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1. *Kentucky Forage Plants—The Clovers and their Allies.*
2. *Notes on True Grasses in the Plots in 1900-1901.*
3. *Analyses of Forage Plants from the Plots.*

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KENTUCKY
Agricultural Experiment Station.

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KENTUCKY AGRICULTURAL EXPERIMENT STATION,
LEXINGTON, KY.

BULLETIN No. 98.

I. Kentucky Forage Plants—The Clovers and their Allies.

By H. GARMAN, Entomologist and Botanist.

Bulletin 87, published by this Station in 1900, relates to the true grasses. Another group of forage plants, including clovers, next to the grasses in importance, and not second to them in some respects, is known under the family name Leguminosæ. These plants have a special importance because of their properties as green fertilizers and as nitrogen gatherers. This bulletin relates to such members of the family as are cultivated in Kentucky, to others that have been grown in plots on the Experiment Farm at Lexington, and to those found growing wild in the State. The number of these latter will doubtless be increased somewhat as we become better acquainted with our native flora. The list presented is considered only as a foundation for a more thoroughgoing account of our species, which we have in preparation.

The same plan of arranging the species is adopted as in Bulletin 87, the technical names being presented in alphabetical order, while an index including only common names is appended.

So much space is occupied in agricultural journals with discussions on the effect of clovers and their allies on soils, that it may seem like thrashing over very old straw to give the matter attention here. Farmers, it may be said, understand very well that these plants improve their land, and are ready to make use of them without caring very much how the improvement is brought about. It may be questioned if this attitude is one that is likely to contribute to an improved

agriculture. The explanations brought out by a study of plant physiology and of bacteriology may not be all they should be, but are the best we have, and will at least serve as a foundation for further investigation and thinking. Future work may lead to their complete overthrow or to their being more firmly established. Earnest students of these subjects are not likely to raise any serious objection to either result.

Yet in view of the care with which experiments have been made, showing that clovers and allied plants appropriate the free nitrogen of the air and thus put it within the reach of other plants, such as wheat and corn, that cannot draw upon this source of nitrogen, it may be considered very improbable that future investigations will greatly alter our conceptions of the part played by these plants in restoring to soils this important element.

Good reasons can be given for the belief that these plants do not take free nitrogen from the air by means of their leaves, and evidence has been recorded showing that they do not gain free nitrogen in any way unless certain knots or tubercles appear on their roots; that minute bacteria in the tubercles and not the plant itself, are the agents by which nitrogen of the air is fixed in the plant. A very brief review of investigations that have led to the accepted views on these points will help to a clearer understanding of the purpose of some observations and experiments on soy beans reported in what follows.

Leguminous Plants as Nitrogen Gatherers.

The peculiar renovating properties of the clovers have been known in practical agriculture for many years. A French chemist appears to have been first in the field with the purpose of finding an explanation. In 1837 Boussingault began numerous experiments with plants grown in sterilized soil, the plants themselves enclosed and sometimes surrounded with air that had been "washed." At one time, we are told, he held the opinion that nitrogen of the air was fixed in the soil by certain microscopic plants, but later abandoned this view, and finally as the result of many years' investigation con-

cluded that the higher plants cannot assimilate the free nitrogen of the air.

Messrs. Lawes and Gilbert, who became of recent years the leading British authorities on the subject, began work on the problem about the time Boussingault gave it up, in 1857. They also grew plants in sterilized soil under glass covers, and like him reached the conclusion that plants do not appropriate the free nitrogen of the air.

But this conclusion did not satisfy workers. Facts were being observed that could not be explained, assuming that plants do not get nitrogen from some other source than the soil, and the dissatisfaction led at length to renewed experiment. The American chemist, W. O. Atwater, was one of the first, possibly the first, to publish the conclusion based upon experimental evidence that after all some plants do take up the free nitrogen from the atmosphere. In the American Chemical Journal, Vol. 6. pages 365-388 (1884-5), he gives his data in detail, but makes no serious effort to explain just how the nitrogen is taken up.*

The best known work tending to demonstrate that free nitrogen is appropriated by leguminous plants was furnished by the Germans, Hellriegel and Willfarth. The former of these in 1883 grew various plants in washed quartz sand, adding nutrient solutions but no nitrogen. Then to a part of them he gave various known quantities of combined nitrogen. He found that ordinary grasses grew in proportion to the quantity of combined nitrogen supplied them, but that the Leguminosæ did not in all cases agree. Certain plants growing better than any of the others were found to have small nodules, or tubercles, on the roots. In conjunction with his colleague, he began to make use of soil extracts, simply shaking up rich garden soil in a vessel with water, then removing the soil and applying the water to certain plants under experiment. It was found that this treatment led to a good growth of the plants, with a development of nodules on the roots, and as a result of many such experiments they an-

* Atwater appears to have published his results before the American Association for the Advancement of Science in 1881.

nounced in 1886 that Leguminosæ thrive in soils with no nitrogen in them, if only the tubercles are developed, but that without tubercles the growth is poor and no free nitrogen is taken from the air.

Lawes and Gilbert took up the study again in 1888, and during this year and several following, obtained results completely confirming those obtained by the German writers mentioned. In summing up the results of their later work they write (Journal of the Royal Society of Agriculture of England, 3d Series, Vol. 2, 1891, p. 689), "Reviewing the whole of the results which have been brought forward, there can be no doubt that the fact of fixation of free nitrogen in the growth of Leguminosæ under the influence of suitable microbe infection of the soil, and of the resulting nodule-formation on the roots, may be considered as fully established."

The importance of the conclusion reached by these men is not yet fully appreciated by farmers. Nitrogen in some form is essential to the proper growth of plants. It is one of the most costly fertilizing materials when supplied artificially. Yet here is a supply ready to every farmer's hand. He cannot draw on it with wheat or corn or oats; but clover, soy beans, and alfalfa, capture it and place it at his disposal. In the light of this explanation, we may read with a better understanding the words of Monsieur Georges Ville (Artificial Manures, 1882, p. 37), "It cannot be too often repeated that it is one of the secrets of profitable farming, to draw from the air as much nitrogen as possible by the alternation of crops."

The Tubercles.

The root nodules, or tubercles, of clovers and cowpeas are familiar to most farmers. They vary much in shape and average size with the plant on which they grow. On the hairy vetch (*Vicia villosa*) they are variously lobed, young galls frequently consisting of three or four rather slender processes loosely attached to a rootlet, and older galls having numerous lobes, making the general surface very uneven. The diameter of some of those observed in our plots was 5-16 inch. The tubercles formed on the roots of soy beans are

very different, looking like minute potatoes. They are frequently quite spherical, the surface rather smooth, sometimes with a few obscure impressed lines, occasionally with the surface decidedly impressed in places, producing coarse folds. When cut open early in the season the cut surfaces are of a peculiar reddish brown or brick-red color. Late in the fall the cut surfaces are greenish, and as the plants dry out, the tubercles blacken and shrivel, becoming at length coated with a whitish mould-like fungus. They are juicy and rather soft at first, often with an appearance of a small central cavity. The diameter varies from about 1-16 to 5-16 inch. Large numbers are produced on a single plant, some on the central root, others far out on the lateral fibrous branches. On clover, the galls are oval in shape and only about 1-16 inch long.

Tubercles similar to those occurring on the roots of leguminous plants are found on the roots of some plants of other families, and are probably in some cases due to similar organisms. Some others are the result of the invasion of the roots by microscopic plants recognized as fungi proper. Still others are due to attacks by microscopic worms, one of the best known of which is *Heterodera radicola*, of cucumbers, lettuce and other plants.

The Bacteria Causing the Tubercles.

The organisms living in the nodules were recognized as bacteria as early as 1866. Later, and quite recently, the exact nature of the organisms was in dispute, some naturalists considering them fungi, under the genus name Rhizobia, others regarding them as true, though in some features of structure and development, exceptional bacteria. At present the latter view is quite generally held by bacteriologists. The name *Bacillus radicicola* was applied to them in 1888 and is now in common use. Each genus of Leguminosæ appears to harbor an organism in some ways different from those living on others, but yet so much alike that they cannot in all cases be distinguished. Most of them are coming to be regarded as varieties of one species, and in conformity with this view it is held that bacteria producing nodules on clover, for example,

will in time also produce them on other closely related plants that may be planted in soil previously occupied by clover.

How the Bacteria Get Into the Roots.

The life history of the organisms has recently been studied with some care. They have been found to invade the roots by way of the root hairs, making for themselves a slender passage down the centers of the hairs until the root proper is reached in which they occupy larger passages bearing at first some resemblance to the growing threads of a fungus. It was the thread-like appearance of these larger passages that led early investigators to consider them an essential part of the organism, the bacteria being looked upon as reproductive bodies.

The Effect of the Absence of Nodule Bacteria from Soil.

Since it is by the aid of the bacteria that clovers and other leguminous plants can live and thrive in soils containing no combined nitrogen, it has been suspected that in some cases when clovers fail to do well it is because the nodule-producing bacteria are absent, and that by introducing them the plants will be enabled to grow. This matter has now been pretty thoroughly investigated in European countries, and to some extent also in this country. It has been found that land is often greatly improved for clover simply by sowing it with soil taken from good clover land, and thus introducing the nodule-producing bacteria. The method is somewhat inconvenient in practice and has other defects, such as introducing fungus or other pests with the *Bacillus radicicola*.

The Bacteria May be Sown by Means of Cultures.

Any way the use of pure cultures was bound to be considered, and has for some years been tried. Beyerinck, who first described the organisms as true bacteria, appears to have made such cultures previous to 1888. In this country Prof. Atkinson, of Cornell University, made cultures about 1889 from tubercles on the roots of vetches. Dr. Nobbe, of Thar-

and, Saxony, about 1896, began the preparation of cultures of the organisms of leguminous crops on a commercial scale, and they were at one time obtainable in this country, and were to some slight extent employed here in an experimental way. Recent inquiry with reference to obtaining cultures for experiment at this Station, however, disclosed the fact that they could no longer be secured through the representatives of the German manufacturer, and it was only through the kindness of Dr. L. Hiltner, of Berlin, that fresh cultures were finally obtained. These were tested last summer on the Experiment Farm, in the case of soy beans with a success that was quite surprising, considering all the difficulties in the way of sending the living bacteria such a long distance. Further reference to these cultures will be found under the heads of red clover, alfalfa, and soy beans.

The Dissemination of the Bacteria by Natural Means.

The nodule bacteria of our most commonly cultivated leguminous plants, such as garden peas, beans and clover, seem to be quite generally distributed in the soils of the State. This is what would be expected from the fact that these plants have for a long period been cultivated here. In the case of plants which are not generally grown, soy beans for example, tubercles can not be expected to appear on the roots the first year of planting on ground new to the plant, unless bacteria are introduced. This has been the experience in our forage plant plots at Lexington, at any rate. The second year of planting on the same ground the tubercles are always abundant, though nothing is done to encourage them. The bacteria are perhaps carried about to some extent in the air. Atwater and Woods report* that they found tubercles on some plants grown in sterilized soil and kept moist with sterilized water, and suppose the organisms to have been conveyed in the air from a neighboring garden. It has been observed in our plots, however, that the special bacteria of new forage plants remain very closely restricted to soil in

*Bulletin 5, Storrs School of Agriculture Experiment Station, 1889.

which such plants are grown, not even crossing a three-foot path to plants of the same sort. For a whole season two plots from the same lot of seed have stood thus side by side, the one with roots loaded with tubercles, the other with none. One would expect that particles of earth carried on tools used in working the plots and on the shoes of workmen would inevitably inoculate the new plots, but no evidence of this has been witnessed. It may be that the destructive effect of sunlight and drought on the bacteria in the surface layer of soil accounts for these facts, in which case we can hardly suppose the bacteria would, in their growing state at any rate, survive dissemination in the atmosphere. It has seemed to me from observations of this sort that the bacteria must be scattered chiefly, if not entirely, during cool, moist weather, in fall and spring, by the washing of soils, otherwise they would surely appear before the end of a summer in new plots standing beside old ones. But this does not explain the sudden appearance of the special bacteria adapted to soy beans in an isolated plot of ground, while land all about remains free from them. It must be assumed in such cases that the organisms of some commonly grown plant become adapted to the soy bean, that by virtue of some change either in the soy bean or in the bacteria, the association of the two becomes possible after the first season.

Other Nitrogen-Fixing Plants.

It has been shown by Dr. Hiltner that some other plants (alders among them) besides the Leguminosæ fix nitrogen of the air with the aid of the bacteria residing in tubercles on their roots. Certain of the lower green plants (Algæ and mosses) which grow on the surfaces of moist soils have been thought to appropriate free nitrogen without aid from bacteria; but results obtained in experiments with these plants have been criticised because the growths under experiment were not freed from bacteria, these latter being assumed by critics to have secured the nitrogen while getting the carbon from the Algæ, the association of the two being thus similar in charac-

ter to that of tubercle bacteria and clovers. At any rate the tendency for some time past has been to consider the evidence of fixation by Algæ and mosses as not completely satisfactory.

Nitrifying Bacteria.

The bacteria producing tubercles on the roots of clovers and cowpeas are very different from those described by the naturalist Winogradsky, and which he obtained in 1891 from soil, and succeeded in growing in pure cultures on a medium containing soluble silicates. These nitrobacteria are of three sorts, one of which (Nitrosomonas) attacks organic matter at a certain stage of decay, producing nitrites, after which, acting on the nitrites, a second form (Nitrobacter) produces the nitrates which are assimilated by growing crops. It thus appears that the plants employed for crops are completely dependent on lowly soil-inhabiting bacteria; upon the nodule-forming species for the free nitrogen obtained from the air; and upon the nitrobacteria of Winogradsky for rendering nitrogenous material already in the soil available as plant food.

Bacterial Cultures for Wheat and Corn.

