable seed, purchasers are advised to buy seed of domestic varieties and strains."²²

Variegated or Hardy Alfalfas

Variegated alfalfas, which include Baltic, Canadian variegated, Grimm, Hardigan, and Cossack, are so named because of the variation

in the color of the blossoms. The common alfalfas have a blossom that is rather consistently purple, while the variegated alfalfas show a variety of colors and hues. The predominating color among the variegated strains is violet, but brown, greenish-yellow, yellow, and grayish or smoky shades will also be noted. This variation in color is thought to be due to the natural hybridization that has taken place between the common purple-flowered alfalfa and the yellow-flowered species.

This group is also known as the "hardy" group because of the distinct resistance of the strains to freezing or winter injury. The characteristic of winter resistance was for a number of years largely

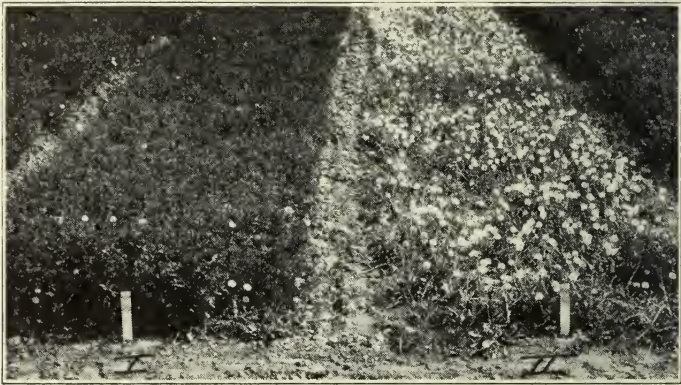


FIG. 9.—ALFALFA PLANTED IN ILLINOIS SHOULD BE WINTER-HARDY

There is a great difference among varieties in winter-hardiness. Plot I above was planted with Hardigan, hardy northern-grown seed from Michigan. Plot II was planted with hairy Peruvian, southwestern-grown seed. The nonhardy alfalfa was killed and the plot produced a heavy crop of dandelions.

attributed to the branched, spreading, fibrous, root system thought to be characteristic of the variegated alfalfas, whereas the common alfalfa was thought to have the single or straight nonfibrous type of root system. More recent researches have shown, however, that while there is a tendency for a more fibrous branching root system in the variegated alfalfas, this character is also to be found in other strains. In reporting the results of his investigations Carlson⁵ states that "in compact soil all varieties and strains developed branch roots, while in open soil the taproots predominate."

Another character which has come to be recognized as typical of the variegated alfalfas is the large, submerged crowns, contrasting with the smaller, higher standing crowns of the common strains. This crown character is not sufficiently striking to the layman who has made no study of alfalfas and is governed more or less in his choice

of variety by the prices of seed. It is possible, however, by observing the color of the blossom and the broad, deep-set crowns and numerous fibrous roots, to distinguish variegated from common alfalfas with a fair degree of accuracy.

The members of the variegated group, like the members of the common group of alfalfas, are practically indistinguishable one from the other. There are five commercially important strains within this group: Grimm, Baltic, Canadian variegated, Hardigan, and sand lucern. It is possible, however, as the plants approach maturity, to distinguish with a fair degree of certainty between members of this group and members of the common group. In addition to the difference in flower color noted in the variegated alfalfas, there is also more variation in seed-pod character. The predominating type of seed pod is compactly curled, like the common alfalfa, but in fields of variegated alfalfa some pods will be found that are loosely coiled, and some will be circular in shape, and some will be semicircular.

Sand Lucern. This is a variegated alfalfa of Europe and is grown generally over west-central Europe. It has not been of much consequence in this country, altho it seems to have been grown here for considerable time. It probably is the progenitor of our Grimm, Baltic, and Canadian variegated.

Commercial sand lucern is very much like a mixture of our American alfalfas. It apparently is of hybrid origin, carrying some of the yellow-flowered strain, as indicated by the yellowish colored flowers and also by the procumbent plants which show up quite generally over the fields. Lucern also has the rather loosely coiled seed pods which are considered typical of Grimm alfalfa.

