LEGUMINOUS FORAGE CROPS.

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INTRODUCTION.

Leguminous crops play a very important part in agriculture. Their cultivation is being deservedly extended, and the increase in acreage devoted to their growth will undoubtedly continue until their full utilization as soil renovators and as cheap producers of fodder rich in nitrogenous compounds is attained.

HISTORY OF CULTIVATION.

The oldest cultivated forage plants and the best for enriching the soil are those of the clover family. Not one of the now well-known hay or pasture grasses has been cultivated more than three hundred years, while a number of leguminous crops have been grown for forage from prehistoric times. The chick-pea, or gram, dates back full thirty centuries. It is to-day one of the leading grain crops and soil renovators of Spain, India, and central Asia.

Alfalfa, which is recognized as the best forage plant in the semiarid Western States, or wherever dependence must be placed upon irrigation, was cultivated by the Romans at least two hundred years before the commencement of the Christian era. The soy beans have been grown in China and Japan, and lentils in Hungary, from prehistoric times. The field pea, originally from northern Italy, was introduced into cultivation eight or ten centuries ago. Sainfoin was grown in France and red clover in Media during the early years of the fifteenth century, and white or Dutch clover in Holland at the beginning of the eighteenth century. Sulla, which is largely grown in southern Italy and northern Africa, and which seems to be admirably adapted to well-drained soils in Florida and the Gulf States, was first introduced into cultivation in 1766. The cowpea has been known in this country nearly as long as sulla. Alsike or Swedish clover was taken up as a forage about thirty years later, while during this century and within recent years a score or more of valuable legumes have been brought to the attention of the farmer, and hardly a year passes that new ones are not added to the list.

There are now in cultivation as forage plants upwards of seventy different kinds or species of plants of the botanical order **Leguminosae**. This family of plants includes, among others, the clovers, vetches, lupines, beans, peas, beggar weeds, sainfoin, alfalfa, velvet bean, cowpeas, serradella, and melilotus.
All green plants during the process of growth take carbonic acid gas from the air and water and soluble mineral salts from the soil and build up by the life processes the starch, sugars, fiber, oils, and other carbohydrates of the plant body. In addition they gather through their roots such compounds of nitrogen, mostly in the form of nitrates, as are available or are soluble in the water of the soil.

Leguminous crops alone of all those in cultivation have the additional power of drawing directly upon the enormous and ever-present supplies of atmospheric nitrogen. They transform it into crude protein, which is so valuable and so necessary as an animal food, and also into fertilizing compounds which, when left in the soil with the roots and stubble, may be utilized by succeeding nitrogen-feeding crops.

Nitrogen in the plant occurs in the protoplasm or life substance of every plant cell and in certain unstable compounds which approach in chemical composition gelatin or the white of an egg. The sum total of nitrogenous compounds in the plant is referred to by chemists as "crude protein," or albuminoids. The function of crude protein in plants is like that of albumen in the animal body. Without it neither animal nor vegetable existence is possible.

Following the process of digestion of food by a herbivorous animal, the carbohydrates become the sources of heat and energy, and whatever surplus remains above immediate wants is stored up in the animal carcass as fat. The crude protein is used during growth in the production of new tissues and in the repair of worn-out ones. Its nitrogen enters into the fibrin of blood, the albumen of muscle, the gelatin of bones and tendon, the casein of milk, and to a certain extent into the surplus fat. None of the animal albumens can be formed unless there is digestible crude protein in the food. Hence, the digestible crude protein in the fodder is its most important constituent.

To produce flesh and blood or any albuminous compounds within the animal body a ration containing crude protein must be fed. Determinations have been made of the exact proportion in which the different forage elements must be used to produce the greatest gain at least cost. Thus, a milch cow of 1,000 pounds live weight requires 24 pounds of dry, organic matter per day, of which about 16 pounds must be digestible. The ratio between the digestible crude protein and the digestible portion of the fats, nitrogen-free extracts, and fiber is known as the "nutritive ratio."

COMPARISON OF RATIONS.

The fats have two and one-fourth times as much heat value as starch and fiber, which is taken into account in determining this
ratio. Where the percentage of digestible crude protein is large in comparison with that of the other digestible constituents, it is spoken of as a narrow ration, while a wide ration is one in which the percentage of digestible crude protein is small compared with that of the whole. The ration is "complete" if all the essential food elements are present in the right proportions.

It has been found as the result of numerous feeding experiments that a narrow ration is a much more economical one to feed than a wide one, especially in the production of milk or in promoting a rapid and continuous growth in the case of young animals. Thus, it will be seen that for the most economical, and hence the most scientific, method of feeding, it is necessary to use forage crops which contain a large percentage of digestible crude protein, rather than those which are richest in starch, sugars, gums, and oils.

Of the coarse fodders, those richest in digestible crude protein are the various legumes. The leguminous forage plants are superior in feeding value to the true grasses, because they usually contain a larger proportion of digestible protein. The most economical and most profitable method of feeding domestic stock is to feed according to the rules which have been laid down as the results of scientific experiments. In feeding two rations, a narrow one which provides for the actual needs of the animal, and a wide one, weighing as much as the first but deficient in crude protein, the former will be the most economical. The rate of gain will be greater and the relative cost of every pound of gain according to the amount of food consumed will be less. Looking at the forage question from this standpoint, it can be seen at once why the cultivation of leguminous forage plants ought to become more extended. If the necessary crude protein is bought in the form of wheat bran, cotton-seed meal and hulls, gluten meal, or any other of the so-called concentrated foods, it is necessarily expensive. But, grown upon the farm in the shape of leguminous forage, the essential crude protein may be procured at no greater outlay than is necessary in the production of forage crops of less feeding value.

USE OF FODDERS IN RATIONS.