Of late a preparation known as "alinit" has been distributed to stations in this country by a European manufacturer*, which is claimed to encourage the growth of wheat and allied plants by its action on nitrogenous materials in the soil, its effect being like that produced by the Nitrosomonas and Nitrobacter of Winogradsky. Samples received at this Station last summer were put up in small vials of brown glass, each vial containing enough for an acre of ground. The brown powdery contents include with other material compact masses of an organism that may easily be the Nitrosomonas. The enterprise appears to be an effort to utilize Winogradsky's discoveries. The preparation has not been tested by us in a practical way. A French worker, Malpeaux, has recently announced that he has obtained results from pot experiments indicating that alinit has a beneficial effect in soil very rich in

*Friedr. Bayer & Co., Elberfeld, Germany.

organic matter, but that it has no such effect on cultivated land*. I have called attention to it here merely to point out that it is not like tubercle bacteria, calculated to increase the nitrogenous matter in the soil, but only to render available to growing crops certain fertilizing materials already present.

Useful Literature Relating to Nitrogen-Fixing and Nitrifying Bacteria.

Following are the titles of a few of the most commonly accessible articles on the action of bacteria in providing and preparing food for the higher plants. For the farmer, numbers 2, 3, 8 and 9 give information of special value. The agricultural student will find numbers 1, 4, 5 and 6 highly interesting.

1. W. O. Atwater, The Acquisition of Atmospheric Nitrogen by Plants: American Chemical Journal, Vol. 6, pp. 365-388 (1884-5).

2. J. B. Lawes, and J. H. Gilbert, The Sources of the Nitrogen of our Leguminous Crops: Journal of the Royal Agricultural Society, Vol. 2, 3d Series, p. 657 (1891).

3. R. Warington, Lectures delivered before the Association of Agricultural Colleges and Experiment Stations: Bulletin 8, Office of Experiment Stations, U. S. Dep. Agr. (1892).

4. Albert Schneider, Observations on some American Rhizobia: Bulletin Torrey Botanical Club, Vol. 19, p. 205 (1892).

5. Albert Schneider, A New Factor in Economic Agriculture: Bulletin 29, University of Illinois Agricultural Experiment Station, p. 301 (1893).

6. G. F. Atkinson, Contribution to the Biology of the Organism Causing Leguminous Tubercles: Botanical Gazette, Vol. 18, pp. 157, 226, 257 (1893).

7. R. Warington, Contribution to Recent Investigations upon Nitrification: Agricultural Science, Vol. 7, p. 34 (1893).

8. J. Augustus Voelcker, "Nitragin" or the Use of "Pure Cultivation" Bacteria for Leguminous Crops: Journal Royal Agricultural Society, Vol. 7, 3rd Series, p. 253 (1896).

9. P. P. Deherain, Origin and Formation of Organic Matter

*Journal Royal Microscopical Society, 1901, p. 577 (abstract).

in Plants: Experiment Station Record, Vol. 9, p. 903 (1898).

10. E. F. Smith, Notice of a paper by O. Zinsser on the root-tubercles of Leguminosæ: American Naturalist, Vol. 32, p. 365 (1898).

11. H. von Schrenck, Notice of a paper by L. Hiltner on root-tubercles of alders and Eleagnaceæ: American Naturalist, Vol. 33, p. 450 (1899).

The Characters of the Clovers and Allied Plants.

While these Plants are often used for hay and pasturage in the same manner as grasses, they are very different in their botanical characters from true grasses. Plants belonging here generally have leaves composed of divisions known as leaflets, irregular, perfect flowers, often very showy and attractive to insects, the seeds generally enclosed in a single-celled pod or legume.*

Many valuable plants besides those used for forage belong to the group: Indigo comes from one; gum-arabic from a second; rosewood from another; and the dye, logwood, from still another. It includes also some species, such as the Darling pea of Australia, that are accused of poisoning stock.

List of Kentucky Leguminosae, with Notes.

Acuan illinoensis (ILLINOIS MIMOSA).—An erect herb with finely divided leaves and clustered pods. Credited to Kentucky by several authors. Observed in cultivation at Lexington. Said to be eaten by stock turned out on bottom lands.

Amorpha fruticosa (FALSE INDIGO).—A shrub often seen about lawns. Probably of no great value as forage. Perhaps native also, since it was credited to Kentucky by Short and Peter.

Anthyllis vulneraria (KIDNEY VETCH).—European. Thrives on dry and rather poor soils, where it furnishes good pasture for sheep. It has the general habit of the clovers, being inclined to grow in tufts, the upper stem leaves with slender divisions, the yellow flower-clusters about the size of red clover

*The word legume is sometimes applied to *plants* of the family; thus, clover, alfalfa and cowpeas are by this usage, legumes.

heads, but broader in proportion to the length. It has been grown twice in plots on the Experiment Farm, and presented a very pretty appearance the second season in both cases, but did not last. It was planted April 25, in one case, and May 19, in another. The first season the leaves were rather short, and no blossoms were developed. The second season in both cases it bloomed freely, being in one planting at its best June 13, and in the other, May 23, the difference being the result of different weather conditions. But one yearly cutting can be secured from it on our soil. From our experience with it, I would commend the plant as worthy of trial in a small way by farmers living in hilly sections where there is some sand in the soil.

Apios apios (GROUND-NUT).—A perennial vine, observed along the Kentucky River.

Apios priceana.—A species collected in the State by Miss Sadie F. Price, of Bowling Green.

Astragalus carolinianus (CAROLINA MILK VETCH).—A native plant credited to Kentucky by Drs. Short and Peter.

Baptisia alba (WHITE WILD INDIGO).—Kentucky (Short and Peter).

Baptisia leucantha (LARGE WHITE WILD INDIGO).—Kentucky (Britton and Brown).

Baptisia tinctoria (WILD INDIGO).—Kentucky (Britton and Brown).

Cassia chamæcrista (PARTRIDGE PEA).—An annual, with numerous very small leaflets and bright yellow flowers. Common locally in Western Kentucky.

Cassia marylandica (WILD SENNA).—Coarser and taller than the preceding species, and perennial. Frequent. Occurs through the State.

Cassia nictitans (SENSITIVE PEA).—Eastern Kentucky. A specimen in the Station collection was collected by Prof. A. R. Crandall; another from Jackson County was collected by Mr. G. M. Sullivan.

Cassia tora (LOW SENNA).—Kentucky (Short and Peter).

Cercis canadensis (RED-BUD).—This well known tree is

very common in Kentucky, being especially abundant along the Kentucky River.

Cladrastis lutea (YELLOW-WOOD).—The yellow-wood is becoming scarce in Kentucky, though young trees from 10 to 15 feet in height, and 1½ to 2 inches in diameter of trunk can still be found in some numbers on the cliffs of Kentucky River in Jessamine County. The tree is well worthy of cultivation. Flowers white, like those of black locust, but the cluster more straggling, and often 15 inches long. Leaflets of young growth often 5 to 6 inches in length.

Clitoria mariana (BUTTERFLY PEA).—A specimen in the collection was collected at Cumberland Falls by Prof. C. W. Mathews.

Cracca spicata (GOAT'S RUE).—Collected at Cumberland Falls by Prof. Mathews.

Cracca virginiana (CAT-GUT, GOAT'S RUE).—Frequent on hill tops throughout much of Kentucky. The seeds sometimes badly infested with a small snout-beetle. Aden Springs; King's Mountain; Cloverport.

Cytisus scoparius (SCOTCH BROOM, HAGWEED).—This has been grown in the Vivarium of this Division, but does not seem calculated to be of value for forage. It is a coarse, straggling plant, with scant foliage and woody stems, such that they could only be browsed while young. It has been recommended as a soil renovator for rather arid regions.

Falcata comosa (HOG PEANUT).—A perennial vine credited to the State by Kearney.

Falcata pitcheri (HOG PEANUT).—A perennial vine. Clay's Ferry, August 22, 1892.

Galactia volubilis (DOWNY MILK PEA).—Kentucky (Miss Sadie F. Price, also Britton and Brown).

Gleditschia aquatica (WATER LOCUST).—Collected by me only along the Mississippi River in Western Kentucky.

Gleditschia triacanthos (HONEY LOCUST).—A very common tree throughout Kentucky.

Gymnocladus dioicus (KENTUCKY COFFEE-TREE, COFFEE BEAN).—One of the most characteristic trees of Blue-grass

Kentucky in woodland pastures, where the large pods become conspicuous during the fall and early winter months.

Glycine hispida (SOY BEAN, SOJA BEAN).—This forage plant caught the attention of Kentucky farmers recently, and has risen rapidly in favor; promising in the end to displace the cowpea. Its upright growth gives it the advantage of cowpeas in cutting and curing. It makes good hay and silage, is a convenient soiling crop, and the seeds make good feed for most stock. They make a very acceptable dish for the table also, either picked green or when thoroughly ripe. The plant is a soil renovator, and endures severe drought well. In short, it has more good qualities than any other forage plant that has recently engaged the attention of our farmers.

The soy bean is an annual, with a strong central root, broad leaves, somewhat like those of ordinary beans, small purplish flowers, and short, downy, few-seeded pods, clustered in large numbers along the main branches; the seeds small, roundish generally, though in some varieties flattened like navy beans, resembling in a general way the seeds of the common garden pea, but with a long scar and the surface never indented. In color the seeds vary from white through shades of yellow and green to black.

The plants may be dwarf and early-maturing, or medium, 3 to 3½ feet high, or late and tall, reaching a height of 3½ to 4 feet or more, and maturing their seeds so late that at this latitude they are likely to be caught by frosts. A moderately early yellow, or green pea is best adapted to the State.

Soy beans should never be sown until the soil is thoroughly warm. Plots planted on the Experiment Farm with the idea of giving them an early start have not done as well as those planted two weeks or a month later. They are hot weather plants. Immediately after planting corn is generally a good time to put the seeds in the ground. If planted for seed, sow with a grain drill, stopping up the holes so as to make rows about 32 inches apart. When grown for hay, or soiling, they may be drilled like wheat, using about 5 pecks of seeds to the acre; but they are vigorous plants, and even for hay

better results will generally be obtained by giving them more room. They may be cultivated with a weeder, or one-horse cultivator, at the outset; later they cover the ground and take care of themselves until ready to cut. The cutting can be done with a special bean harvester, if the soil is soft enough to permit, or with an ordinary mower, though it should be remembered that the stems become tough and hard to cut as the plant ripens, and on this account it is well not to delay the harvest longer than is necessary. For hay, the plants may be cut soon after they begin to blossom; for silage, as soon as the pods are developed and before they are ripe. If grown for seed it is well to harvest as soon as the seeds are ripe and before the pods dry out and begin to split, otherwise much of the crop may be scattered in the field, or lost in handling.

Yield. The yield of seeds and hay varies much with variety, season, soil, and culture. Our best yield was obtained from seed imported from Japan by the United States Department of Agriculture, and sent us numbered 4913. In 1900 this variety yielded at the rate of 26⅔ bushels per acre, the plants without tubercles. In 1901 some of the seed of this variety, sown in the same plot as in 1900, yielded at the rate of 36 bushels per acre, the plants bearing many root tubercles. Some of this same home-grown seed was planted also in new ground in 1901, and yielded 34⅔ bushels per acre, the plants being without tubercles. Some of the original imported seed left over from 1900 was planted in ground new to soy beans in 1901 and yielded, without developing tubercles, at the rate of 40 bushels to the acre. It must be added that plants were at various times during the summer taken from these plots, sometimes to examine the roots, sometimes for chemical analysis, occasionally for photography and herbarium specimens, and the yield was therefore somewhat reduced, and perhaps not to the same extent in all of the plots. The final yield of seed obtained in October is thus rather below what this variety can do in a good soil during a trying season.

A second variety of yellow soy bean (No. 4912 of the U. S. Dep. Agr.) does not average as well as 4913, though one of

the plots yielded in 1901 at the rate of 40 bushels per acre. In 1900 this variety yielded at the rate of 35⅓ bushels per acre.

Two other varieties grown in the plots are too late for the production of seed, but in 1900 were favored by a prolonged open fall, and mature seeds were secured from both. One of these (No. 4914, U. S. Dep. Agr.) produced seeds at the rate of 34⅔ bushels per acre, while the other (Seed bought of J. M. Thorburn & Co.) yielded only 20½ bushels per acre. Both of these late varieties would make good hay or silage.

Two plots of 4914 were cut in 1901, and yielded green fodder at the rate, respectively, of 14.08 and 11.84 tons per acre, and dry fodder at the rates of 6.16 and 5.44 tons per acre. They were cut (Sep. 18) when pretty well matured, hence the yield is greater than can be expected in field work, where the plants are commonly cut when in bloom.

Its value as forage. The readiness with which stock of all kinds eats the soy bean, fed as green fodder, as silage, or as hay, is good evidence concerning its food value. Barring cases of perverted appetite, animals prefer for food that which affords them most nourishment. Chemical analysis, while admitted not to be the final test, strongly confirms evidence of other sorts. It shows that the plant contains a somewhat higher percentage of the materials that produce muscle and fat than does the cowpea. Actual feeding tests made so as to exclude as far as possible chances of error, show that soy beans are a nourishing food. Professors Voorhees and Lane, of the New Jersey Station, give the following as the result of tests of soy beans and cowpeas:

DIGESTIBLE FOOD PER TON.

	Fat, lbs.	Protein, lbs.	Carbohydrates, lbs.
Soy beans	6.6	34.2	174.0
Cowpeas	6.0	28.8	119.0

Its value as a fertilizer. Without any very exact data at hand as a basis for comparison, it may still be said without danger of going far wrong that soy beans have the same effect as a green fertilizer as cowpeas.