The seed of sand lucern comes from widely different regions; thus it varies greatly in its hardiness. Some strains are just as hardy as Grimm or Baltic, while others are no more resistant to severe winter or drouth conditions than are strains of native common alfalfa.

Grimm. This strain of hardy alfalfa, according to Brand,² is the result of fifty years of natural selection under Minnesota conditions. "Wendelin Grimm, who introduced alfalfa into Minnesota in 1857, was born in October, 1818, in the little village of Kùlsheim, in the northern part of the grand Duchy of Baden. This little German settlement is located in a splendid agricultural section about midway between Wertheim on the Main and Bischofsheim on the Tauber. . . . In May, 1857, he left Baden, determined to go to Minnesota He reached Chaska, Carver county, Minn., about September 1." Grimm brought with him a small quantity, probably not more than 15 to 20 pounds, of alfalfa seed and this seed was sown in the spring of 1858. The strain now recognized as Grimm is thought to be the result of natural selection and crossing of this hardy strain of sand lucern brought over by Grimm with other strains in this country at that time.

During the succeeding half-century this strain was carefully husbanded and became scattered over quite an acreage in Carver and adjoining counties. This alfalfa by the year 1900²⁹ had gained considerable local importance. It was called to the attention of Prof. W. M. Hays, then of the Minnesota Station, "who recognized its hardiness and general value for Minnesota conditions." Since that date Grimm alfalfa has been tested by most of the agricultural experiment stations thruout the United States. Results of these trials, as well as trials by the U. S. Department of Agriculture on a number of their substations in the West and Northwest, seem to warrant the statement that true Grimm

alfalfa is one of the hardiest strains of variegated alfalfas known and is generally adapted wherever winter resistance is a factor.

Grimm alfalfa probably has no advantage over common alfalfa where the latter has sufficient resistance to withstand the average winter. Maryland, West Virginia, Ohio, southern Indiana, central and southern Illinois, Missouri, Kansas, Nebraska, and Colorado seem to form the boundary between the hardy, or Grimm, alfalfa belt on the north and the common alfalfa region on the south.

Baltic. This strain of variegated or hardy alfalfa is named for Baltic, South Dakota, near which town the first known field of this strain was grown. Tho its origin is not definitely known, it is thought to be from an imported stock of variegated alfalfa. Its hardiness is probably due to natural selection under South Dakota conditions and the fact that it has yellow-flowered alfalfa in its ancestry. Baltic has essentially the same plant characteristics as Grimm and to the casual observer is not distinguishable from it. The description given for Grimm will apply equally well for Baltic.

Like Grimm, Baltic has the advantage of great winter resistance and is adapted to conditions throuout the northern portions of the United States and Canada, where the ordinary alfalfa winterkills.

Baltic has been credited with marked resistance to a bacterial disease which seriously injured nine other varieties growing under the same conditions.²³ Whether this strain will exhibit any degree of resistance to bacterial wilt, now found generally over the corn belt, is a very important question as yet unanswered.

While the trials in northern Illinois seem to favor Baltic, similar tests in other states²³ "have shown very little difference in the hay yields of the Baltic and Grimm varieties. . . . From the evidence that is now available, it is safe to conclude that seed of these alfalfas should be approximately the same price and the farmer would not be justified in purchasing seed of one at a considerable advance in price over the other." Comparatively little seed of this strain is now available.

Canadian Variegated. Canadian variegated is another strain of hardy alfalfa that has found its way into corn-belt markets in increasing quantities during the past few years. As the name indicates, this is another strain of the same type as Grimm and Baltic, having a blossom of variegated color and the submerged or deep-set crown

This variety attracted attention a few years ago because of the splendid showing it was making in the United States. Seed appearing on the market under this name came largely from Ontario. A study of the alfalfa production and history of the province of Ontario revealed the fact that²⁴ "at least part of the original stock came from France, and it is quite probable that some of it was from the sand lucern which is grown in that country as well as in other parts of Europe, since the strain as now produced has its characteristics, including variegated flowers."