The coarse fodders and concentrated food stuffs should be combined in the daily ration of every animal on the farm according to the laws that govern the disposition within the animal body of the digestible crude protein, fat, and carbohydrates. Knowing that the best nutritive ratio for a milch cow is about 1:5, it is absurd to feed a 1:10 ratio and expect the best results. ¹ Tables giving analyses of American feeding stuffs and their digestible constituents have been published by the Department of Agriculture and by almost every State experiment.

¹A 1:5 ratio means that the forage contains five parts of digestible carbohydrates to one part of digestible crude protein.
station, so that ignorance of the reasons for feeding rations of a definite composition can no longer be advanced as a valid excuse for the wasteful use of fodder.

Leguminous forage plants are of vast importance to those farmers who would adopt scientific methods. They are the cheapest sources of crude protein. Other crops, in order to manufacture crude protein, must have the full equivalent of inorganic nitrates present in the soil. As already stated, these plants alone can draw nitrogen from the air as well as from the soil. By the use of leguminous crops the farmer may produce upon his own land fodders which approach in feeding value the various meals and oil cakes, and at the same time be growing a fertilizer crop that will supplant the expensive nitrogenous saltpeter, guano, bone, fish scrap, and animal wastes that otherwise must be purchased.

FERTILIZING VALUE.

It has been noted by competent observers that the point of decadence in the agriculture of a country is marked by the decreasing acreage devoted to the growth of forage plants. It is also true that, other things being equal, the rate of deterioration in the soil fertility is less in pastoral regions than where grain and the more specialized crops are raised. There is a constant drain or leakage of plant foods from all cultivated lands, but the annual loss is least where the farm produce is marketed in the shape of meats and animal products. The agricultural wealth per capita is higher in communities where the principal line is the growing and fattening of cattle, or the production of bacon, milk, butter, wool, and cheese.

In the cattle-growing States the rate of profit on investment may average as high as from 20 to 35 per cent per annum among those who thoroughly understand the cattle business. On the dairy farms which supply the great cities of the land the same high rate of earnings often prevails. This condition of affairs is, in a measure, due to the fact that much of the most valuable fertilizing elements of the forage plants used are returned to the land, combined in a form well adapted to the growth of succeeding crops, while only a minimum amount is lost from the holding of the producer. The land thus used becomes richer instead of poorer.

The production of forage crops and their use upon the lands where they are grown becomes, then, one of the best agricultural practices. But in growing and feeding the forage crops, as in all other branches of farm industry, it is necessary to use those plants which will give the greatest returns for the least given outlay in the shape of the fertilizing elements removed from the soil. Farmers have long recognized the necessity of leguminous crops in a feeding ration or a field rotation. Thus, a mixture of red clover and timothy was known to be a better ration than timothy hay alone long before chemists had
worked out the laws which govern the proportions between crude protein and the carbohydrates in a well-balanced food. And it has been known since the days of the earliest Roman agricultural writers that the cultivation of leguminous crops upon a field tended to improve the soil.

**HOW LEGUMES IMPROVE THE SOIL.**

Modern agricultural chemists searching for the true answers to these problems have discovered that leguminous crops are not only consumers of available plant foods, but that they actually manufacture the most valuable and most essential nitrogenous compounds, using the free gaseous nitrogen of the air. This transformation of an inert gas takes place through the agency of minute, almost infinitesimal bacteria, which live within the tissues of the roots of plants of this order, producing knot-like swellings or galls upon them (fig. 17). Each variety of legume has its own peculiar bacterium, on whose presence it is dependent, and unless its particular species of bacterium comes in contact with and infests the roots, the plant can not get more nitrogen than could be secured by the roots of a grass or tobacco plant. It can then only take up such nitrogen as is already present in the soil in available or soluble form. If these bacteria are entirely absent from the soil, the clover or bean will not fully develop unless an abundance of soluble nitrates are present.

This wonderful dependence of plants of the clover family upon the minute bacteria which live within the root tissues offers an explanation of the failure of such crops when tried upon soils not previously devoted to their cultivation. It has been found by experiment in this country and abroad that such new leguminous crops may be successfully cultivated by inoculating the land either with artificial preparations or cultures containing these germs, or with soil from a field where this crop has been previously grown. Good results are also sometimes secured by treating the seed preliminary to sowing. By such an inoculation the yield of total dry matter has been increased sometimes from tenfold to thirtyfold. Moreover, it is found that there are no gall tubercles formed on the roots of leguminous crops when these nitrogen-bacteria are not present in a soil, and hence there can then be no utilization of gaseous atmospheric nitrogen by them.

Nitrogen is the most important plant food. It is the most expensive fertilizer when purchased in artificial manures. It is also the most necessary element of animal foods; for when it is entirely absent, or present in insufficient quantities, there can be neither growth nor the complete repair of worn-out tissue. Hence, it can readily be understood why the abundant cultivation of leguminous crops is so necessary. The legumes are the only crops which will, when plowed under, increase the total of fertilizing materials of the soil.
Leguminous crops are, furthermore, valuable soil renovators, because they are deep feeders. Their roots extend down into the stiffer and more compact subsoil, loosening and opening it to the action of the air and rendering it more permeable by water. The roots bring up from below great quantities of potash salts and phosphoric acid and leave them near the surface, where they may be utilized by potash-devouring cereals, tobacco, and root crops.

In sandy soils and reclaimed marsh lands or in soils containing large amounts of organic matter the quantity of potash is usually deficient. Here the deeper-rooted legumes, such as gorse, broom, alfalfa, lupines, sulla, and the perennial beans, may be of great value, not only taking nitrogen from the air, but potash from the subsoil, and increasing the quantity of both of these fertilizers in the surface layers of the soil. The roots and stubble largely increase the quantity of organic matter left at the disposition of surface-feeding crops. The rank-growing velvet bean, cowpea, soy bean, melilotus, and beggar weed are on this account valuable annual crops for use in the improvement of the heavier clay soils, which usually have an abundance of potash but lack humus. The humus acts as a storehouse for nitrogen, potash, and phosphoric acid, improves the physical condition of the soil, and increases its capacity for retaining water in time of drought, especially in the presence of an abundance of lime.