If the number of tubercles produced on the roots shows its value for this purpose, from my own experience I should consider it the better plant of the two. But farmers are liable to make the mistake of assuming from a first year's experience that the soy bean will not develop tubercles on their land. In 1900 four varieties were grown in our forage plots, and all made a fine growth. But none of the plants developed nodules. They were dug up with special care to avoid the chance of breaking the nodules off and leaving them in the soil. None were found. In the spring of 1901 three of these plots were planted with seed gathered from them in the fall of 1900. The fourth plot was some distance away in 1900, and it was decided to plant seeds obtained from it next the other three. The plot chosen for this seed bore in 1900 an imperfect stand of blue lupines. To my surprise the plants in the three plots that had borne soy beans in 1900 produced tubercles in 1901 in large numbers, while on those of the third plot, which, so far as known, had never before borne soy beans, not a single tubercle was to be found.

Other plots planted from the same lots of seed, but in another section of the forage plant garden, where soy beans had not before been grown, bore no tubercles in 1901. Several plantings of considerable extent on another part of the farm and from seeds obtained from various sources, also produced no nodules. The soils in which all these plants grew contained more or less nitrogenous material, and those with no tubercles appeared to thrive as well as the others. If combined nitrogen had been wanting in the soils it is probable that the beans planted on new land would have failed.

Just why the tubercles should not appear the first year and should appear in large numbers the second, is not at present easy to explain. But the fact is important as offering an explanation of the disappointment which some farmers experience with the plant. *Planting a second season on the same land appears to be necessary to get the soy bean at work as a nitrogen fixer.* In soils deficient in combined nitrogen, the crop is at first likely to languish because of failure to develop root nodules.

The nodules can be grown artificially the first season. It

was demonstrated in our plots in 1901 that the tubercles can be grown in great numbers on the roots of soy beans by the use of pure cultures of the tubercle bacteria. Through the kindness of Dr. L. Hiltner, of Berlin, Germany, I received in June, 1901, test tubes containing cultures of bacteria for soy beans, red clover, and alfalfa. It was too late when they arrived to get fair tests of the cultures on red clover and alfalfa, and the attempts failed. On the soy bean the time appeared to be most opportune. The growth in one of the tubes was turned into a small beaker containing enough distilled water to moisten thoroughly seeds sufficient to plant 1-80 acre. The gelatine bearing the growth was broken up so as to mix the bacteria with the water. After sprinkling the soy beans with this, they were mixed with sand and set away in a dark cupboard until ready to plant. The sand and seeds together were then sown in drills, and beside the plot another 1-80 acre was sown with untreated seed. Both lots grew off well, with no apparent difference above ground in the plants of the two plots. But when about eight inches high, tubercles began to appear on the roots of the treated lot and a little later they became thickly covered. Probably not a plant was entirely free from them. The plants in the adjacent check lot produced no tubercles during the season.

The experiment was a complete success, and if I may judge by these results, the cultures for clover and alfalfa would also have succeeded if tried at the proper season for sowing these plants. I wish to acknowledge here the kindness of Dr. Hiltner, and to thank him for this opportunity to test the cultures.

Insect and other enemies. At present the plants are attacked by but few insects, and appear to be equally free from fungus enemies. Grasshoppers (mostly the red-legged grasshopper) gnawed the leaves during a dry period last summer, and a reddish brown hairy caterpillar (*Spilosoma virginica*) at one time ate numerous holes in the leaves of both soy beans and cowpeas, but was destroyed later by a parasitic fungus (Empusa) that left the dried bodies in large numbers sticking to the leaves. A few leaf-mines were ob-

served at one time, occupied by the grubs of a small beetle (Odontota sp.). The character of the grubs as well as the egg-mass at the edge of each mine, showed this to be a near relative of our locust leaf-miner (*Odontota dorsalis*), but it was impossible to rear the grubs to maturity and thus identify the species, because of the quickness with which the leaves dry out. My record with reference to them, made July 19, reads: Occasional brown blotches on upper sides of leaflets, reaching a diameter of ¾ inch and occupied by 3-5 flat larvæ, which can be seen by holding the leaf up to the light, busily gnawing away the green substance between the upper and under cuticles. On the under side of each mine is a blackish mass of eggs, covered with gum so as to conceal its true nature.

In a single case the leaflets of a plant were drawn together by an active worm, the young of some leaf-folding moth.

A few plants of one plot were found to have the bean root-louse (*Tychea phaseoli*) on the underground parts of the stems.

Kraunhia frutescens (AMERICAN WISTERIA).—A woody vine, frequently seen in cultivation about verandas.

Kuhnistera candida (WHITE PRAIRIE-CLOVER).—Kentucky (Short and Peter).

Kuhnistera foliosa (LEAFY PRAIRIE-CLOVER).—Kentucky (Britton and Brown).

Kuhnistera purpurea (VIOLET PRAIRIE-CLOVER).—Kentucky (Short and Peter).

Lathyrus palustris (MARSH VETCHLING). — Kentucky (Short and Peter).

Lathyrus sylvestris (FLAT PEA).—A trailing perennial, introduced from Europe. Grown in our plots it has not done well, producing only a small amount of forage, and appearing to suffer from heat. The roots are very thick and strong, however, and would be thought to render it a good drought resister. We have never secured enough forage to give it a fair test with stock, but others report it as not relished, though chemical analysis shows it to stand well as regards nutrient constituents. It did not develop flowers at any time in the plot.

Lespedeza angustifolia (NARROW-LEAVED BUSH-CLOVER).—Kentucky (Short and Peter).

Lespedeza frutescens (WAND-LIKE BUSH-CLOVER).—Junction City, June 19, 1892.

Lespedeza hirta (HAIRY BUSH-CLOVER).—Frequent in the mountainous sections of the eastern part of the State. Reported by Col. Jay H. Northup, of Louisa, as relished by stock.

Lespedeza nuttallii (NUTTALL'S BUSH-CLOVER).—Collected in Lawrence County, in 1894, by Professor A. R. Crandall.

Lespedeza striata (JAPAN CLOVER).—As seen growing along roadsides in southern and western Kentucky this is a low straggling plant, with light green foliage, generally grazed close to the ground by roaming stock. It is an introduced annual and furnishes a very good forage in sections where the soil does not furnish much forage of other sorts. In the northern counties it does not persist, being killed by frost and apparently generally failing to mature its seed. It has been tried several times in our plots. Sometimes the seed failed to germinate. Only once was a good stand secured, and no trace of plants was to be seen the next season, though the land was left undisturbed in the hope that some dropped seeds were left in the soil. It is a nitrogen fixer and soil improver and hence proves a boon where it grows spontaneously. It has been noted as especially common at Nortonville, Adairsville and Clinton.

Lespedeza stuvei (STUVE'S BUSH-CLOVER).—Kentucky (Miss Price.

Lespedeza violacea (BUSH-CLOVER).—Kentucky (Short and Peter).

Lespedeza virginica (SLENDER BUSH-CLOVER).—(Kentucky) Kearney.

Lupinus albus (WHITE LUPINE).—This is an annual European forage plant grown for the purpose of enriching soils. It was planted in one of our plots in 1900 and made a fine stand of thrifty plants averaging, June 29, about 31 inches in height. The pods are about 3½ inches long and ¾ inch wide. The seeds large (7-16 inch in diameter), flat, and of a

pinkish white color. It is a nitrogen fixer, and from our experience with it would seem calculated to serve well in poor soils as a green manure. The seeds are not edible, being bitter, but the young plants may be fed to stock.

Lupinus hirsutus (BLUE LUPINE).—This is grown for the same purpose as the white lupine, but in our plots proved a much slighter and less vigorous plant, with very slender (linear) leaflets. Height about two feet. Pods in a terminal cluster, 1¾ inch long. Seeds much smaller and rounder than those of the white lupine, of a gray blue color, mottled with white. The seed did not germinate well, and only a few plants were secured.

Lupinus luteus (YELLOW LUPINE).—This plant is somewhat like the preceding. Leaflets nine, linear-oblanceolate. Flowers yellow. Whole plant gray, and about 11 inches high in plot, with a very long tap-root measuring 13 inches in a plant pulled up by hand. The seeds did not germinate well, and the few plants secured did not thrive. Seeds about the same size as those of the blue lupine (¼ inch in greater diameter), but flatter. Yellow, speckled with black. Both plant and seeds make good feed for stock. The lime in our soil may explain its failure in the plots, since it is said to be partial to sandy soils.

Medicago lupulina (BLACK MEDICK).—A rather slight, introduced annual clover, in our plots not producing as much forage as white clover, and otherwise not very promising. Flower clusters rather less than ¼ inch in diameter and bright yellow, appearing about May 23, when the average height of plants is about 8 inches. Some plants came up the second season, but it is practically an annual here. The plant is frequently found along roads and in fields, growing spontaneously, the seeds having been scattered with other clover or grass seeds.

The seeds, contained in black pods (coiled at tips), are ripe June 20. The seeds themselves resemble very closely those of red clover, but can be distinguished by the presence of a small prominence or tubercle next the scar. They are said to be

used extensively for the adulteration of red clover seed, which may account for the frequent appearance of plants in cultivated ground. Insects do not attack it as much as they do red clover, which is to be regarded as an indication that it is not as palatable for stock, since insects in the plots generally eat most freely of the most valuable forage. This clover is highly valued in some parts of England for sheep pasture, and is there known according to Sowerby as shamrock and black nonesuch. An analysis published by Professors Jenkins and Winton is as follows:

Water, 78.52; ash, 1.37; protein, 3.40; fiber, 6.31; nitrogen free extract, 9.29; fat, 1.11.

Medicago sativa (ALFALFA, LUCERNE).—While this well-known forage plant has not on the Experiment Farm given us reason to feel enthusiastic about it as forage for Blue-grass Kentucky, it has yet given evidence of possessing some very exceptional qualities that may render it even here useful on occasion. In some sections of the State farther west it has been found of great value as forage for beef cattle. Mr. J. J. Botto, of Boston, Nelson County, has had special proof of its value for this purpose, and is disposed to rate it very high. His soil, he tells me, is second bottom land. But it is well to keep in mind the fact that alfalfa requires *good deep soil*, not too wet, and that yields which some have secured from such land can not be obtained from heavy, shallow, imperfectly drained, clayey soils. I have concluded from my experience with it that our subsoil is too hard, and contains too little available food to suit its very long and deeply penetrating roots. It appears not to develop root-nodules in any numbers.

But it lasts well, better than red clover, and after the first year stands drought pretty well, although we can always see in it the effect of protracted dry weather. Farmers who may try it are likely to be disappointed with it the first season. The plants are at first rather slight, and late in the season may lose much of their leafage. The second season, when their roots have pushed deeper into the soil and are stronger, they present a much better appearance and will yield several cuttings of hay. The mistake made in our plots at first was in

not cutting often enough. The plants appear to do better when cut frequently, and even when from drought the yield may be scant, it is often best to remove the growth present, since once it has ceased growing it appears not to recommence readily unless the old growth is removed.

Root nodules are not common in our plots, and an attempt to introduce them last summer gave no results.

It is about as nearly perennial as any of the leguminous forage plants. A plot of ordinary alfalfa from seed, bought of an eastern seedsman, was started in the spring of 1892, and was still growing in the spring of 1901, when it was made part of a paddock for stock. Hogs turned into the enclosure at once attacked this alfalfa, and had soon not only removed what was above ground, but had stirred up the surface soil to get as much of the plant as possible. Alfalfa plainly cannot stand such "grazing" as these animals do.

Some notes giving the record of this plot may be worth presenting here as showing what may be expected of alfalfa from year to year in this part of Kentucky.

May 13, 1893.—A dense and uniform growth. 10 inches high. No flowers.

June 13, 1893.—A splendid growth. Very uniform and thick. With purple flowers. Average height 1 ft., 10 inches. Occasional stalks reaching a height of 2 ft., 9 inches. Flower clusters 0.58 inch in length and the same in diameter. Leaflets 0.72-0.92 inch long. Stems smooth and round, 0.12 inch in diameter. Should make fine hay.

July 19, 1893.—This was cut some time ago and has since grown up again, looking fresh and green. Averages about 1 foot in height. A few flowers.

Aug. 8, 1893.—A good, uniform growth 10 inches high. Has suffered some from drought.

Aug. 26, 1893.—Has suffered from drought. Dropped most of its leaves. Injured by young red-legged grasshoppers (*Pezotettix femur-rubrum*), which are very abundant about it.

Sept. 16, 1893.—This is now 8 to 10 inches high, the stems green, with a very few leaves, the rest having been gnawed

off by grasshoppers. The injuries have been especially severe because of drought and the consequent drying up of other vegetation.

Jan. 20, 1894.—Good. Green at base of last year's stubble.

June 18, 1894.—A uniform growth averaging 14 inches high. With numerous purple flowers, and some fruit. Flower clusters ½ inch in diameter and of the same length. Old clusters bearing seeds, ⅞ inch in length in some cases. Leaves in health dull dark green, but most plants show a yellowing of the leaflets. Occasional plants are 2 feet in height. A close growth over whole plot. Especially subject to insects, partly because of the shelter which the peculiar growth affords, but probably to a considerable extent because of its nutritiousness. An ash-gray blister beetle (*Macrobasis unicolor*) is common. The spotted cucumber-bug (*Diabrotica 12-punctata*) is also common about the plants. A small leaf-hopper (*Empoa albopicta*) is very common, as is also the tarnished plant-bug (*Lygus pratensis*). The flowers are visited by common butterflies (*Colias philodice*, *Pieris protodice*, several Hesperidæ) and by numerous small bees.

July 10, 1894.—Had this cut yesterday. Weight of fresh fodder, 32½ pounds, or at the rate of 1.28 ton per acre.

July 26, 1894.—Since cutting, this has grown well, and is now uniformly green, and averages 10 inches high. Little trace of the yellows, so apparent in first crop. No flowers yet. Insects abundant.

Aug. 23, 1894.—A good second growth 12 inches high, now in blossom. Some yellow leaves. Grasshoppers and blister beetles of several species abundant.

Sep. 22, 1894.—Averages 18 inches high. Somewhat injured by grasshoppers. Not very heavy. Some flowers.

Nov. 6, 1894.—Good. Still green and averaging 15 inches high.

Dec. 4, 1894.—Frosted.

March 6, 1895.—Green leaflets show at bases of old brown stalks. Has wintered well.