Canadian variegated is not distinguishable from Grimm and Baltic. It is adapted to the same general section of the United States and probably should be considered of about the same value. Some of the earlier trials with seed produced in Ontario seemed to indicate that it was a somewhat less-hardy strain than Grimm and Baltic under conditions of limited rainfall. It has been nearly equal to these strains under humid conditions. The variegated is now being successfully grown in other provinces.

Cossack. Another strain of the variegated, or hardy, group is called Cossack. This strain is not distinguishable from Grimm, Baltic, or Canadian variegated. It was introduced from Russia in 1907 by the U. S. Department of

Agriculture along with another selection known as Chernó. These strains were very similar, not only in appearance but also in value, and for this reason the two are now catalogued as Cossack. Cossack has been tried out extensively wherever Grimm alfalfa is adapted and has been found to have very much the same general adaptations and value as Grimm and Baltic. No data are available which indicate that Cossack has any special merit over the other variegated alfalfas under Illinois conditions.

Hardigan. Hardigan is a new strain developed at the Michigan State College. It possesses the low-set spreading crown, the heavier lateral root branches, and the variegated blossoms characteristic of Grimm. It has proved fully equal



FIG. 10.—THE SIDE-DELIVERY RAKE IS EFFICIENT IN HAYING

This rake can be used to advantage where large acreages of alfalfa are to be made into hay. (*Courtesy U. S. Department of Agriculture*)

to the best of Grimm in winter hardiness and forage production in Michigan. It is being tested quite generally, but the tests in other regions have not been of sufficient duration to accurately determine its value for them. Preliminary tests indicate that Hardigan is equally as hardy as Grimm, is a heavier producer of seed than Grimm, and reaches the cutting stage somewhat earlier, a merit worth considering.

Ladak. Ladak is another new strain which has not been tested extensively in Illinois. It came from India and seems most promising in the northern and northwestern areas where the moisture supply is limited and the temperature low. Under such conditions Ladak produces a very heavy first crop but, recovery being slow, subsequent cuttings are generally disappointing. It is doubtful whether this alfalfa has much promise under corn-belt conditions.

Turkestan

Until a few years ago, a large portion of the seed imported annually into this country was from Turkestan.²⁵ A few selected strains from sections of low rainfall and low winter temperatures in that country were brought into the United States by the U. S. Department of Agriculture in 1898. These first strains were quite promising and large quantities of seed began to come in, either directly or indirectly.

Turkestan seed has been tested widely over the United States and found inferior to native sorts under most conditions. It is decidedly inferior to native-grown sorts in Illinois and adjoining corn-belt states.

Despite the fact that commercial Turkestan alfalfa has proved unadapted to Illinois conditions, it might be noted that in certain

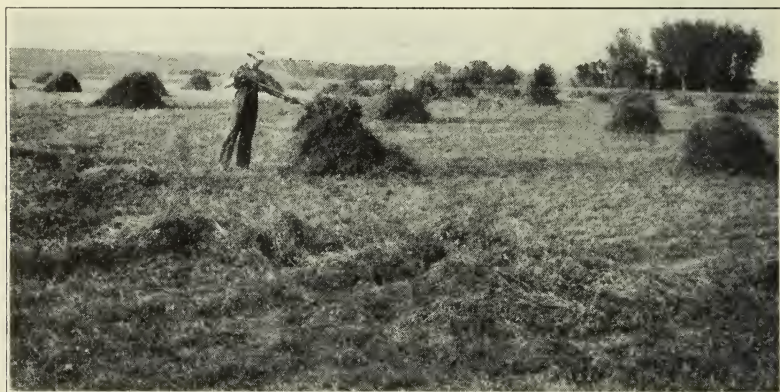


FIG. 11.—COCKING ALFALFA HAY PRESERVES ITS QUALITY

Under Illinois conditions the loss of valuable minerals is checked by cocking the hay and the color of the hay is usually improved.

areas of the West, under dry-land conditions, some strains of this seed are attracting attention because of their apparent resistance to bacterial wilt. Seed of these particular strains has not been available; consequently no trials have been conducted to determine their winter hardiness and productivity under Illinois conditions.