There is opportunity for a great saving by American farmers, and hence a greater profit, if leguminous forage crops can be extensively substituted for those of less feeding and fertilizing value. There are leguminous crops which yield as heavily as the better hay grasses and which require no greater care and attention. There is as wide a range of varieties adapted to all the varying conditions of temperature, soil, and climate. If by the use of clovers, soy beans, vetches, alfalfa, cowpeas, and velvet beans the cost of producing beef, pork, mutton, wool, milk, butter, and cheese could be lessened by ever so little, the aggregate gain to the whole farming population and the country at large would be enormous.

**RED CLOVER.**

Red clover grows best upon deep and well-drained calcareous loams. It is not so well adapted to the lighter sandy soils, to heavy compact clays, nor to gumbo prairie soils. Underdrainage and a plentiful supply of rainfall during the season before flowering have a marked influence on the yield. Red clover is the standard hay crop of the Northern and New England States, and is becoming every year more widely cultivated in the central prairie region. In the South and in the Pacific Coast and Rocky Mountain States other
crops are more successful, and there red clover is only grown in localities where the soil conditions favor it.

The seed is usually sown with grain from March to May or, when intended for a spring soiling crop, from the middle of July to the first of August, without a nurse crop. Twenty pounds of seed are required per acre. The first crop of hay is ready to cut in June. The second crop is generally considered the best for seed, but the condition which governs seed production is the prevalence and abundance of bumblebees, upon which the clover blossoms are dependent for fertilization. The yield of seed per acre varies from 3 to 9 bushels of 60 pounds.

The best time to cut for hay is at full bloom, when not more than one-fifth of the heads have commenced to turn brown, while the leaves are ripe and the stems are still green. The content of digestible crude protein is greatest at this period. After flowering the percentages of crude ash, fat, and crude protein decrease and that of crude fiber and nitrogen-free extract increases until the seed is ripe and the plant reaches full maturity. The yield is also heaviest at the period of full bloom because of the loss of the lower leaves as the stems ripen. The nutritive ratio of freshly cut clover at time of full bloom is about 1 to 5.3, while that of the hay ranges between 1 to 4.3 and 1 to 5.3. The average composition of clover hay according to a compilation from all available American analyses is, in 100 pounds, 15.3 pounds water, 6.2 pounds ash, 12.3 pounds crude protein, 24.8 pounds fiber, 3.3 pounds fat, 38.1 pounds nitrogen-free extract. Of the crude protein, 6.58 pounds are digestible. At the Massachusetts Experiment Station a ton of clover hay contained 46.8 pounds of nitrogen, 9.7 pounds of phosphoric acid, and 49.3 pounds of potash, the manorial value of which was $10.64, estimated at the same prices as were paid for these substances when purchased in commercial fertilizers.

Red clover will not grow in soils containing an excess of organic acids. It is believed that "clover sickness," which prevents the growth of clover upon the same field for an indefinite period, is due to the formation of an excess of humic acids which interfere with the growth and development of the nitrifying soil bacteria. When such a condition arises in the soil an application of lime neutralizes the acids and restores its fertility. To prevent the one-sided exhaustion of any soil which follows the continuous cultivation of this crop and to utilize its full value as a gatherer of nitrogen, red clover should only be used in rotations.

The best fertilizers for red clover are lime upon all acid soils, muriate or sulphate of potash on sandy soils, and superphosphates on the heavier clay soils. An application of well-composted manure, or liquid manure, will prove of benefit to any leguminous forage crop

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1 Computed from tables in Appendix to Yearbook of Department of Agriculture for 1896.
when there is enough lime in the soil to combine with the humic acids produced during decomposition; but large amounts upon land already rich in humus do not usually give a satisfactory increase either of the crop or its crude protein; neither do commercial nitrogenous fertilizers seem to materially increase the total quantity of crude protein in the hay.

**ALFALFA.**

Alfalfa (fig. 18, page 500) is probably the best known and most widely cultivated of all the leguminous forage plants, although in point of date of introduction into this country it does not compare with red clover or cowpeas. Originally of European origin, it was introduced into Mexico by the Spaniards at about the time of the Conquest; thence it spread to Chile and Peru, and was finally brought to California in the year 1854. Previous to this time it had been grown experimentally in various parts of the East, perhaps as early as one hundred years ago, but never on an extended scale. Alfalfa is well adapted to withstand extremes of temperature and summer drought; so that it at once found favor, not only in California, but throughout the Rocky Mountains and Plains regions, and the acreage devoted to this crop has increased with each succeeding year.

Alfalfa is a deep-rooted perennial, growing ordinarily from 1½ to 2 feet, or rarely 3 or 4 feet, high. Wherever the roots find loose and permeable soil they descend to great depths, ordinarily from 8 to 20 feet, though cases are recorded where the roots have been found at a depth of 50 and 60 feet below the surface on river banks in sandy soils. Its successful cultivation depends largely upon the character of the subsoil. Alfalfa will not do well on any soil, no matter how rich or well prepared, if the field is underlaid by an impermeable subsoil, or by rock or hardpan. Neither will the crop stand flooding with stagnant water. Good drainage is absolutely necessary. This crop is affected perhaps more largely than any other generally grown in this country by excess of water.