March 30, 1895.—A bright green growth coming up rapidly.

April 29, 1895.—A fine growth 14 inches high.

May 24, 1895.—Good. Averaging 18 inches high. A very few flowers.

June 27, 1895.—Cut the alfalfa of this plot. Weight, fresh, 37½ pounds, which is at the rate of 1.50 ton per acre.

July 25, 1895.—A good growth about 10 inches high. Some flowers.

Sept. 17, 1895.—This has not been cut a second time. Not very rank. Leaves badly eaten by grasshoppers. About 15 inches high.

March 26, 1896.—Good. A fresh growth beginning to appear.

April 17, 1896.—Growing finely. 6 inches high.

April 27, 1896.—A good growth a foot high.

July 6, 1896.—Now about 25 inches high; still flowering. Not as heavy as it has sometimes been.

July 28, 1896.—Some flowers yet; violet in color. Pods ripe, brown, with 2½ to 3 whorls, and terminating in a filament; somewhat like the spiral of a post-hole auger. Leaflets pale bluish green, gray (glaucus) beneath. Stems green, but tough when old.

July 28, 1896.—2½ feet high. Some flowers yet. Weeds among it, but holds its own fairly well.

May 23, 1899.—Average height 24 inches. Still occupies much of the plot, and is in good condition. Some flowers.

Aug. 23, 1899.—2½ feet high. Some flowers.

Turkestan or Samarcand alfalfa. It has been claimed that this variety of the plant is rather better than that commonly grown. In the plots I have been unable to perceive any great difference. The plants from seed imported by the United States Department of Agriculture do not differ from those obtained from ordinary bought seed sufficiently to constitute them separate varieties. A plot was started May 21, 1898, using seed at the rate of 30 pounds to the acre. It was not cut the first season. The following notes relate to it:

Aug. 2, 1898.—A fair stand 6 inches high. Some flowers. Not a thrifty growth.

May 23, 1899.—This plot started last year from seed furnished by the United States Department of Agriculture is now

in excellent condition, averaging about 16 inches high, and densely covering the ground with a fine green growth, among which some purple flowers can be seen. Can see no difference between it and other alfalfa.

Aug. 23, 1899.—This plot now in excellent condition, some in blossom. All fresh and green and about 18 inches high.

This plot was made a part of the paddock referred to above as including the common alfalfa, and was treated by the hogs the same way, the whole surface of the plot being stirred up.

A second plot of Turkestan alfalfa was planted in the spring of 1900 on better land than that on which the old plots were situated, and in 1901 it was cut as many times as possible. As is usual with alfalfa, it did not grow thriftily during 1900, and in late summer looked exceedingly unpromising. In 1901 it had obtained a good hold on the soil and looked very much better. The yield is given below. Single cuttings are much better than could have been secured from either common or Turkestan alfalfa in the old plots, which goes to show that to do well alfalfa must have good soil.

1st Cutting, June 8, 1901: Weight, fresh, 184 lbs.; weight, dry, 48 lbs., being at the rate per acre of 7.36 tons, fresh, and 1.92 ton, dry.

2d Cutting, July 11: Weight, fresh, 56 lbs.; weight, dry, 29 lbs., being at the rate of 2.24 tons, fresh, and 1.16 ton, dry, per acre.

3d Cutting, Aug. 24: Weight, fresh, 113 lbs.; weight, dry, 41 lbs., being at the rate of 4.52 tons, fresh, and 1.64 ton, dry, per acre.

4th Cutting, Oct. 17: Weight, fresh, 45 lbs.; weight, dry, 22 lbs., being at the rate of 1.8 ton, fresh, and 0.88 ton dry, per acre.

The total yield for the plot during the season was thus 398 pounds, fresh, and 140 pounds, dry, which is at the rate of 15.92 tons of green forage and 5.60 tons of hay per acre. The third cutting contained a good deal of crab grass (*Panicum sanguinale*) which had sprung up in the plot. Ordinarily no fourth cutting would be taken, since it is desirable to leave some growth as a protection to the plants during the winter, but it

was removed to determine just what could be obtained by close cutting during a season.

An average of numerous analyses prepared by Professors Jenkins and Winton is as follows:

Water, 71.75.
Ash, 2.66.
Protein, 4.84.
Fiber, 7.39.
Nitrogen free extract, 12.39.
Fat, 0.97.

Melilotus alba (WHITE MELILOT, SWEET CLOVER, BOKHARA CLOVER).—This plant is often seen in Kentucky growing along roadsides. It is not cultivated, though I believe it is sometimes planted for bee pasture. From the rankness of its growth it is calculated to furnish a large amount of fodder, but animals do not relish it. When old, the stems become very tough. It is biennial, or sometimes annual, with us.

In our plots the dropped seeds germinated and produced a fine growth in the latter part of March. In July of the second season the plants often reached a height of 6 feet. Under date July 14, 1900, Col. W. H. Polk, of Lexington, sent me a portion of a plant of which he wrote: "I enclose a piece of plant from a bush 8 feet high that is a *persistent* grower in waste places about the city. I notice the foliage somewhat resembles that of the pea, but the bush gets more woody as it attains maturity. When young it looks like good forage. A mountain man tells me it will grow in the poorest soils, and that it is called 'mountain clover.' I notice the bees are fond of it, and as it is such a heavy cropper and so easy to grow, I think it would likely make a good bee pasturage. For stock, when young and tender, it appears to me would be good forage, but not so nutritious when full grown, on account of the woodiness of stalk and branches. Would it not, if cut when tender, make a good silage." Notes on the plant as it grew in our plot follow:

May 13, 1893.—A splendid growth nearly 2 feet high. Very dense.

June 13, 1893.—A uniform and thick growth just beginning

to flower. Some stalks reaching a height of 5 feet, 4½ inches. Average about 5 feet. Stems as much as 0.46 inch in diameter; smooth, cylindrical, with lateral branches beginning 1 to 1½ foot from the ground, these 5 to 10 inches long and bearing succulent leaflets, 1½ inch long. A strong-growing plant calculated to furnish a large quantity of forage.

June 20, 1893.—A leaf hopper (*Empoa albopicta*) very abundant, also a beetle (*Chauliognathus marginatus*). A few bees and flies.

July 19, 1893.—This now six feet high in many cases. The tips still in flower. Stalks rather hard and tough. Some of seeds ripe.

Aug. 8, 1893.—Very tall, coarse and dry. Tips of branches still with flowers.

June 22, 1894.—A pretty regular growth of this, now 12 to 14 inches high. [From dropped seed.]

July 26, 1894.—This looks well, is uniformly green, but has no flowers. Now about 18 inches high. Insects about it: Red-legged grasshopper (*Pezotettix femur-rubrum*), leaf-hoppers (*Empoa albopicta*), tarnished plant-bug (*Lygus pratensis*).

Aug. 9, 1894.—Insects about this plant: Tree crickets (Oecanthus sp.), red-legged grasshopper (*Pezotettix femur-rubrum*), leaf-hoppers (*Empoa albopicta*), spotted cucumber-bug (*Diabrotica 12-punctata*).

Aug 23, 1894.—Good; no flowers.

Sep. 22, 1894.—A fine growth, much of it in the neighborhood of 2 feet high. Has grown since late rains.

Nov. 6, 1894.—Good.

Dec. 4, 1894.—Frosted.

March 6, 1895.—Entirely dead above ground.

March 30, 1895.—New growth appearing.

April 29, 1895.—A fine growth 18 inches high.

May 24, 1895.—A fine growth 38 inches high. No flowers. Leaf-roller (*Lozotænia rosaceana*) observed about it.

June 29, 1895.—Tallest stalks 79 inches high. Average height 60 inches. Stalks ½ inch in diameter at base. Branches 12 to 18 inches long begin about one foot from ground. The

white flower clusters at extremities 3 to 5 inches long, maturing from below upward, hence lower show ripe seed pods, while terminal are in bud, and intermediate fully expanded. Flowers now attracting many flies, small Hymenoptera (bees and wasps); also some white butterflies (*Pieris protodice*).

June 25, 1895.—Still flowering. Stems tough. Visited by honey bees, June bugs (*Allorhina nitida*), etc.

Sep. 17, 1895.—Most of the plants now brown and dried out.

March 26, 1896.—Perfectly brown.

April 25, 1896.—Raked off old growth to-day. Young plants [from seeds] appearing.

July 6, 1896.—A good, young growth from seed covers plot closely. No flowers. About 1 foot high.

July 28, 1896.—No flowers. Averages 20 inches high. A fine succulent growth.

While this plant is not commonly relished by animals in this section, it is reported as being eaten readily by stock in Mississippi and other southern states. Of course only feeding tests can decide to what extent the nutriment it contains is appropriated. Chemical analyses show it to compare very favorably with forage commonly employed in Kentucky. The following percentages are from analyses of white melilot at various stages of growth made at different Experiment Stations, and compiled in a bulletin published by the Central Office of Experiment Stations:

Water, 69.20 to 80.55.
Ash, 1.27 to 2.36.
Protein, 2.45 to 4.15.
Fiber, 3.62 to 13.12.
Nitrogen free extract, 7.22 to 16.11.
Fat, 0.44 to 1.13.

Mililotus officinalis (YELLOW MELILOT).—Similar to the preceding, but less tall and with yellow flowers. Frequent along roadsides. Not cultivated for any purpose as far as observed.

Meibomia bracteosa (TICK-TREFOIL).—Kentucky (Miss S. F. Price).

Meibomia dillenii (TICK-TREFOIL).—A specimen in the Station collection was collected by Mr. G. M. Sullivan Aug. 24, 1899, in Jackson County.

Meibomia glabella (TICK-TREFOIL).—Lexington, Aug. 8, 1892.

Meibomia grandiflora (TICK-TREFOIL).—Kentucky River, Elk Lick Falls and Tyrone.

Meibomia lævigata (TICK-TREFOIL).—Kentucky (Kearney).

Meibomia marylandica (TICK-TREFOIL).—Kentucky (Kearney).

Meibomia michauxii (TICK-TREFOIL).—Jackson County, Aug. 24, 1889 (G. M. Sullivan); Corbin, July 14, 1892.

Meibomia nudiflora (TICK-TREFOIL).—Lawrence County, Aug. 16, 1894 (Professor A. R. Crandall); Cumberland Falls, July 14, 1892 (Professor C. W. Mathews).

Meibomia paniculata (TICK-TREFOIL).—Kentucky (Kearney).

Meibomia pauciflora (TICK-TREFOIL).—Henderson, July 28, 1892.

Meibomia rigida (TICK-TREFOIL).—Dix River, Sep., 1887, (Evans).

Meibomia sessilifolia (TICK-TREFOIL).—Kentucky (Asa Gray).

Meibomia tortuosa (FLORIDA BEGGAR-WEED).—A native of Florida and other Gulf states. It is an upright annual, growing in our plots and in the Vivarium to a height of from 3½ to 4 feet, but along the Gulf reaching a height of 10 feet at times. When young it bears a profusion of broad leaves and is at its best for forage. Later the stems become woody. In September the terminal branches bear numerous slender, jointed, and frequently twisted pods which like those of other members of the same genus, break apart readily. It produces a large amount of forage farther south, and is claimed to be a better green fertilizer than cowpeas.

Meibomia viridiflora (TICK-TREFOIL).—Kentucky (Kearney).

Mucuna utilis (VELVET BEAN).—We have had few forage plants on the Experiment Farm that make such a rampant growth as this. It covers the ground thickly, spreads beyond the boundaries of the plots, carpeting all adjacent paths, then if furnished with a trellis climbs up this to the extremity and launches into the air, and when by its weight brought back to the support, the new terminal growth wraps itself again and again about the old, forming a confused and tangled mass of leaf and vine, the like of which is produced by no other forage plant grown by us. But its very rankness of growth makes it a somewhat unmanagable plant.

It does not ripen its seeds at Lexington, and I have never heard of its doing so elsewhere in the State. In 1900 it produced its singular long purple flowers early in October, when the pods began to develop very rapidly and in large numbers. They appear in clusters in the axils of the leaves. The very young pod at first carries at its extremity the long style of the flower, and becomes darker as it grows, from the presence of a dense coat of erect black hairs, the whole having the effect of plush. In our plot it reached a length of 2½ inches, and a diameter of ½ inch, being rather short and stout, but produced no mature seeds, although not destroyed by frost until October 19, at which date some flowers were still being produced. The ripe seeds are not less remarkable than the plant, flower and pod. They are roundish, about ½ inch in length, the scar with protruding lip, the ground color whitish, mottled with brown, like a bird's egg.

In Florida the fodder is cut several times, and the yield during a season sometimes exceeds four tons of hay per acre. It is claimed that cowpeas will produce about as much fodder, though as seen growing the velvet bean impresses one as much the more productive. The fodder is nutritious, containing about the same per cents. of fat and protein as the cowpea. Very decided improvement in soil has been secured in southern states by plowing under the velvet bean stubble.

Onobrychis sativa (ESPARSETTE, SAINFOIN).—This has been highly recommended as forage in hilly and rather sterile sections. It is a perennial, and a good bee plant. Seeds planted

in 1900 in a plot did not germinate, probably because they were old. They are quoted in a 1901 seed list before me at $9.00 per 100 pounds.

Ornithopus sativus (SERRADELLA).—A slight, low-growing annual, introduced from Europe. It is said to be partial to sandy soil. It produces with us only a small amount of forage, and has proved rather difficult to grow, suffering especially from dry weather. We have soils in the State containing some sand in which it might do better. In the plots, where it has been grown several seasons, it produced tufts 6 inches high and about 8 inches in diameter of soft herbage of a grayish green color. The flowers began to appear about the middle of June and continued until November.