Nonhardy Alfalfas

Alfalfas from mild or subtropical regions have been introduced along our southern and southwestern boundaries into the states of Texas, Arizona, New Mexico, and from southern California. Natural selection, as well as origin of strain, no doubt is having its influence on the alfalfas produced in this region. The result is a type of common alfalfa that resembles other regional strains in some characters but

differs markedly in others. These strains, because of their inability to withstand low temperatures, have been called nonhardy.

The nonhardy group of alfalfas is characterized by tall plants, erect growth, quick recovery from cutting, and abundant yearly production. These strains have an extremely long season of growth and are further characterized by their ability to grow during the cool season and during relatively short days after common alfalfas would cease growth.

Two strains have been recognized in this country, Peruvian and Arabian, but only the Peruvian is grown today. This strain is found to some extent in the states along the Gulf Coast, but is most important in the Southwest.

Peruvian. The U. S. Department of Agriculture made the first importation of Peruvian alfalfa seed in 1899. Little or none of this was perpetuated. A second lot was brought in 1903. The crops grown from this introduction seemed very promising and additional seed was imported in 1908.

The first lots of alfalfa from Peru proved to have an abundance of hairs on the leaves and stems and were known as "hairy Peruvian." The importation of 1908 was evidently of a different strain, as the plants exhibited a smoother leaf and stem and were shorter and slower growing. This later importation was called the "smooth-leaved Peruvian." Neither of these strains is of any value under Illinois conditions.

Arabian. Arabian is another nonhardy strain of alfalfa. Like Peruvian, it has a distinctly hairy leaf and stem, is erect in its habit of growth and sets well out of the ground on a relatively high-bunched crown. The chief difference noted between Arabian and hairy Peruvian is that Arabian is less hairy, grows somewhat shorter, and has a larger, broader leaf.

Yellow-Flowered Alfalfas

Another type of alfalfa, which a few years ago received considerable publicity, is the yellow-flowered or so-called Siberian. Since, however, not all of the yellow-flowered alfalfas come from Siberia,²⁶ the term Siberian is misleading.

Altho imported as early as 1898 by the U. S. Department of Agriculture and quite generally tested since that date, this group of alfalfas has not become of great economic importance. The various members of this group differ somewhat from other alfalfas in that they have more-spreading or procumbent stems, do not grow as tall as the average common strains, have a much-branched root system and a sickle or crescent-shaped seed pod. The crown of the plants of the yellow-flowered alfalfas is distinctly submerged, which typifies a plant that may be expected to be resistant to severe changes of temperature as well as to drouth. Alfalfas of this group ordinarily produce only one good cutting in a season and many plants fall down so that they are hard to harvest. They are also very poor seeders.

These yellow-flowered alfalfas appear to be of value chiefly in crossing with other types, particularly with the common, in an effort

to produce new strains that combine the winter and drouth resistance of the yellow-flowered types with the more desirable habits of the common alfalfas.

Semipalatinsk and Orenberg. Two strains of this group have been recognized, Semipalatinsk and Orenberg, which have received their names from the provinces in Siberia and Russia from which they were imported. These strains have been tested quite extensively over the northern states and are winter-hardy but they are not so productive, as a rule, as Baltic and Grimm. Pure seed is no longer available. The limited quantity now on the market has become crossed naturally with purple-flowered alfalfas and is now variegated.

ALFALFA DISEASES¹

Alfalfa is subject to a considerable number of diseases. The three most important in Illinois are leaf spot, yellows, and bacterial wilt.

Leaf Spot. This is the most common of the three diseases just mentioned. It no doubt occurs to some extent in every alfalfa field in every season.