This forage plant is not so well adapted to use as a pasture plant as many others, although it is quite a general practice in the West to graze alfalfa at certain seasons of the year. It has been found by experiment that the total yield of hay or green fodder will be larger where the field is not pastured. When an alfalfa field is grazed the soil is trampled and packed too much. Moreover, when the stems are cut or grazed the stalk dies down to the very base. The new shoots come from the upper part or crown of the root. The stems of many other forage plants when cut or broken branch out above the ground, forming lateral shoots that immediately grow up and take the place of the old stems; but with alfalfa the vitality of the roots may be much impaired if the young stems are grazed as fast as they appear, because the new growth comes directly from the root itself and not from the bases of the old stems.
FIG. 1.—ALFALFA, BELLE FOURCHE, SOUTH DAKOTA, 1897.

FIG. 2.—SOY BEANS GROWN IN GRASS GARDEN, U. S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.
Alfalfa requires clean ground, and should never be sown on weedy or poorly prepared fields. The seedlings are very susceptible to changes of temperature, and are more tender than those of red clover; so that they are more liable to be crowded out by weeds or a nurse crop.

In Louisiana alfalfa is grown in two-year rotations upon low, alluvial valley lands, and may there be cut at intervals of from six to eight weeks throughout the season. In the Northern States three crops per annum is perhaps the average.

**Cutting and Curing Alfalfa.**

Alfalfa should be cut for hay (Pl. XXXI, fig. 1) at the time the first flowers appear. After that period the stems rapidly become woody, the amount of crude fiber increasing and the amount of fat and crude protein decreasing until the seed is fully ripe. The yield is slightly greater at the time of full blossom, but the quality of the hay is not so good as that cut a few days earlier, when fewer flowers have opened. After the period of full blossoming the lower leaves commence to fall, and as there is a much larger percentage of crude protein in the foliage than in any other part of the plant it is desirable to retain as many of the leaves as possible in the forage.

The average yield of hay is higher than with red clover, amounting to nearly 4 tons per acre. Yields of 6 to 10 tons of dry hay per acre in one year are sometimes reported. On land adapted to its cultivation, alfalfa does not attain its fullest development until after the third year, and if the land is occasionally partially broken up and fertilized with lime and fertilizers containing potash and phosphoric acid it will hold the land, yielding three annual crops, for twenty-five or fifty or even one hundred years.

Alfalfa is more difficult to cure into good hay than some of the other leguminous forage plants, because the leaves break off very easily. For this reason the hay is cured in windrows or is made up into small piles 5 or 6 feet high and as narrow as will stand, using the same precautions to prevent heating and molding as are customary with other succulent hay crops. The second crop is the one usually cut for seed. The third crop contains the largest amount of crude protein. Stacks of alfalfa, whether cut for hay or seed, will not turn rain, and a cap, or stack cover, of grass, hay, or canvas should be used. The average yield of seed ranges from 5 to 10 bushels per acre, and, as there is always a good demand for alfalfa seed, it is one of the best money crops of the Western farmer.

**Feeding and Fertilizing Contents of Alfalfa.**

One hundred pounds of freshly cut alfalfa contain at time of flowering 28.2 pounds of dry matter,¹ and of this the amount digestible

¹Appendix to Yearbook of the Department of Agriculture for 1896.
is 3.89 pounds of crude protein, 11.2 pounds of carbohydrates, and 0.41 pound of fat, so that the nutritive ratio is 1 to 3.1. One hundred pounds of alfalfa hay contain the following digestible constituents: 10.58 pounds of crude protein, 37.33 pounds of carbohydrates, and 1.38 pounds of fat, with a nutritive ratio of 1 to 3.8. At the Massachusetts Experiment Station 1,000 pounds of the dry substance of alfalfa hay was found to contain 81.1 pounds ash, 16.5 pounds crude fat, 760.2 pounds carbohydrates, and 142.2 pounds crude protein.

The fertilizing value of 1,000 pounds of dry matter is 22.75 pounds of nitrogen, 5.61 pounds of phosphoric acid, and 16.53 pounds of potash. In Colorado 1,000 pounds of alfalfa hay were found to contain 22 pounds of nitrogen, 4.14 pounds of phosphoric acid, 25.48 pounds of potash, and 20 pounds of lime, and during one year three crops amounting to 3.8 tons per acre contained 167 pounds of nitrogen, 31 pounds of phosphoric acid, 194 pounds of potash, and 152 pounds of lime. In Kentucky the analyses of freshly cut alfalfa showed 4.22 per cent of crude protein, 0.81 per cent of crude fat, 10.9 per cent of carbohydrates, and 2.14 per cent of ash. Thus, it will be seen that the composition varies somewhat in different portions of the country. These differences in composition may result from such causes as differences in development or variation in the amount of available plant food in the soil.

To secure the best results in feeding alfalfa hay, cut when it contains the largest amount of crude protein, it should be fed with some such fodder as prairie or timothy hay, ensilage, straw, or corn stover, containing an excess of carbohydrates over crude protein. A narrow ration like green alfalfa is suitable for young pigs and is considered one of the very best crops to be fed to young animals, but for fattening mature animals or for the production of milk the ration should be a wider one. Alfalfa hay is much richer than clover hay, containing for every 100 pounds 54.5 pounds of digestible substances, of which about 11 pounds are protein. The relation of the crude protein of alfalfa hay to that of red clover is as 11 to 7. Altogether, alfalfa is one of the best forage crops grown in the United States and is adapted to cultivation in a greater range of latitude than red clover. It has succeeded as far north as central New York, southern Michigan and Montana, and as far south as southern California, Louisiana, and Florida—a wider range than that of any other of our forage plants except Indian corn. Its points of superiority over other legumes are that when once well rooted it withstands drought; it may be cut oftener, thus yielding a larger amount of hay or green forage per acre in the course of a year; and the hay is richer in muscle-making crude protein than any of the clovers. Its disadvantages are that its tough, woody roots make it difficult to plow under;
it requires better drainage than red clover; is more liable to cause bloating of sheep and cattle; is not as well adapted to pasturing, and is more tender while young, so that it is more difficult to get a stand.