Pisum arvense (CANADA FIELD PEA).—This is highly recommended for planting at the north, but does not do well here owing to the heat of summer. On May 18, 1898, a plot of the "Russian field pea" and another of the "Rostow sugar pea" were planted. They started evry well, but were soon suffering from mildew, and by the first of August the sugar peas began to wither without having produced good pods, those developed containing only one or two seeds. The Russian field pea is later, being in flower about the first of August, a peculiarity that renders it unsuitable for this climate, since our most trying season for shallow rooting annuals such as these, comes in late summer when they should be growing most rapidly.

It is doubtful if these field peas will prove valuable here. Seed has sometimes been sold under the name "stock pea." As this name is commonly applied in Kentucky to the cowpea, farmers have sometimes bought the northern pea supposing they were getting the cowpea, and the result was disappointment. In one instance known to me a buyer who made this mistake took the matter into court and won his case. The seeds of the Canada field pea are nearly spherical, but without the decided indentations commonly present on garden peas, and are of a uniform yellowish white color, without markings. The cowpea or stockpea, on the other hand, is a true bean, and shows it in the general shape of the seed, which is somewhat

flattened and elongate, while the colors may be red, black, mottled, white with a black eye, or, in a few varieties, such as the "white table" and the "lady," are white and unmarked. The foliage of the field pea again is much like that of the common garden pea, while that of the stock or cowpea is plainly that of a bean.

Phaseolus polystachyus (WILD BEAN).—Kentucky (Short and Peter).

Psoralea onobrychis.—Kentucky (Britton and Brown).

Psoralea pedunculata.—Jackson County, June 25, 1889 (G. M. Sullivan); Corbin, June 19, 1892.

Psoralea stipulata.—Kentucky (Gray).

Robinia pseudacacia (BLACK LOCUST).—A well-known tree, to be found throughout the State about dwellings, and sometimes encountered among natural growths. In flower about May 18.

Rhynchosia erecta.—Kentucky (Miss Price).

Rhynchosia tomentosa (TWINING RHYNCHOSIA).

Strophostyles helvola (TRAILING WILD BEAN).—Lexington, Ky., Sept. 24, 1901, (Miss Mary L. Didlake).

Strophostyles pauciflora (SMALL-FLOWERED WILD BEAN).—Clinton, Ky., July 29, 1901.

Strophostyles umbellata (PINK WILD BEAN).—Fulton, Ky., Aug. 11, 1892; Lexington, Aug. 26, 1892.

Stylosanthus biflora (PENCIL FLOWER).—Corbin, June 19, 1892; Lawrence Co., Aug. 16, 1894 (A. R. Crandall); Jackson Co., June 15, 1889 (G. M. Sullivan).

Trifolium alexandrinum (EGYPTIAN CLOVER).—This has been tried but once at the Station. A moderately good growth was secured, resembling alfalfa in some ways. June 29 the height was about 12 inches. The flower clusters are white and small, like those of white clover, the corollas at length disappearing, leaving the developed seeds in a compact head about ¾ inch long. Mr. D. G. Fairchild, of the U. S. Department of Agriculture, says it is the important forage crop of Egypt. One variety is employed for sowing on mud, immediately after the subsidence of an overflow of the Nile River. Might it not be so used by our farmers on bottom-

lands along the Ohio and Mississippi Rivers? It is possible that the clover will some time find a place in the agriculture of this country. It is an annual.

Trifolium arvense (RABBIT-FOOT CLOVER).—In several counties west of Louisville this little annual has been found to be common on rather poor soils. It was observed to be abundant June 25, 1896, on the banks of Nolin River at Dickey's Mills in Edmonson and Grayson Counties. It has since been collected at Big Clifty in Grayson County, and last summer was found to be very common along roadsides at Vine Grove in Hardin County. It is a slight plant of upright growth, measuring in preserved specimens from 10 to 12 inches high, the flowers forming finally an elongate woolly head, which has given the species the name "pussy clover." It was introduced originally from Europe, but is thoroughly at home here. Probably of no agricultural value.

Trifolium hybridum (ALSIKE CLOVER, ALSATIAN CLOVER).—Alsike clover looks like a hybrid between red and common white clover. It is intermediate in size, its flower clusters rather larger than those of white clover and with more purple, the leafage more like that of white than red clover. It is adapted to wet situations, where it will produce a very good yield of nutritious forage. On our drier soils in Blue-grass Kentucky it is likely to be affected by dry weather in late summer, from which it suffers more than red clover. Because of this weakness it has not lasted well in our plots. A plot in the spring of 1892 was in very good condition in June of 1893 when ready to cut. The average height was 1 foot, 6 inches; the flower heads about ¾ inch long and ¾ inch in diameter, the central flowers white with a pink tinge, the outer of a decided rose color, but at length turning brown. Stems 0.10 inch in diameter. Leaflets about one inch long.

When cut it sent up a fresh growth, but with the advent of dry weather ceased to grow, though showing signs of life until January, 1894. In June of 1894 no trace of it was left in the plot. In the spring of 1895 the plot was replanted, with the same result, the plants having disappeared in the spring of the following year. A plot planted on better land April

14, 1900, showed a fair stand on April 20. June 29, it was noted as 8 inches high and looking well in the main, but with the tips of leaflets reddish as if from the effect of the sun. It was not cut. In 1901 it was in full bloom May 31, and averaged 16 inches high. It was cut June 18, yielding at the rate of four tons of green fodder and 1.44 ton of hay. This yield is less than the clover is capable of, since the stand was not a perfect one, only about ¾ of the surface being fully occupied.

The plant is a native of Europe, North Africa, and parts of Asia, where it is a perennial. Thus far it has proved with us little more than an annual, though a different report might have to be made if it were grown in soil that kept its moisture better than ours.

Trifolium incarnatum (CRIMSON CLOVER, ITALIAN CLOVER). With good seed, planted at the proper time, this clover has done well in the plots. It has value for this region, as a catch crop both for fodder and for improving land. Planted in August, it may be cut by May 20 of the following season, giving a crop of good hay and furnishing a valuable stubble to be turned under for the use of some hot weather crop, such as corn. I have several times tried sowing it in the spring, but it has failed invariably. Two plantings noted below illustrate our experience.

A plot planted April 14, 1900, was up by April 20, only a fair stand, however. By June 29 it was about 10 inches high, but looked feeble, and from this time began to decline with a very scant production of imperfect flower clusters.

Another plot planted August 25, 1900, gave a good stand of young plants by August 31. These were in full bloom and should have been cut May 20, when the plot presented a beautiful sight. Cut June 7, the plot yielded 174 pounds of fresh fodder (6.96 tons per acre,) and 52 pounds of hay (2.8 tons per acre).

Unlike common red clover this annual is very attractive to honey bees, and they are always very busy about our plots when the clover is in flower.

In the matter of nutritiousness it is quite the equal of red

clover, but it is necessary to cut it for hay as soon as the flowers expand, for the reason that as the seeds develop the heads become dry and hairy, and are accused of causing digestive troubles. "Hair balls" are sometimes thought to result from eating hay from over-ripe plants.

The soil should be well prepared for the seed, and the sowing may be either broadcast or in drills, followed by the use of a drag or roller. About 15 pounds of seed per acre may be used.

Trifolium medium (MAMMOTH CLOVER).—A near relative of common red clover, which it greatly resembles. It is a coarser plant, makes a greater amount of forage, and is somewhat later. Common red clover seed is often sold by dealers under this name; the result is that one sometimes encounters people who think they know this clover, but who have never seen it. It should be planted like red clover, but because of its rank growth a little less seed can be used. In our plots it averaged 8 inches in height by the middle of May, and is ready to cut from the 15th to the 20th of June. A plot grown in 1893 is referred to in the following record, made June 13:

A very rank growth here. Taller and coarser than on No. 34 [common red clover]. Very few heads. Those present so nearly like those of red clover in size and color it would be hard to find a difference. Average height of this clover 2 ft., 4 inches. Looks like splendid forage. Has the appearance of being more succulent and tender than red clover. Stems hairy, at base nearly ¼ inch in diameter. Leaflets 2 to 2½ inches long.

It lasts about as well as red clover, and is of about the same nutritive value, although farmers sometimes claim that the hay is not quite as good as that made from common red clover. It is better adapted to wet land than the common species.

Trifolium pratense (RED CLOVER).—We have few forage plants to which farmers are more attached than to this. For hay, for pasture, for renewing exhausted land, he has so long depended on it that it is with great reluctance he turns his attention to less familiar plants. Red clover still does very well

in this part of Kentucky, and we have never failed to get a stand in plots on the Experiment Farm. But complaints are becoming frequent that red clover does not do as well as formerly. Such complaints come most often from farmers residing in the western half of the State. No satisfactory explanation is offered by the farmers themselves, though the suggestion is sometimes made that insects have to do with it.

We have in the State many of the clover insects known to occur in the eastern United States, but none of these seem to be at the bottom of the trouble. Nor is it, apparently, the work of parasitic fungi. Certain of our soils appear to be clover sick, and I would suggest the use of moderate applications of lime in sections where the per cent. normally in the soil is low. I referred to this matter at a Farmers' Institute held at Lebanon some months ago, and my remarks will be found on pages 508 to 510 of th 14th Biennial Report of the State Bureau of Agriculture, recently issued.

In some of the field work of this Station, Director Scovell found that a deficiency of potash in some soils led to a failure of clover, and that when muriate of potash (160 lbs. per acre) was applied, clover grew well. In an article written by him for the Farmers Home Journal and published in the issue of April 7, 1900, he suggests that the Station will co-operate with farmers in experiments made to test applications of potash for restoring clover sick soils.

In most of our blue-grass sections the root nodules appear to be normal to clover. It is possible that in some of the poorer soils in the State these nodules may not be present, and that if they could be induced to grow by artificial means clover would be helped. There are several ways of introducing the nodule bacteria into soils.

(1) Soil may be taken from a field of thrifty clover and sown over one in which clover does not grow well. It should be remembered in doing this that the soil used for the purpose must not be allowed to become dry, and should not be exposed for any length of time to sunlight. It can be best introduced while the land is being plowed or harrowed, so that it will be worked in at once.

(2) Soil from a field of clover bearing nodules may be stirred thoroughly into a quantity of water in a barrel, and seed to be planted may then be immersed for a time in the water.

(3) Pure cultures of the nodule organism may be applied to seed just before these are planted. Cultures of the bacteria were tried by us at the Station this season, but owing to the lateness at which they were received no perceptible results could be discerned.

Sowing. The quantity of seed used by farmers varies widely. Some use as little as three pounds per acre; others use as much as fifteen pounds on the same area. Very early spring sowing on wheat or rye land is perhaps the favorite practice. But clover may be, and frequently is, sown successfully in fall, the seeding being followed by a light harrow. The hay is cut when the plants are in full bloom.

Testing clover seed. Clover seed is sometimes mixed with medick, and the two are so closely alike that it is difficult for the farmer to detect the fraud. Weed seeds, such as the narrow-leaved plantain, or buckhorn, are sometimes common in samples offered for sale. The samples submitted to the Station for testing have, however, generally proved well cleaned, and of very good quality. Farmers themselves can easily test seeds for germination. It is only necessary to place a sample between moist cloths and keep these between a couple of plates for a few days. If less than 85 per cent. germinates the seeds are not as good as they should be. Samples sent to the Station for testing sometimes test as high as 90 per cent.

Trifolium procumbens (LOW HOP-CLOVER).—In pastures and along roadsides this slight annual is often seen in Kentucky, where it appears to have been introduced with the seeds of more valuable plants. Cattle eat it, but the product is so insignificant that it can not be said to have an agricultural value. The flowers are pale yellow. It has sometimes been sent to the Station by correspondents under the supposition that it was Japan clover. It is in flower during June and the early part of July.

Trifolium reflexum (BUFFALO CLOVER).—This is a native annual or biennial clover that was credited to the State by Drs. Short and Peter. It differs from the running buffalo clover, also credited to the State, in the stems being slightly downy, in the seed pods containing more than two seeds, and in lacking the running habit. It has been grown by me from seed in the Vivarium of this Station, and made a very attractive growth. It has not often been encountered growing wild in Kentucky. A specimen was sent me from Greenville, Muhlenberg County, June 8, 1897, by Mr. J. W. Barkley. It was observed on the place of Downer and Brother at Guthrie, July 31, 1901. Its transient character will probably prevent its ever becoming of value on the farm.

Trifolium repens (WHITE CLOVER, DUTCH CLOVER).—This is the common pasture and lawn clover of Kentucky, being sown sometimes with blue-grass seeds, but oftener grows spontaneously and without receiving attention. The flowers begin to appear about the middle of May, and by the middle of June the plant is at its best, the height of flower stems being about 10 inches, while the growth of leaves will average 6 inches. It is a valuable honey plant. For pasture it is also good, and animals often eat the young growth in preference to blue-grass. When the growth is very succulent cattle are sometimes made sick by it, and horses are made to "slobber." In moderate quantity, however, it is to be considered a valuable ingredient of pasturage.

Trifolium stoloniferum (RUNNING BUFFALO-CLOVER).—A native perennial, possibly worth trial on the farm. Kentucky (Short and Peter).

Trigonella fænum-græcum (FENUGREEK).—An annual from South Europe and North Africa. It was formerly much used as a medicine for horses, and is still employed for forage. In a plot grown on the Farm in 1900 it stood about 12 inches high June 29, bearing long, slender, tapering pods (5½ inches long in some cases). The central root is very long and tapering, with few lateral branches. The leaves are thick, somewhat like those of the garden plant known as live-for-ever, but smaller and 3-divided, like the clovers. The plants give off a singular

odor, difficult to describe, perhaps as near that given off by the inner bark of slippery elm as anything we have in this country.

Ulex europæus (FURZE, GORSE, WHIN, BROOM).—A prickly, perennial shrub, common on barren hills, etc., in Ireland, Wales, and other parts of Great Britain, where it is valued for forage. Its valuable quality appears to be its capacity to grow on sterile soils. It has been grown in our Vivarium.

Vicia americana (AMERICAN VETCH).—Kentucky (Britton and Brown).

Vicia caroliniana (CAROLINA VETCH).—Filson, Ky., May 8, 1893.