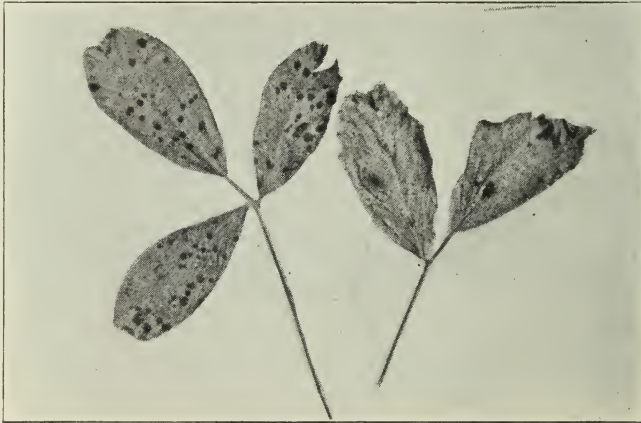


FIG. 12.—TWO ALFALFA LEAF-SPOT DISEASES

The common leaf spot at the right, rounded in outline, is caused by *Pseudopeziza medicaginis*. The larger and more irregularly shaped leaf spot on the left is caused by *Pyrenopeziza medicaginis*.

In reality there are several of these alfalfa leaf spot diseases. The one that occurs most commonly is caused by a fungus, *Pseudopeziza medicaginis* (Fig. 12). Small circular spots, usually averaging about one-sixteenth of an inch in diameter and dark brown in color, appear on the leaves. When these spots become numerous, growth is checked and in severe cases the leaves, especially the lower ones, drop off.

The spores of the fungus are produced on the surface of the spots, and

¹The material in this section has been contributed by Benjamin Koehler, Assistant Chief in Crop Pathology.

from these spores new infections take place rapidly throughout the field. Some of the infected leaves that drop off remain in the fields and thus serve to carry the infection over to the next season. The spores are carried considerable distance by the wind.

Sometimes the first crop of the season is relatively free of these leaf spots and the second and third crops more heavily infected. It is usually recommended that when leaf spot infection is abundant, the crop should be cut early, even before it has begun to bloom. At this time the infected leaves have not yet fallen, and thus nearly all the infected material is removed from the field and the next growth may have a better chance. This procedure, however, should be carried out only when the disease is very severe, for the practice of early cutting is likely to result in winter injury to the plants.

The best recommendation for controlling this disease is to have the soil in a good state of productivity. On poor soils leaf spot may soon bring growth to a standstill, and when the crop is cut, it consists of a high proportion of stems while the leaves, which are the most valuable part of the crop, are underdeveloped and many have fallen off. On productive soils, under Illinois conditions, the plants grow and produce new leaves so fast that the fungus is not able to keep up with the alfalfa plant, so to speak, and the injury is of relatively small consequence.

Yellows. Alfalfa fields frequently turn yellow in midsummer. It was discovered only within recent years that this condition may be caused by leafhoppers. Young stands sometimes are killed outright. The nature of the injury is different from that of most kinds of insect damage in that leafhoppers, when feeding, inject something which causes the punctured leaves to turn yellow, and the stems to cease growth and wither. Sometimes only a portion of the field is outstandingly yellow, and in that case the yellowing is the result of intensive feeding and consequent injury by leafhoppers migrating from the freshly cut areas to older plants, or into cut areas where the new plants have had opportunity to make some growth and thus offer the insects an attractive feeding ground. The portion of the field that has been deserted will come up green and will stay green unless reinfested with leafhoppers.

Leafhoppers are light green in color and about one-eighth of an inch in length. When one brushes a hand thru the alfalfa foliage where these hoppers are abundant, they can be seen flying and jumping about.

As growth practically ceases after an alfalfa patch has turned very yellow, it is best to cut the crop regardless of the stage of development. Very often the new growth will develop fairly normally, the leafhoppers for the most part apparently disappearing in the meantime. Cutting before the normal time, however, should be practiced only when the "yellows" condition is severe.