COWPEAS.

Cowpeas have been in cultivation in this country for about one hundred and fifty years, having been originally introduced into South Carolina. They have spread from that source and from other importations of seed direct from China and India, until now they are in general use throughout the region south of the Ohio River and on the Pacific Coast, and as a soiling crop in the New England and Northern States. There are over one hundred named varieties of cowpeas grown in this country. These are distinguished from one another chiefly by the color and shape of the seed, the arrangement of peas in the pod, and the general habit of growth of the plant.

Thus, there are the bush peas, which grow in an upright form, having short lateral branches from a single central stem; there are trailing varieties with prostrate runners 15 or 20 feet long, and there is every possible gradation between these extremes. The peas are of every shade of white, yellow, green, pink, gray, brown, red, and purple to black, of uniform color or variously mottled, spotted, and speckled.

There is also variation in the length of the season of the different varieties, from six weeks to as many months. The usual method of cultivation of cowpeas is to sow them alone broadcast, or in drills, or between the corn rows at the last cultivation, the rate of seeding varying from 8 to 24 quarts per acre. Care must be taken not to plant the seed before the ground has become warm, as, like other beans, the cowpeas do not germinate well if the soil is wet and cold. This crop is even more susceptible to unfavorable conditions than Indian corn, but in midsummer the vegetation becomes most luxuriant.

Cowpeas are the best soil renovators for the Southern States, and will grow on land too poor to support any of the clovers, producing a large amount of herbage which may be plowed under as green manure. Cowpea vines are, because of their luxuriant growth and long, trailing stems, difficult to make into good hay, but by proper care, curing them in racks or over poles, so that the air may enter into every portion of the pile, an excellent quality of hay is produced, and if the bunch varieties are sown rather late in the season, they may be mowed without difficulty. Cowpea hay containing 89.3 per cent total dry matter averages higher (10.79 per cent) in crude protein than clover hay. It is even more difficult to make good cowpea hay than good alfalfa hay, so that the content of crude protein often falls below that figure. One thousand pounds of cowpea hay¹ contain, according to an average of all available American analyses, 19.5 pounds nitrogen, 5.2 pounds

¹ Appendix to Yearbook of the Department of Agriculture for 1896.
phosphoric acid, and 14.7 pounds potash. The nutritive ratio of cow-
peas is 1 to 3.9. The crop is usually cut for hay when the first pods
are ripe and the stems are commencing to turn yellow.

When growing cowpeas for fertilizer, it is best either to feed the
vines and return the manure to the soil or to plow them under at once,
instead of letting them stay on the ground all the winter. By the latter
practice there is often a loss of two-thirds of the fertilizing value of
the vines because of the leaching out of soluble fertilizers by the
winter rains. The feeding value is far greater than the fertilizing
value, so that it is better to use them either green or as hay than to
turn the crop under.

THE SOY BEAN.

The soy bean (Plate XXXI, fig. 2) has been cultivated as human
food and for green manure in China and Japan for many centuries,
but has only been brought to the attention of American farmers as a
forage crop within the last twenty years. In Oriental countries vari-
ous preparations from the seeds are made, which take the place of
meats and meat products in the dietary of the people. Here, however,
the seeds are used only as cattle foods or, when parched, as a substi-
tute for coffee. They are especially rich in fats and nitrogenous com-
ounds. Of all legumes in cultivation the peanut alone exceeds it in
the amount and digestibility of its food constituents.

The soy bean requires about the same class of soils as Indian corn,
and will grow about as far north as that crop can be depended on.
The best results with it have been obtained in the region between the
thirty-seventh and forty-fourth parallels east of the Rocky Mountains.
The region best adapted to it, then, is the "corn belt," a circumstance
which argues well for its future use and value in conjunction with corn
for fattening animals.

The soy bean should be planted in late spring or early summer,
after the ground has become warm. In general, the early varieties
should be used if a seed crop is desired, and the medium or late
varieties if it is to be used as forage, it having been found that the
latter much excel the former in value for that purpose. In some
parts of Virginia the soy bean is planted in the corn rows in alter-
mate hills, or between the rows at the time of the final cultivation.
Usually, however, it is grown as a main crop, either broadcast, for
forage, or in drills when cultivated for seed. The amount of seed
required when it is sown in drills is less than when planted broad-
cast, varying from 2 to 3 pecks per acre, and in the latter case 3 to 4
pecks. The rate of growth is quite rapid, and unless the field is very
weedy the crop does not require much cultivation.

The crop should be cut for hay from the time of flowering until the
pods are half formed. Later than that the stems are coarse and woody,
and the feeding value rapidly declines. One hundred pounds of soy-
bean hay contain 88.7 pounds of dry matter. Of the 51 pounds of digestible substances, 10.8 pounds consist of crude protein, and the nutritive ratio is about 1 to 3.9.

The crop may be converted into good silage, and for this purpose should not be cut until the seed is nearly ripe. The chief value of silage is that it provides a succulent food during the winter time when green forage is not available; but as certain changes take place in the silo, which render a large part of the protein indigestible, it is better to depend upon corn than to use any leguminous crop for this purpose.

The ripe soy beans are among the richest of concentrated foods. An average of American analyses shows them to contain 34 per cent of protein, 17 of fat, and 33.8 of carbohydrates. The rate of digestibility is high. Thus, there are in 100 pounds of soy-bean seed 10.8 pounds of water and 66.8 pounds of digestible food, consisting of 29.6 pounds protein, 16 pounds fat, 2.6 pounds fiber, 17.6 pounds carbohydrates, and 1 pound of ash, with a nutritive ratio of about 1 to 1.3. On a basis of 8 tons of green forage it has been estimated that about 1.1 tons of digestible substances are contained in the hay crop grown on 1 acre, of which amount one-sixth is protein and

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1 Appendix to Yearbook of the Department of Agriculture for 1896.
2 Farmers' Bulletin No. 58, "The soy bean as a forage crop."
three-fourths fat and carbohydrates. The yield varies, according to soil and season, from 6 to 13 tons of green forage. The yield of seed varies from as low as 15 to as high as 100 bushels per acre, the average being about that of corn—from 25 to 40 bushels.