Vicia cracca (TUFTED VETCH).—Kentucky (Gray); Lexington, May 26, 1893.

Vicia sativa (COMMON VETCH).—Accidental in grass plots, Experiment Farm, June 23.

Vicia villosa (RUSSIAN VETCH, HAIRY VETCH).—This is a trailing plant with weak stems and soft gray-green foliage, that has done remarkably well wherever planted on the Farm. It is an annual, but when left to itself sends up a profusion of young plants each year from seeds dropped the preceding summer. It produces large numbers of lobed tubercles on the roots and is thus an active nitrogen gatherer. From its trailing habit it is not an easy plant to cut, and it is probable it will be found better as a catch crop to turn under than for anything else. Its vigorous growth is a pleasure to see when other plants are suffering from unfavorable weather. To keep it from the ground it may be sown with some small grain, such as wheat, oats, or rye. It may be planted either in the spring or fall, using about one bushel of seed to an acre.

Vigna catjang (COWPEA).—During the past eight years cowpeas have risen rapidly in favor with Kentucky farmers. Hundreds of bushels are planted every year, and the demand for seed is still growing. It has been learned that they have a decidedly beneficial effect on soil, furnish a good quality of hay, though requiring special care in curing, make good silage, while the seed makes good feed for most kinds of stock, some varieties furnishing besides a welcome addition to our

table fare. Originally from China or India, the plant has long been known in the southern states, to which from its sensitiveness to cold it will probably always be somewhat closely restricted, though it can be and is to some extent grown at the North as a green fertilizer. The seeds do not germinate and start off well while the soil is cold, and better crops are always secured by delaying planting until unbroken warm weather arrives.

Practice in this State varies a good deal in regard to manner of sowing. If for hay and "turning under" the seeds are generally sown broadcast, covering with a harrow. But some farmers prefer to sow with a wheat drill without stopping any of the holes. For seed, some sort of drill is generally used, the rows being thirty inches or more apart, so that the plants can be cultivated a couple of times. From about three pecks to a bushel and a half of seed per acre are sown.

The plant will grow in most soils, clay, sand or loam, and has a special value for poor soils, in a rotation with crops of grain.

The variety most often grown in the State is the "whippoorwill." It makes a good quantity of fodder, and a fair crop of seeds, which can be counted on to mature before frosts occur. Next in favor with Kentucky farmers is the "black." It also matures its seeds here. In our plots it has given the better yield of seeds of the two. Seeds of other varieties are sold, but for one reason or another have not proved as popular as these two. Notes on varieties grown in the plots in 1901 follow:

Whippoorwill. Trails moderately. Planted May 3. Many seeds ripe Aug. 10, but still flowering. Pods 7 to 8 inches long; 0.375 inch from front to back; simply curved; 1 to 2 in a place. 16 seeds in a pod; length of seed, 0.36 inch; diameter from scar to back, 0.27 inch; thickness, 0.22 inch; light leather color, varying to decided tan-brown, rather closely speckled with purplish brown. Product of vine, medium. Product of seeds, 5⅓ bushels per acre.

Seed bought of T. W. Wood & Sons, Richmond, Va.

Black. Trails moderately. Planted May 3. Pods all young

and green Aug. 10; numerous blossoms; foliage gray-green. Pods 7 to 8.50 inches long; 0.44 inch from front to back; simply curved; 1 to 2 in a place. 14 seeds in a pod; length of seed, 0.40 inch; diameter from scar to back, 0.30 inch; thickness, 0.25 inch; black. Product of vine good. Product of seeds, 21⅓ bushels per acre.

Seed bought of T. W. Wood & Sons.

Clay. Trails; foliage small. Planted May 3. Very few pods formed Aug. 10. Still growing Aug. 31. Oct. 17 still green where not killed by frost. Few ripe pods. Pods 5 to 7 inches long; 0.37 to 0.50 inch from front to back; 1 to 3 in a place, generally 2. 12 seeds in a pod; length of seed, 0.38; diameter from scar to back, 0.30; thickness, 0.20; light leather color, more or less rust color about scar. Product of vine good. Product of seed 2⅔ bushels per acre. Too late for seed in Blue-grass Kentucky, but could doubtless be grown profitably in the southwestern part of the State.

Seed bought of T. W. Wood & Sons.

Calico. Trails moderately. Foliage gray-green. Planted May 3. Numerous green pods Aug. 10. Some ripe pods Aug. 31. Pods 6 to 7 inches long; with a compound curve; plump; 0.37 inch from front to back. 15 seeds in a pod; length of seed, 0.32 inch; diameter from scar to back, 0.25 inch; thickness, 0.20 inch; color, cream-white, with an extensive area about scar drab, and frequently with scattered dots of this color. Product of vine, medium; of seeds, 10⅔ to 13⅓ bushels per acre. This seems well adapted to this region.

Seed bought of C. S. Brent, Lexington, Ky.

Taylor. Trails moderately. A vigorous grower. Numerous flowers August 10; some small pods. Great numbers of pods August 31, some ripe, foliage rather scant. Pods 8½ to 9 inches long; 0.50 inch in diameter from front to back, 2 pods in a place; 14 to 16 seeds in a pod; length of seed, 0.42 inch; diameter of seed from scar to back, 0.30 inch; thickness of seed, 0.24 inch; of a pale leather color, flecked with dark blue, gray, or black, the scar enclosed with black. Product of vine medium; of seed, 26⅔ bushels per acre. Well adapted to Kentucky. The seeds resemble in a general way those of the

whippoorwill variety, but are larger and the dots are smaller with an evident bluish cast, though ordinarily they would be considered black.

Seed bought of T. W. Wood & Sons.

Extra early black-eye. A bunch cowpea, but with some disposition to trail. Planted May 3. Some pods ripe July 19; some blossoms same date. Pods 5 to 9 inches long; 0.40 inch from front to back; forming a compound curve; frequently contracted and containing imperfect seeds in outer portion; 1 to 3 in a place, generally 2. 14 seeds in a pod; large, elongate, incurved at scar; finely wrinkled crosswise; cream-white, with a large black blotch about scar; length 0.48 inch; diameter from scar to back, 0.32 inch; thickness, 0.26 inch. This is a good table variety, and does well here. Yield of seed, 18⅔ bushels per acre.

Seed bought of T. W. Wood & Sons.

Large black-eye. Trails moderately. Foliage gray-green. Some ripe seeds August 10; some flowers same date. Pods variable, often with tips and space at middle with imperfect seeds; 6 to 9 inches long; 0.37 inch from front to back; 1 to 3 in a place, occasionally as many as 6. 14 perfect seeds in a pod; length of seed, 0.42 inch, diameter from scar to back, 0.28 inch; thickness, 0.24 inch; cream-white, with black blotch about scar; not impressed at scar nor finely wrinkled. Yield of seed, 18 bushels per acre. Not adapted for forage, but a good table variety.

Seed bought of T. W. Wood & Sons.

Red ripper. A trailer, and late. Planted May 3. Some flowers and small pods Aug. 10. Aug. 31, still growing. Oct. 17, still green. Pods short and plump; 4 to 5 inches long; 0.37 inch from front to back. 15 seeds in a pod; crowded, so that ends are blunt; length of seed, 0.26 inch; diameter from scar to back, 0.28 inch; thickness, 0.25 inch; color, a deep shade of red. Product of forage, good; product of seed, 2⅔ bushels per acre. A late variety for this region, possibly better adapted to the western end of the State.

Seed bought of the J. Stechler Seed Company, New Orleans.

Red. Trails moderately. In flower July 22. Some young pods Aug. 10. Pods 8 to 9 inches long; diameter from front to back, 0.44 inch; 2 to 3 in a place; straightish. 17 seeds in a pod; length of seed, 0.36 inch; diameter from scar to back, 0 26 inch; thickness, 0.22 inch; color varying from orange red to a purplish red. Product of seed, 2⅔ bushels per acre. The seeds resemble those of red ripper in general color, but are flatter and not blunt at the ends, while the pods are much larger and entirely different in appearance. It is a little too late for this region, judging by one rather unfavorable season with it.

Seed bought of C. S. Brent, Lexington, Ky.

Wonderful or Unknown. A great trailer. Planted May 3. Aug. 10, no flowers yet, but a large growth of vines. Aug. 31, a few flowers, the vines still growing. Oct. 17, still green, where not injured by frost. Pods 7 to 8 inches long; 0.50 inch from front to back; one pod in a place, sometimes two. 17 seeds in a pod; length, 0.38 inch; diameter from scar to back, 0.28 inch; thickness, 0.21 inch; uniform tan-brown. Product in fodder, the best of all the varieties tried. Too late for this region.

Seed bought of T. W. Wood & Sons.

Lady. Trails a little. Slight. Foliage gray-green. Pods small and slender; 5 to 5½ inches long; diameter from front to back, 0.31 inch. 14 perfect seeds in a pod; length of seed, 0.32 inch; diameter from scar to back, 0.20 inch; thickness, 0.18 inch; cream-white, faintly yellow about scar. Very late. No seeds of consequence obtained. Seeds smaller than those of any other variety known to me; elongate, like those of many common beans.

Seed bought of the J. Stechler Seed Company, New Orleans.

Another variety with a round seed is sometimes called by the above name, according to acquaintances who live south. We have in this State a variety with uniform white seeds that is grown for table use. It is known under the name "white crowder" or "white table" cowpea. It has not been grown in the plots.

2. Notes on True Grasses Growing in the Plots in 1900-1901.

By H. GARMAN, Entomologist and Botanist.

Agrostis alba (Red-top).—Plot planted April 13, 1900. Grass cut June 20, 1901: Weight, fresh, 4.80 tons per acre; dry, 3.04 tons per acre.

Agrostis canina (Rhode Island Bent-grass).—Planted April 13, 1900. Cut July 2, 1901: Weight, fresh, 3.68 tons per acre; weight, dry, 1 ton.

Alopecurus pratensis (Meadow Foxtail).—Planted April 12, 1900. Cut May 17, 1901: Weight, fresh, 3.48 tons per acre; weight, dry, 1 ton.

Andropogon sorghum (White Millo Maize).—This is one of the non-saccharine sorghums, adapted for green fodder. Planted May 10, 1901, in hills 3 feet apart each way. August 24, 1901, ten feet high. Blades 32 inches long, 3¾ inches wide. Panicles rather compact, 9½ inches long, and about 1½ inch in diameter. Stems at base ⅞ inch thick. Cut September 6: Weight, fresh, 25.04 tons per acre; weight, dry, 14 tons.

Andropogon sorghum (Yellow Millo Maize).—This is another non-saccharine sorghum adapted for soiling. Planted May 10, 1901, in hills, 3 feet apart each way. August 24, nine feet high. No panicles. Blades 33 inches long, 3¼ inch wide, sometimes reaching a width of 4½ inches. Some stems 1½ inch in diameter at base. Long-bladed to top of stem, and this calculated to produce a heavy yield. Cut September 6: Weight, fresh, 28.16 tons per acre; weight, dry, 14.08 tons per acre.

Anthoxanthum odoratum (Perennial Sweet Vernal Grass).—Planted August 31, 1900. Cut June 18, 1901: Weight, fresh, 2.80 tons per acre; weight, dry, 1.28 ton per acre.

Arrhenatherum elatius (Tall Oats grass).—Planted April 13, 1900. Cut June 19, 1901: Weight, fresh, 6.08 tons per acre; weight, dry, 4.08 tons per acre.

Bromus erectus (Meadow Brome-grass).—Planted April

10, 1900. Cut June 1, 1901: Weight, fresh, 7.28 tons; weight, dry, 2.40 tons.

Bromus inermis (SMOOTH BROME-GRASS).—Planted April 10, 1900. Cut June 17, 1901: Weight, fresh, 7.2 tons per acre; weight, dry, 3.04 tons per acre.

Bromus unioloides (RESCUE GRASS).—Planted April 12, 1900. Cut June 17, 1901: Weight, fresh, 5.84 tons per acre; weight, dry, 2.48 tons per acre.

Dactylis glomerata (ORCHARD GRASS).—Planted April 12, 1900. Cut June 12, 1901: Weight, fresh, 8.4 tons per acre; weight, dry, 3.6 tons per acre.

Euchlæna luxurians (TEOSINTE).—Planted April 30, 1901, in hills, 3 feet apart. Cut September 3: Weight, fresh, 45.44 tons per acre; weight, dry, 14.02 tons per acre. A second plot planted in drills, 3 feet apart, May 10, 1901, was cut September 3: Weight, fresh, 53.6 tons per acre; weight, dry, 15.52 tons per acre.

Festuca ovina (SHEEP'S FESCUE).—Planted April 10, 1900. Cut June 12, 1901: Weight, fresh, 5.44 tons per acre; weight, dry, 2.24 tons per acre.

Festuca elatior (ENGLISH BLUE-GRASS).—Planted April 10, 1900. Cut June 12, 1901: Weight, fresh, 9.28 tons per acre; weight, dry, 3.44 tons per acre.

Lolium italicum (ITALIAN RYE-GRASS).—Planted April 13, 1900. Cut June 19, 1901: Weight, fresh, 3.68 tons per acre; weight, dry, 2.24 tons per acre.

Lolium perenne (PERENNIAL RYE-GRASS).—Planted April 13, 1900. Cut June 8, 1901: Weight, fresh, 6.56 tons; weight, dry, 2.32 tons per acre.

Panicum texanum (TEXAS MILLET). — Planted May 3, 1901. Cut Aug. 24, 1901: Weight, fresh, 17.8 tons; weight, dry, 9.44 tons per acre. The weight of forage from this plot was most surprising.