Bacterial Wilt. Bacterial wilt is relatively new in Illinois, but it has already been found in most of the counties of the state and in some localities nearly half the fields are infected. The first conspicuous external symptom of infected plants is a dwarfing in size (Fig. 13). The stalks are slender and the leaves are light green and considerably smaller than normal. When a wilt-infected plant is dug up and the root is cut crosswise, a yellow ring can be observed beneath the bark, as shown in Fig. 14. The depth of color and width of the ring vary with the severity of the disease. A rot that often occurs in the center of the roots has no connection with the wilt disease.^a

This disease is spread from the infected plants to the healthy ones by harvesting machinery, especially the mower, by drainage water, and probably

^aIn alfalfa plants three years old or more, the heart wood is low in vitality and is easily invaded and rotted by organisms that cannot attack thrifty parts of the plant. Although certain kinds of "heart rot" do appear to hasten the death of plants at times, ordinarily this kind of rot is of relatively small importance.

by some other agencies as well. The better the stand and the more thrifty the alfalfa, the faster the disease spreads over a field. A large number of plants showing foliage symptoms of this disease were marked in the falls of 1927 and 1928. In the following spring of each year it was found that none of the marked plants had come thru the winter alive.



FIG. 13.—BACTERIAL WILT OF ALFALFA

Note the dwarfed condition of the wilt-infected plant on the left above as compared with a normal, healthy plant on the right.

The first time wilt occurs in a field it usually does not become evident until the stand is two years old. When, however, an infected field is plowed under and reseeded to alfalfa without an intervening crop, the disease may become prominent even in one year. Thus bacterial wilt is a disease that is rather slow in developing, but having started in any of the alfalfa strains now in common use in Illinois, it cannot be checked and sooner or later will ruin the field. After it becomes conspicuous and widely distributed, the ground may as well be planted to something else the following year, for the next season's

alfalfa crops would not amount to much. Recovery from this disease has never been observed under Illinois conditions.

After the disease becomes established in a field, it is difficult to prevent it from becoming distributed over surrounding fields. But even after the infection becomes established in the soil there is a possibility that it may still be grown in a short rotation and profitable crops obtained during two or more seasons. On soil where the disease has occurred, seedings should not be made for a number of years, at least not until all of the old alfalfa remains have entirely disappeared.

Fields planted with hardy northern-grown common seed have shown the disease less often than those on which seed produced in the Central West has been used. Investigators are now working on the development of resistant varieties. Some strains of Turkestan seem very promising in this respect.