This crop is a heavy potash feeder, and requires fertilization with lime, and with potash and phosphoric acid when grown on such lighter soils as are deficient in these elements.

The soy bean is withal one of the most promising of the annual leguminous forage crops, and, as before indicated, may prove of special value in connection with Indian corn, the latter supplying the "roughness," the soy bean producing the digestible crude protein necessary to make a complete and well-balanced ration.

**CRIMSON CLOVER.**

This annual clover has not become firmly established as a valuable winter soil mulch and green-manure crop. It is of comparatively recent introduction into American agriculture, although it has been grown in southern Europe for fifty years or more. As in the case of all the new forage crops, extravagant claims have been made concerning its value. It is not adapted to the Northern States, where the winters are severe, nor does it succeed in the prairie region. Crimson clover thrives on the lighter sandy loams, requires a great deal of moisture, and will not withstand either summer droughts or severe winter cold. These conclusions have only been arrived at after wasteful expenditure of thousands of dollars by Northern farmers in the purchase of crimson-clover seed. This crop may be grown in the States south of a line through New Jersey, east Tennessee, and central Texas. Above this line crimson clover often matures fine crops, but can not be depended on. It is better adapted to the needs of the Southern farmers.
The seed is usually sown in July or August, using 12 to 15 pounds per acre. It needs to be only lightly covered, and a good plan is to sow on the fresh plowing and cover with a light harrow. A drought at any time is fatal to the stand, the plant dying quickly unless the ground continues moist. South of the latitude of Washington, D. C., it remains green all winter, and even makes some growth during occasional warm periods. In early spring the growth is very rapid, and it is in bloom, ready to cut for soiling purposes, from two to four weeks before red clover. It comes immediately after rye in the soil- ing series, and is ready to feed as soon as that crop commences to make its stalks and becomes unpalatable to most cattle. Or the crop may be turned under for green manure and its nitrogen-gathering qualities utilized by following with a nitrogen-requiring grain or grass crop.

Crimson clover is an excellent preparatory crop for Indian corn, sowing it in the corn rows in late summer and turning it under in time for the spring planting. It may be used in the same way for cotton or tobacco, supplying much nitrogen which has been drawn from the air and fixed in available and convenient form for the use of these crops. Its value as a winter soil mulch can not be overesti- mated. Moreover, it is better to have a useful clover mulch than one of weeds and annual grasses. Most Southern soils are deficient in organic matter, and their fertility can be rapidly increased by the use of leguminous crops, which may be turned under to supply this need- ful humus.

The digestibility of crimson clover is about equal to that of red clover, and it requires the same fertilizers—lime, potash, and phosphoric acid. The yield when cut for hay is necessarily much less than that of red clover, because it is an annual, supplying only the one cutting. It does not displace that crop in rotations, but occupies a season when the perennial clovers are dormant. Crimson clover is especially valuable to dairymen, being ready for use at a time when succulent green food is at a premium, when the pastures are compara- tively bare. It is also valuable as a green manure crop in orchards, providing nitrogen in the best form and quantities, where an application of bone, nitrate, or barnyard manure would act too strongly, producing foliage at the expense of fruit.

It is very important that crimson clover should be cut for hay not later than the time of full bloom. The calyx is covered with rough, sharp-pointed hairs, which become stiff and brittle when the clover is fully ripe. It has been found that these hairs are liable to cause the formation of intestinal concretions, phyto-bezoars, or hair balls, especially when the ripe seed heads of the crimson clover are eaten by horses or cattle. Many losses are liable to occur unless care is taken in the feeding.1

1 Circular 8, Division of Botany, "Crimson clover hair balls."
FLORIDA BEGGAR WEED.

This annual, which has recently come into cultivation, is a native of Florida and the West Indies. It is only adapted to the warmest parts of the Southern States, especially to Florida and the country bordering on the Gulf. Florida beggar weed is closely related to the beggar weeds, or beggar's lice, of our Eastern woodlands, but in its upright habit and unbranching stems (fig. 19) resembles the prairie beggar weeds. On rich land the growth is very rank. It thrives on the lighter sandy soils and rich clays, growing from 6 to 10 feet high, producing a great bulk of hay or of green manure. Wherever the ground has once been seeded beggar weed grows spontaneously during the month of June. In cornfields it comes up after the last cultivation. The seeds will not germinate until the ground is warm, so that this forage plant is only adapted to regions where there is a long summer season. It grows best in well-cultivated lands, making as rank a growth as the sunflowers along the creek bottoms in Kansas and Nebraska.

In from three to four months from germination the plant has ripened seed and may be plowed under, adding a large amount of organic matter to the soil and at the same time reseeding the field. Where beggar weed is not spontaneous the seed should be sown broadcast at the rate of 12 to 18 pounds per acre, and covered lightly. A thick seeding is better for hay than a thin one, as in the latter case the stems become coarse, woody, and indigestible.