Pennisetum typhoideum (PEARL MILLET, PENCILLARIA, MAND'S WONDER FORAGE PLANT, ETC.).—This forage plant is being extensively advertised among farmers, chiefly under the name Pencillaria. It was tested on the Experiment Farm for the first time in 1901. It is a tall, coarse annual, with a long

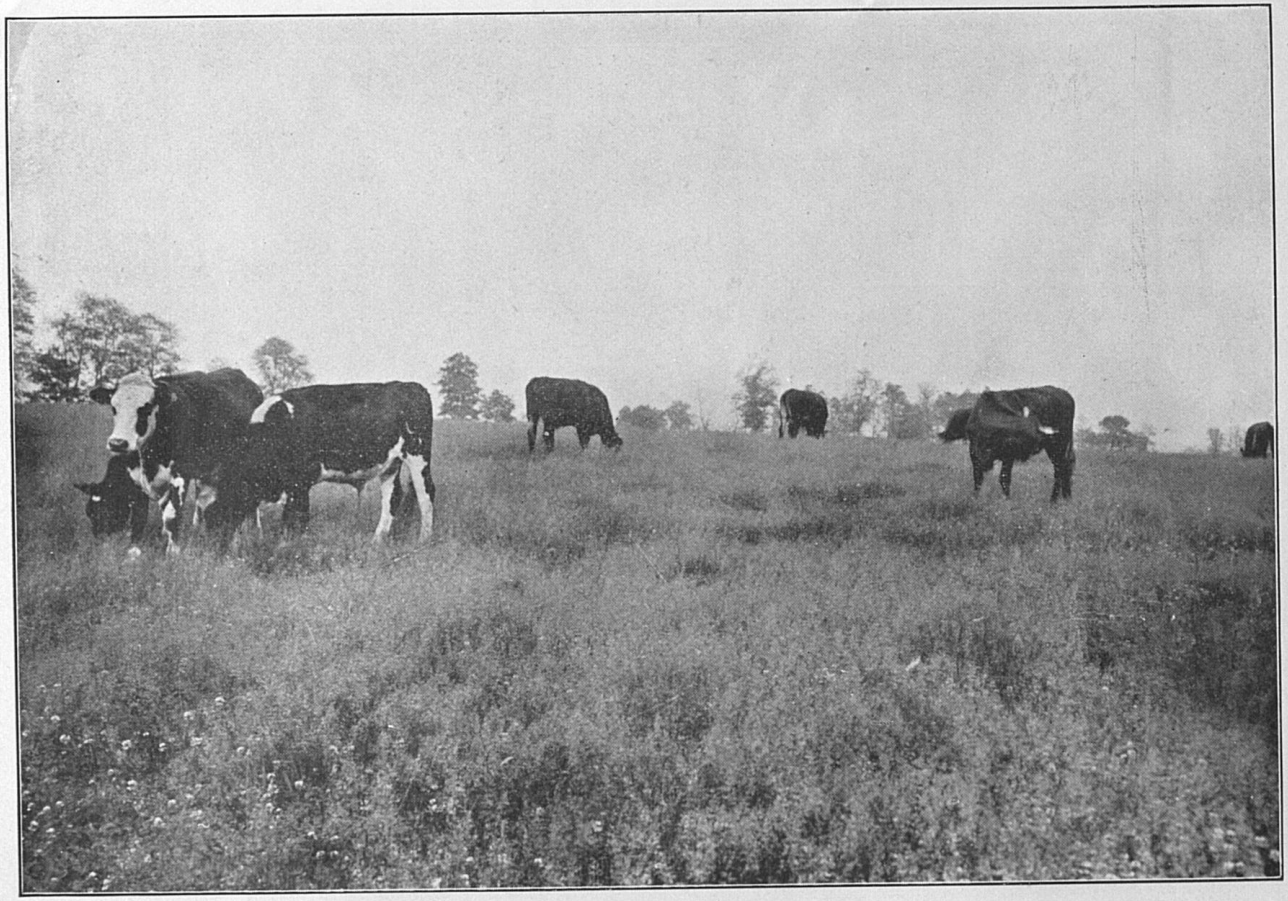

FIG. 1.—White Clover and Blue-grass Pasture, Nicholasville Pike, 3 miles South of Lexington, May 26, 1900. Photographed by H. G.

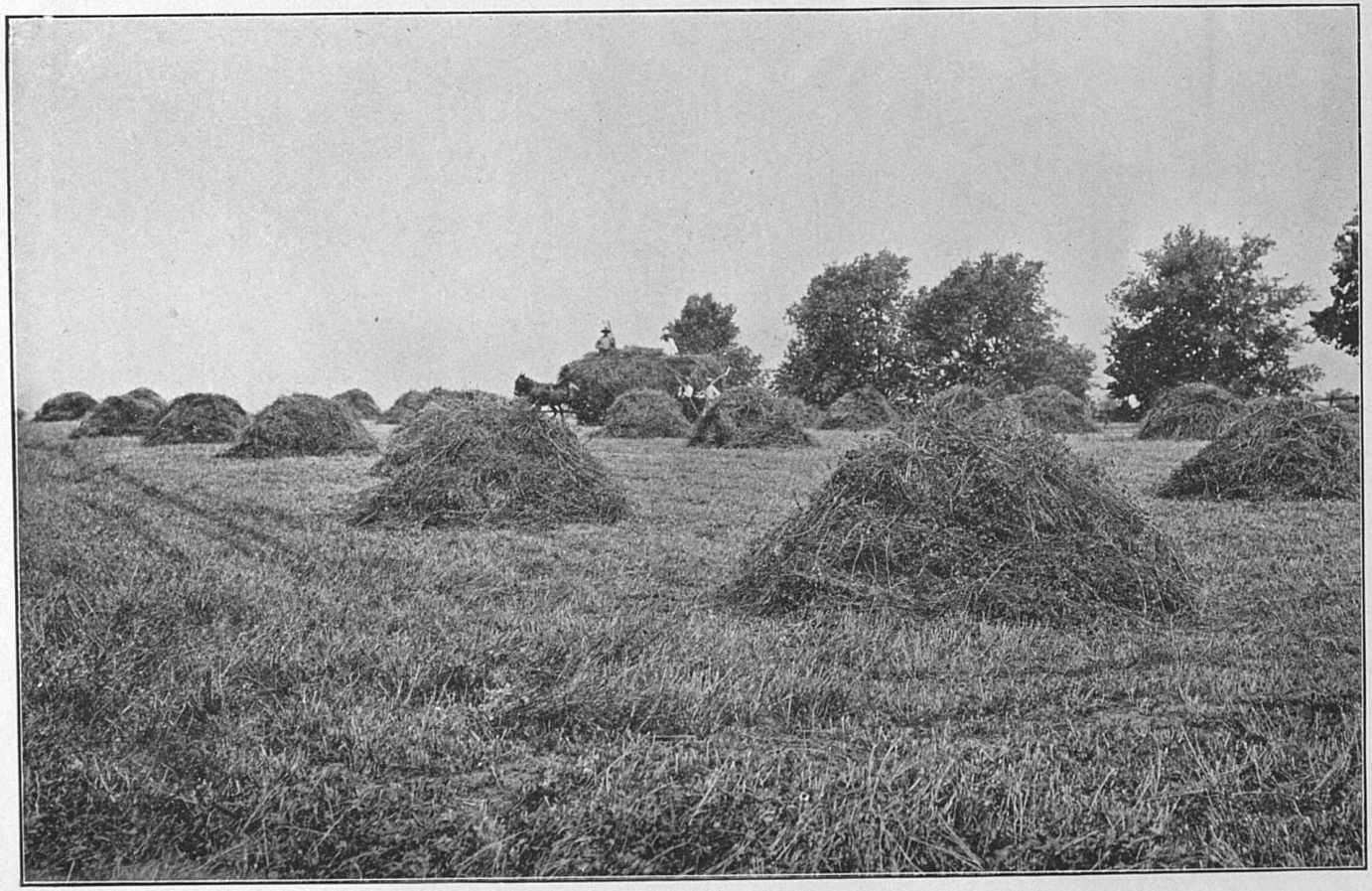

FIG. 2.—Harvesting Red Clover on the Experiment Farm, June 19, 1900. Photographed by H G.

FIG 3.—Crimson Clover from Plot, May 28, 1901. Natural size. Photographed by H.G.

FIG. 4.—Crimson Clover Plot, May 20, 1901. Photographed by H. G.

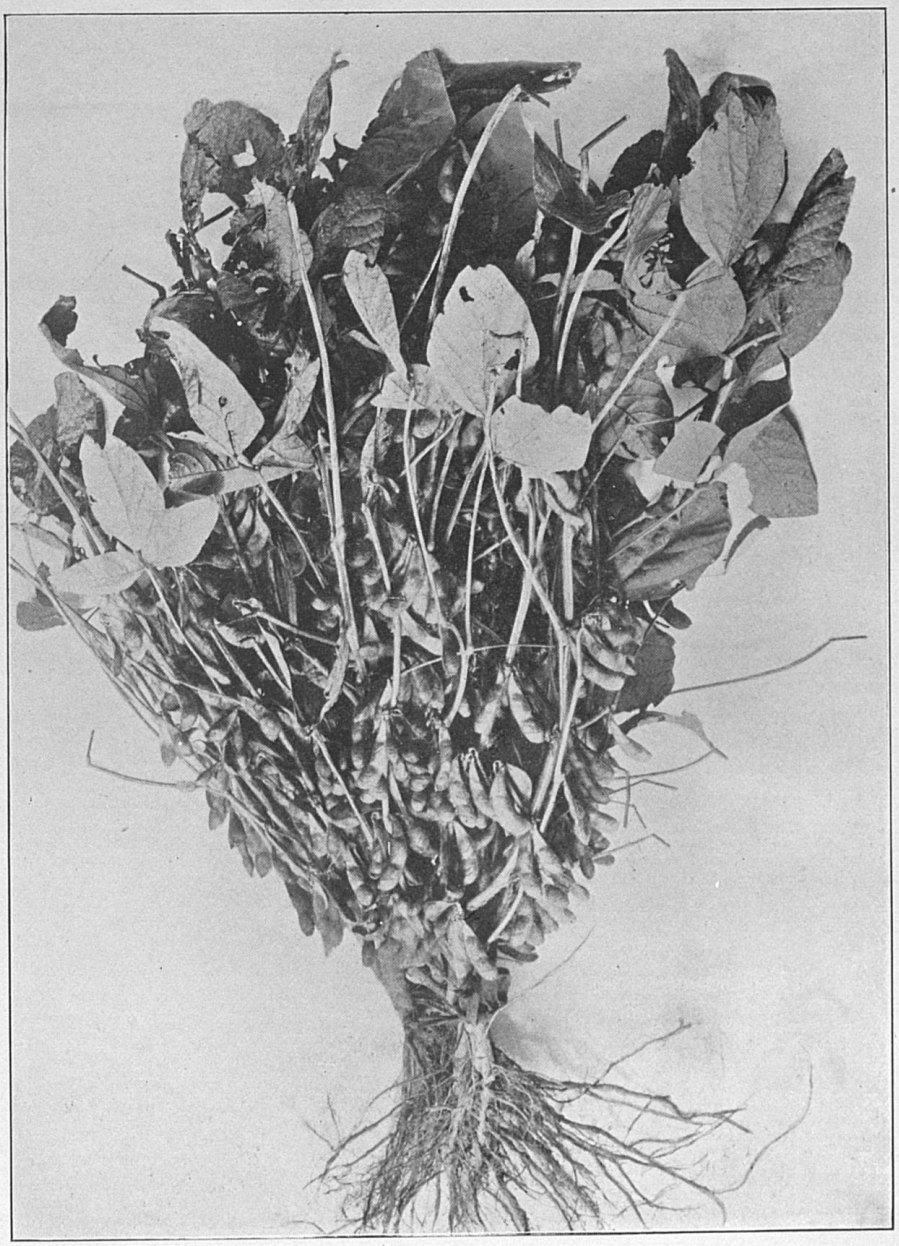

FIG. 5.—Soy Bean Plant from Plot, Aug. 20, 1900. Photographed by H. G.

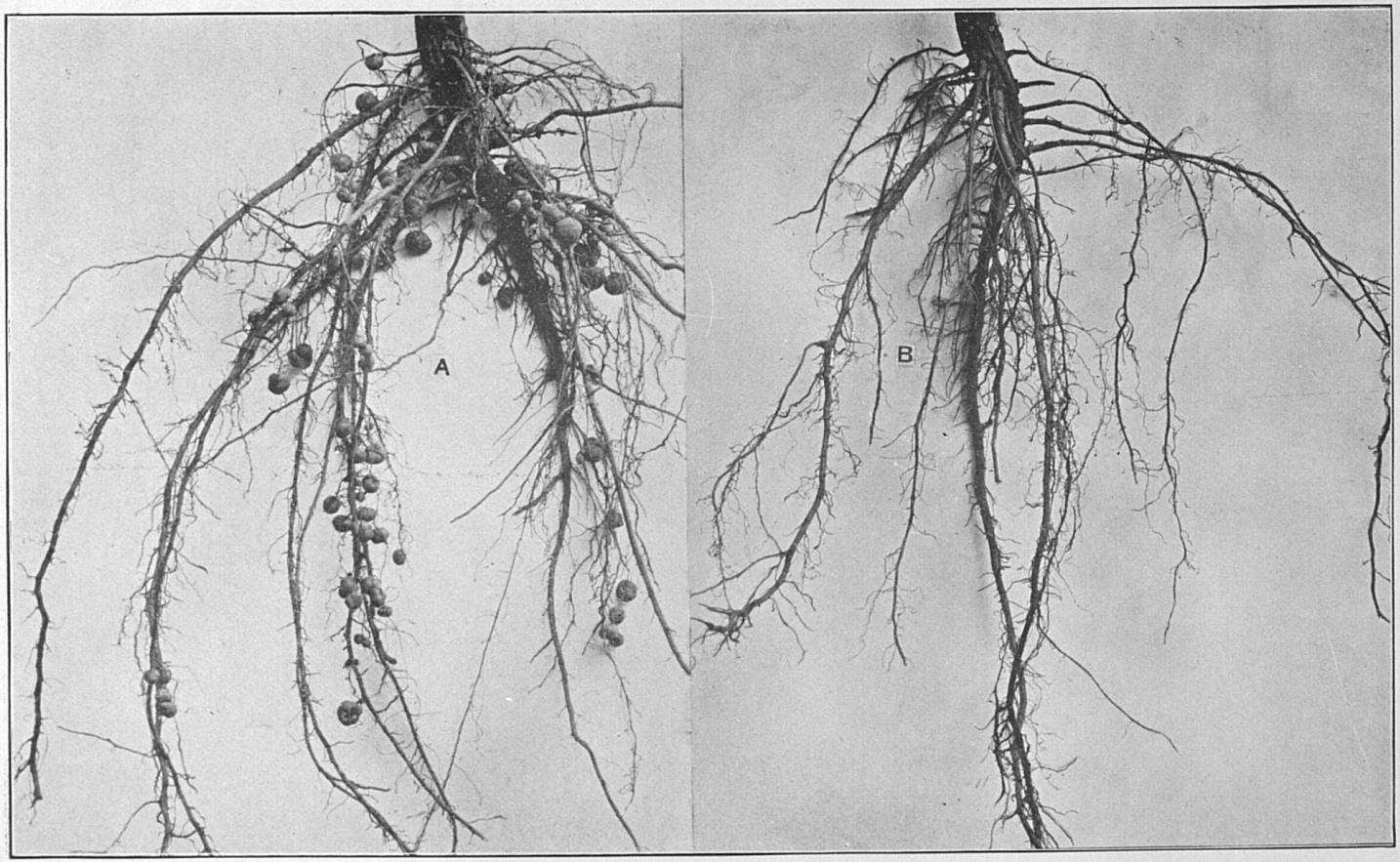

FIG. 6.—Roots of Soy Beans from Plots: A, Seed Treated with Bacterial Culture from Dr Hiltner; B, Seed not Treated. Reduced to one-half natural size. Photographed, Oct. 1, 1901, by H. G.