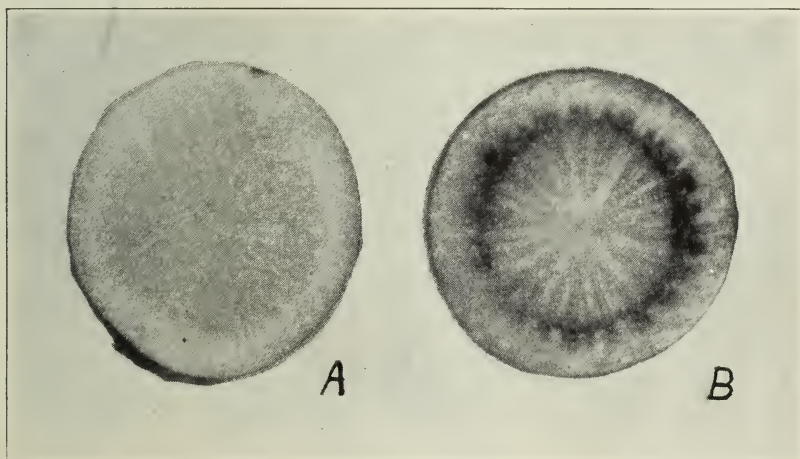
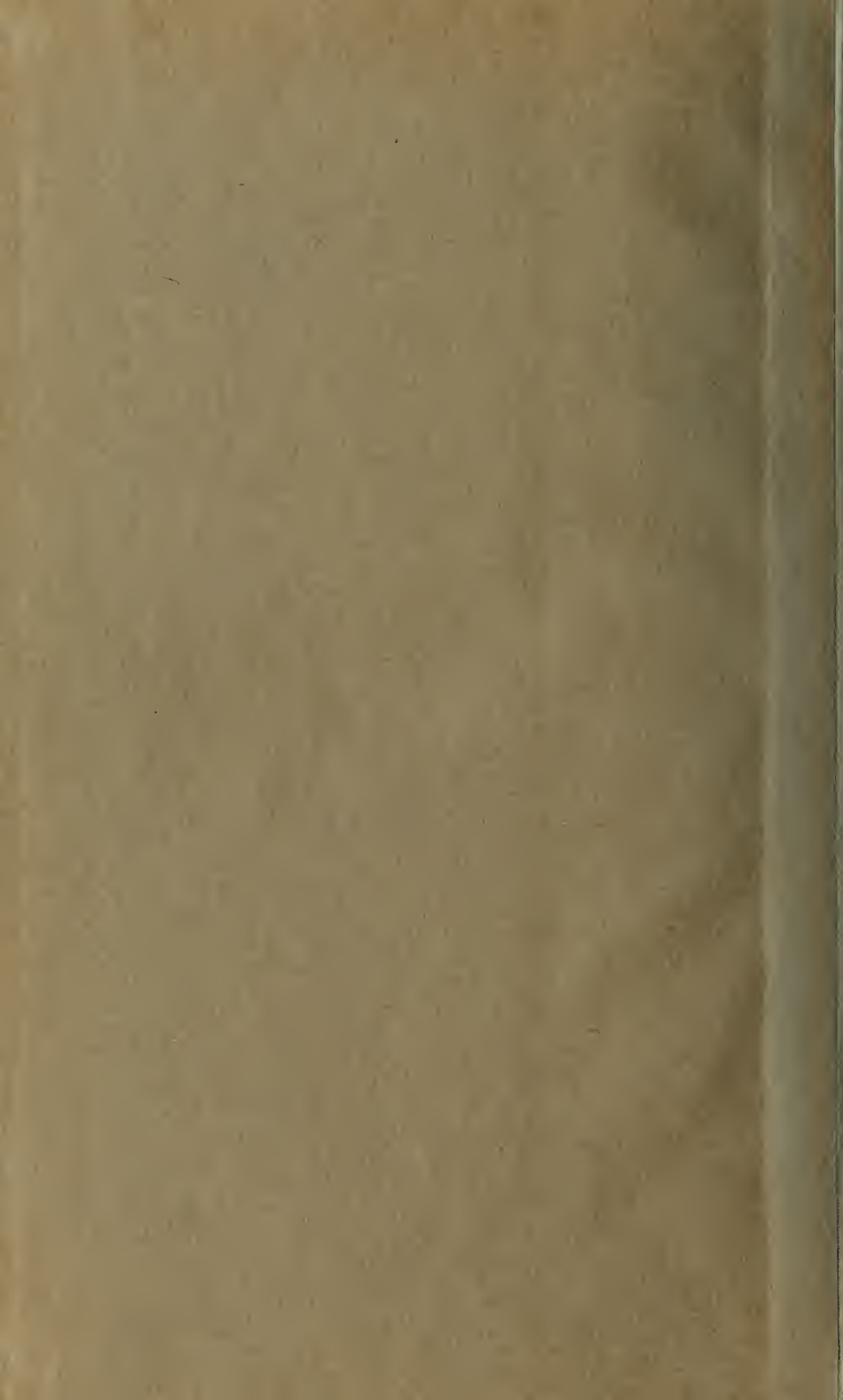


FIG. 14.—CROSS-SECTION OF HEALTHY AND WILT-INFECTED ALFALFA ROOTS, ENLARGED FIVE TIMES

Healthy root tissue (A) is light cream to nearly white in color. Wilt infection causes a yellow to brownish discoloration beneath the cortex, as shown by the dark ring in B. The discoloration always begins in the region here shown, but in advanced stages of the disease it may be more extensive, involving more of the central part of the root.

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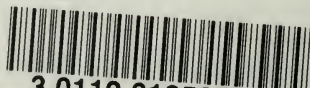
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