According to analyses of beggar weed made at the Florida Experiment Station, 100 pounds of hay consisting of the upper portion of the plant, mainly leaves and branches, contained, before maturity,

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1Florida Experiment Station, Bulletin No. 11, 1890.
19.42 pounds of crude protein and 65 pounds of carbohydrates; and when seed was ripening, 15.75 pounds of crude protein and 69.15 pounds of carbohydrates. Analyses at the Department of Agriculture gave as high as 21 per cent of crude protein before flowering. Digestion experiments have not been made, but as the hay is readily eaten by horses, mules, and cattle, and seems to be relished by them, it is undoubtedly as digestible as red clover. This plant, like other legumes, takes a part of its supply of nitrogen from the air, and does not depend wholly on the nitrates in the soil. It produces a greater bulk of feed than the cowpea, and grows without much care on cultivated lands, but rapidly degenerates into an insignificant weed if the field is no longer cropped.

Beggar weed thus becomes one of the most valuable forage plants of subtropical regions on rich lands, excelling cowpeas both as a hay plant and soil renovator. Yields of from 4 to 6 tons of hay per acre are not unusual.

THE FIELD PEA.

There are many varieties of the field pea (fig. 20) in cultivation, showing conclusively that it is one of the oldest forage plants, and yet it has not been brought to the attention of American farmers so largely as it deserves. In Canada the acreage is about the same as that of winter wheat. Much of the success of the Canadian farmers in fattening beef and pork for export is said to be due to their extensive use of pea and oat hay and pea meal.

The field pea is adapted to cultivation in the northern tier of States, from New England to Washington. It is sown in early spring at the proper time for seeding grain, using from 1 to 1 ½ bushels of peas and an equal quantity of either oats, wheat, or barley. The crop is ready to cut for hay when the dominant variety in the mixture is nearly ripe. If there are more peas than grain, then the yellowing of the pea vines and pods marks the proper time for cutting, or if the oats exceed the peas the mixture should be cut when the grains are in the dough stage. For a seed crop, the peas are often grown alone.

The field pea is not suitable for cultivation in the Middle or Southern States, because of the ravages of a vine mildew which affects the
yield of forage and seed. It requires a long, cool season, with gradually increasing heat toward the time of maturity.

According to average analyses, 100 pounds of Minnesota-grown pea hay\(^1\) contained 12.4 pounds of crude protein and 66.2 pounds of fat and carbohydrates. Of this, 7.6 pounds of protein and 41.5 pounds of the carbohydrates were digestible, giving a nutritive ratio of 1 to 5.7. One hundred pounds of the seeds contained 90.2 pounds of dry matter, of which 80.2 pounds were digestible, having a nutritive ratio of about 1 to 3. The average of all American analyses\(^2\) shows a nutritive ratio for the seed of 1 to 2.8 and for pea meal of 1 to 3.2. This shows the peas to be a richer food than wheat bran, but less concentrated than the gluten, linseed, cotton-seed, and soy-bean meals. The field pea is an excellent soil ing crop for late spring and early summer use, furnishing a large amount of succulent forage, which is relished by cattle. It deserves wider cultivation by Northern farmers.

**CROPS OF LESS IMPORTANCE.**

In addition to these widely grown and well-known leguminous forage crops, there are several which have only local importance for particular soils or special purposes. There are also many native species belonging to this group of nitrogen gatherers that have not passed the experimental stage of cultivation, but which might be recommended for trial by those who wish to have a more diversified list of forage plants on which to draw.

Of the former class, perhaps the most important are alsike, or Swedish clover, for wet meadows in the northern tier of States; the broad bean, or horse bean, in New England; the white, blue, and yellow lupines for reclaiming the sand dunes along ocean coasts; the velvet bean for the Florida orange groves; serradella in Pennsylvania; Japan clover in the South; the spring and winter vetches, which serve a like purpose with crimson clover and are adapted to a wider range of climate; sainfoin and sulla taking the place of alfalfa in the South; goat's rue in the central Rocky Mountain region; the white-flowered variety of crimson clover in Virginia; white clover in every pasture, and melilotus, or sweet clover, for the reclamation of sterile lands. Each of these sorts has had its especial merit, but some have undesirable qualities. Thus, the seeds of horse bean and the lupines contain alkaloid poisons highly injurious to stock. The melilotus is offensive to cattle, and in rich ground becomes a weed; and fresh alsike clover forage is bitter and gives a rank taste to milk.

Others of less value might be cited, such as the flat pea, which is one of the most widely advertised, although with very little to recommend it.

\(^{1}\) Minnesota Agricultural Experiment Station, Bulletin No. 36.

\(^{2}\) Appendix to Yearbook of the Department of Agriculture for 1896.
The eastern half of the United States is well supplied with leguminous forage crops. There are fully two dozen kinds of known value to choose from. The soils and the climatic conditions are similar to those of Europe, whence have come most of our cultivated crops, as well as our farming methods. But the West has soils and a climate of its own, necessitating longer trials before any variety of forage plant can be pronounced a success. It is not possible to transplant bodily to this region a European system of agriculture. Thus far the East has not undertaken the cultivation of a single wild legume of all the species which form its rich native flora. The needs of the West are greater, and, as might have been expected, a number of wild sorts have been tried, though none are as yet cultivated on a large scale.

The Dakota vetch (Lotus americanus) is botanically related to the birds'-foot trefoil and the square-pod pea which are useful European species. It grows throughout the northern prairie region from Kansas to Montana, and is abundant on the Pacific Coast. Ranchmen in the Upper Missouri Valley consider the Dakota vetch one of the best forage plants on the range. Where it is abundant, cattle are sure to get fat. It has been cultivated to some extent on plowed lands. It is quite a common practice to save the chaff that collects in the hay-baling machines and in the wagon beds when hauling hay to the balers. This chaff, containing often considerable quantities of seed, is scattered over the bottom lands in the valleys to further increase the amount of vetch in the hay.

Analyses of South Dakota grown hay, consisting entirely of this vetch, gave 17.6 pounds of crude protein in each hundredweight of hay. The per cent digestible has not been determined, but it is undoubtedly high, as cattle become "seal fat" where Dakota vetch is abundant. The Dakota vetch seeds freely in good seasons. In times of drought or shortage, stock eat it down closely and prevent its ripening seed. Hence, the stand on the open range varies greatly, depending on the abundance or scarcity of other feed. This vetch often grows 2 to 3 feet high in good soils and seasons, or may not be more than a few inches high during dry seasons or on sterile soils, but it roots deeply and is well adapted to its native prairies. The seed may be had for the gathering, and need not cost any more than clover or alfalfa, if the trouble is taken to run the chaff through a fanning mill.

The ground plum (Astragalus crassicarpus) is a prairie legume found throughout the Mississippi Valley. It has straggling fleshy stems, narrow leaflets and racemes of purple flowers, and produces

1 South Dakota Agricultural Experiment Station, Bulletin No. 40.
every year an enormous number of succulent pods, whence the plant received its name. Sheep and cattle eat both the pods and leaves. In Texas, where the razor-back hog runs at large on the ranges, the ground plum is rapidly becoming extinct, and is only found in fields and pastures protected by hog-proof fencing. The pods, or "plums," are sometimes used as a vegetable.

The ground plum appears very early in spring, long before the clovers are ready to use, at a period when rich, succulent food is needed for cows and young stock. If it proves to be adaptable to cultivation, it will be a valuable addition to early spring foraging crops. The pods of the ground plum attain their full size from the last of April in southern Texas to the first of June in North Dakota. They are then succulent and juicy. Later, as the seeds ripen, the pods dry out and by midsummer have become hard, tough, and inedible.

THE METCALFE BEAN.

One of the most valuable groups of American Leguminosae is that of the wild beans, which are botanically closely allied to the common garden beans. There is one species common to the Eastern United States, from Maine to Louisiana, occurring in copses and thickets, and valued in woodland pastures. In the Southwest there is a great variety of wild beans. They are scattered through every mountain canyon, on wooded slopes, and through the little parks along the streams. Formerly they were much more abundant, but are now relegated to cliffs and canyon walls, inaccessible to sheep and cattle, or to dry valleys, far from living water. In the mountains between the Rio Grande and the Gila the wild beans formerly supplied a great amount of feed for deer and cattle. Wherever there were wild beans cattle became fat.

One of the best of these wild sorts is the Metcalfe bean (Phaseolus retusus). This bean and all of its near relatives are perennials. They develop enormous fleshy roots that are often 4 to 6 inches in diameter and weigh 30 pounds or more. The top of this fleshy root (fig. 21) is usually 6 or 8 inches below the surface, so that the ground may be plowed or given a shallow cultivation without destroying the beans. The vines (fig. 22) grow out in every direction from the crown much like sweet potato.
vines, varying from 6 to 10 or even 20 feet in length at the end of the first season. The racemes of scattered pink flowers (fig. 23) appear from July to September, and the pods and seeds (fig. 24) ripen freely in cultivation.

All perennials which grow in semiarid and desert regions have some especial adaptation for preventing the loss of water. These may include modifications of the protective surfaces of leaves and stems, such as thickening of the epidermis, the development of a dense covering of hair, or it may consist, as in this case, of an enlargement of the stems or roots, thus providing reservoirs in which water and plant food may be stored up during the season of growth for use during periods of drought or scarcity of water and food. Because of this special modification, the wild beans ought to be of great importance and value in Southwestern agriculture. As drought-resistant crops, they should be much superior to any forage plant which has not this fleshy perennial root.

The Metcalfe bean is one of the most promising of our native forage plants. The amount of forage which it produces is naturally large, but it also shows a tendency to improve in quality and quantity with cultivation. There is constant and growing demand for drought-resistant forage crops in the West and Southwest, and the cultivation of those leguminous forage plants that show an adaptation to natural conditions is an exceedingly promising line of work.
TEXAS PEA.

The Texas pea (*Astragalus nuttallianus*) is a perennial. It is like the ground plum in habit and general appearance, but with narrow curved, bladdery seed pods on an upright stem. It is abundant in central and northern Texas, preferring the drier ridges and stony hills, while the ground plum grows best in moister valley lands. It is much relished by cattle and is disappearing wherever the ranges have been overstocked.

It grows well on cultivated land, increasing in height and amount of seed produced, thus indicating adaptability to improved conditions. The seeds ripen about the first of May, after which the leaves and stems die down and, becoming brittle, are broken to pieces and blown away. On the ranges the Texas pea supplies a large amount of highly nitrogenous forage in early spring, when such feed is most needed in the Southwest. With plenty of rain there is always plenty of grass for summer and autumn grazing. Forage plants that will supply feed before the grass starts are of the greatest possible value to stockmen. The wild peas and vetches ought to be protected from extermination, and more extensively grown.

THE STOLLEY VETCH.

Another early pasture plant from central Texas is the Stolley vetch, which grows wild on the granite soils and red prairies. This vetch has the same habit and much the appearance of the hairy vetch. It branches from the base, the weak, trailing vines being 2 to 3½ feet long. As many as 50 or 60 stems and branches have been observed from a single root. This vetch has a somewhat local distribution, occurring in central and western Texas. It grows in the creek bottoms and among the underbrush along streams, and where protected from destruction by cattle, spreads to the open prairies.

The seed lies dormant in the soil through the summer. With the coming of the fall rains it germinates, grows slowly during the winter, and blossoms about April 10. By the first of May it covers the ground with a dense mat of tangled herbage. The seeds ripen uniformly about the first week in May, after which the vetch straw dries and breaks up after the fashion of other annual plants. Cattle are very fond of this vetch, and devour all that is not protected by fences, so that it is now practically extinct except in favored localities. This vetch is one of the most promising of the many native sorts. It is reported as abundant in central Texas, and is there highly esteemed by stockmen. The Stolley vetch bids fair to be one of the very best early spring forage plants, and deserves further and more extended trials.