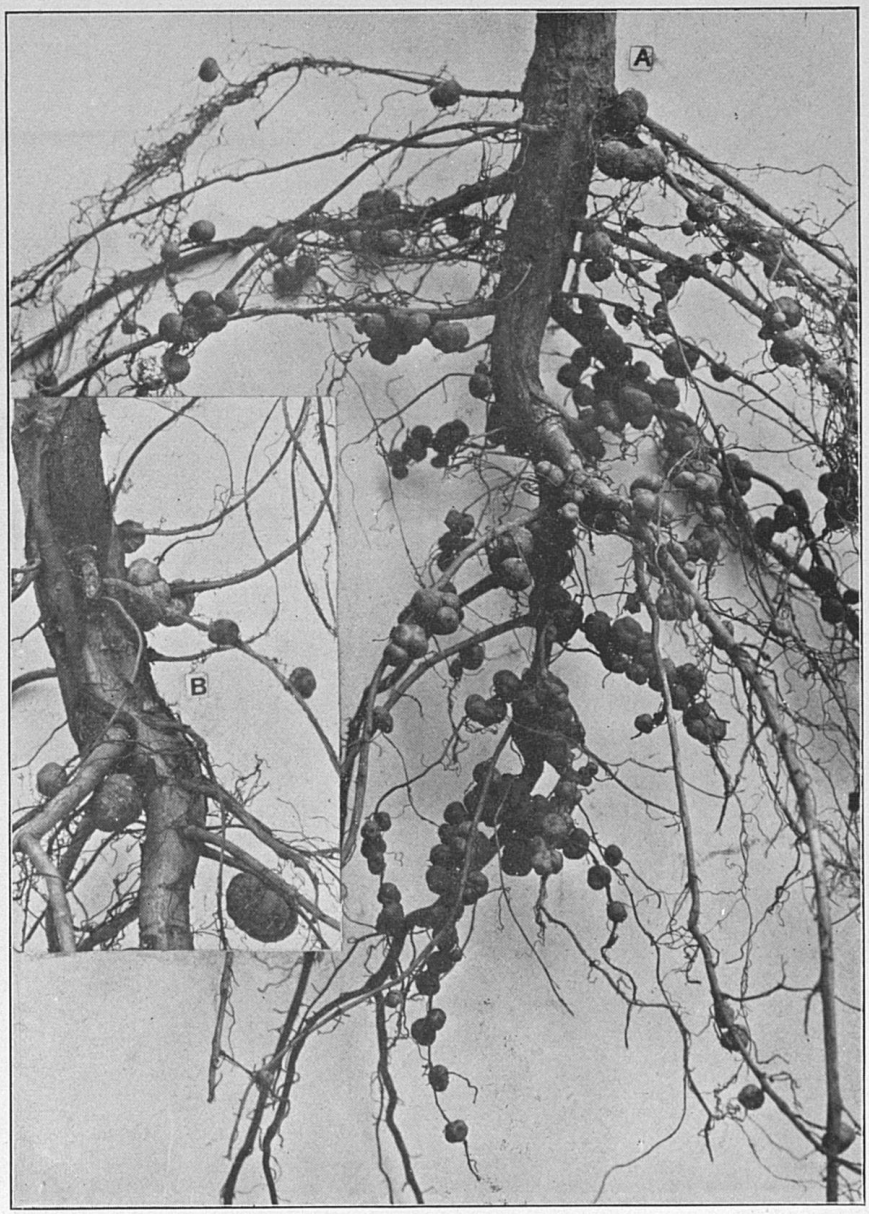

FIG. 7.—Roots of Soy Bean Grown the Second Season on the Same Soil. Both A and B, natural size. Photographed, Sept. 26, 1901, by H. G.

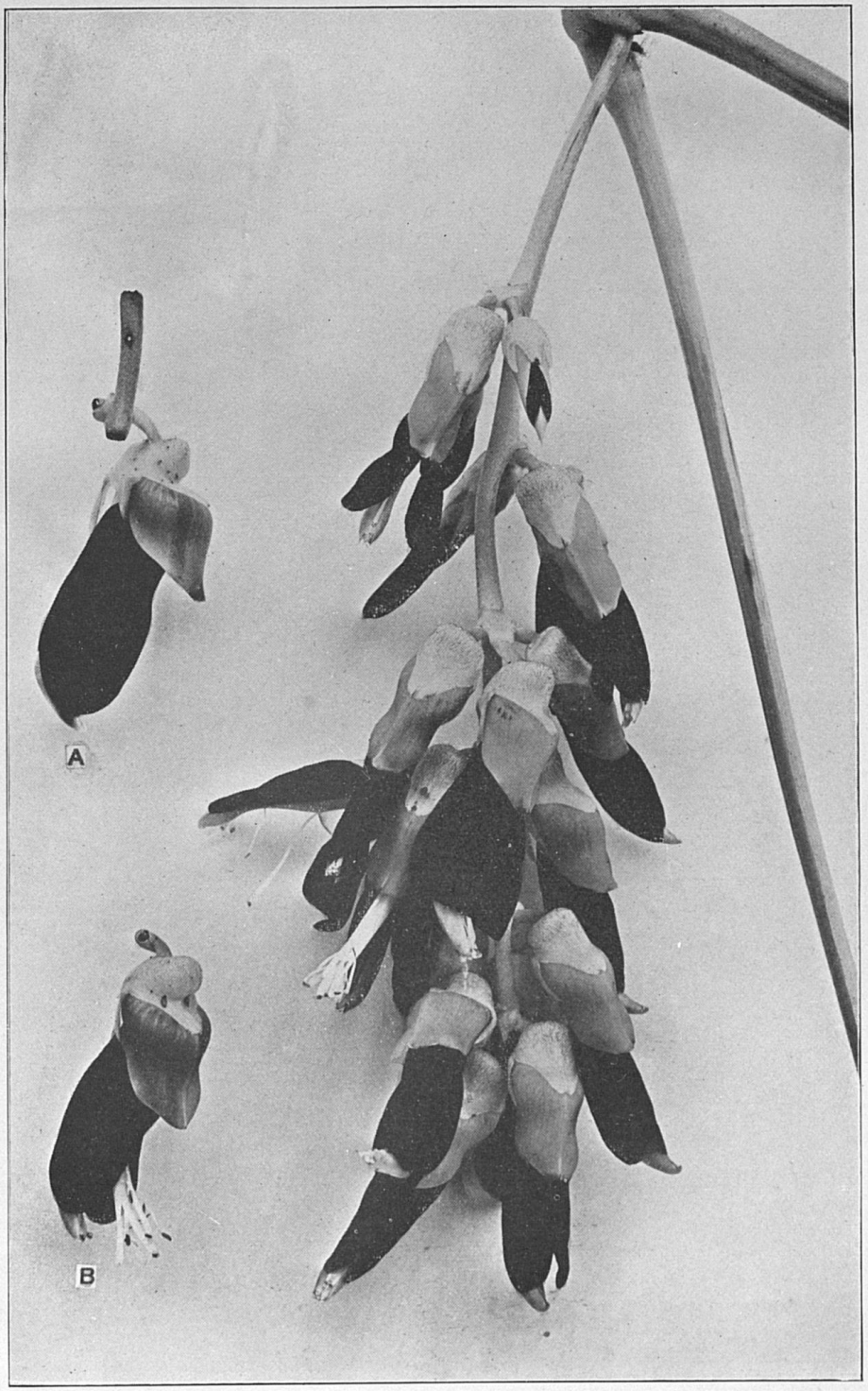

FIG. 8.—Flowers of the Velvet Bean, from Plot, Oct. 5, 1900.
Natural size. Photographed by H. G.

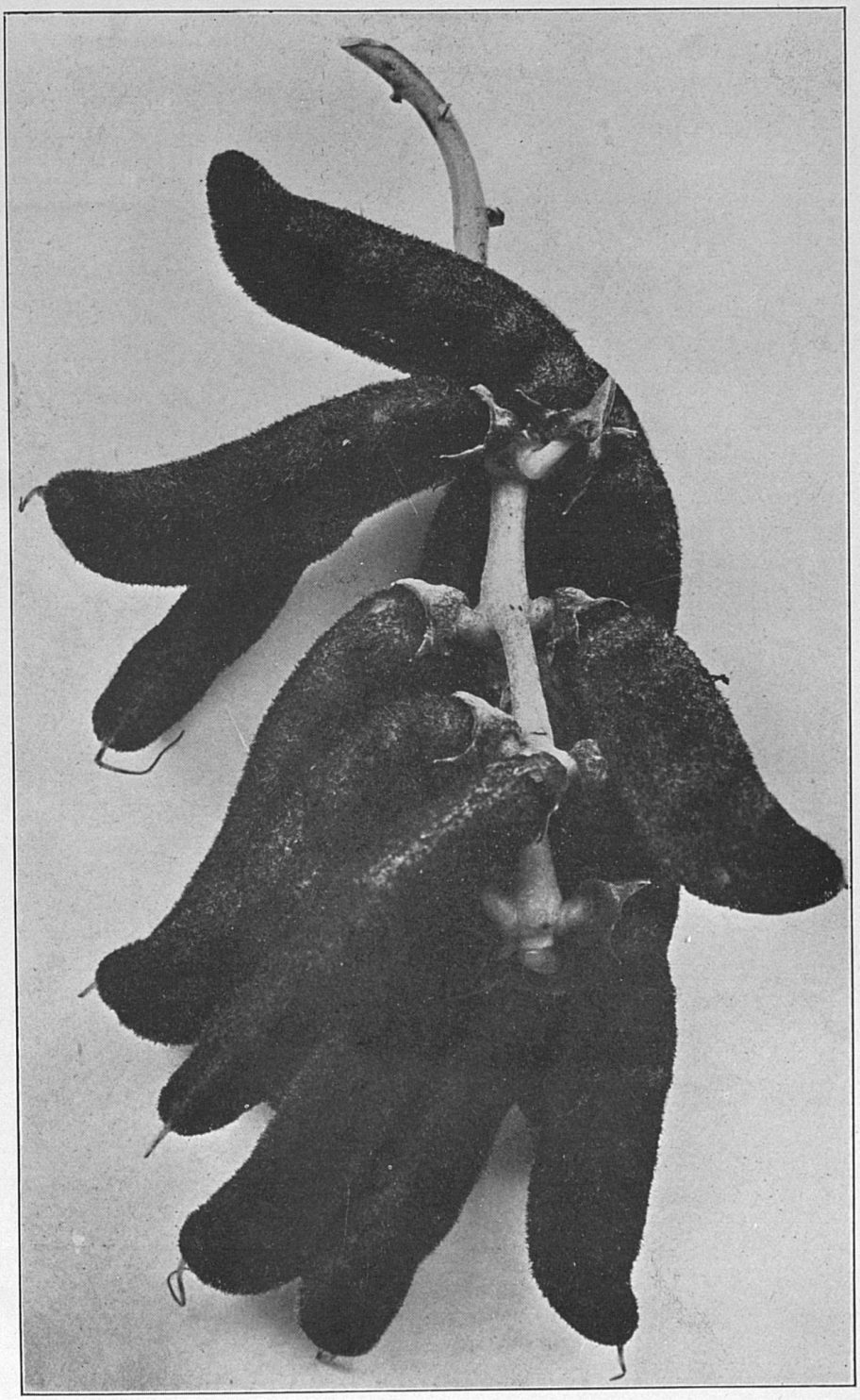

FIG. 9.—Pods of Velvet Bean from Plot, Oct. 5, 1900. Natural size.
Photographed by H. G.

FIG. 10.—Kentucky Blue-grass Ready for the Stripper. Woodland Pasture at Ashland, The Home of Henry Clay, June 4, 1900. Photographed by H. G.

FIG. 11.—A Plot of Teosinte, Aug. 20, 1900 (at A). Burnet at B. Photographed by H. G.

FIG. 12.—A Plot of White Millo Maize, Aug. 24, 1901. (Soy Beans in the foreground.) Photographed by H. G.

FIG. 13 —A Plot of Yellow Millo Maize, Aug. 24, 1901. (Soy Bean in the foreground.) Photographed by H. G.

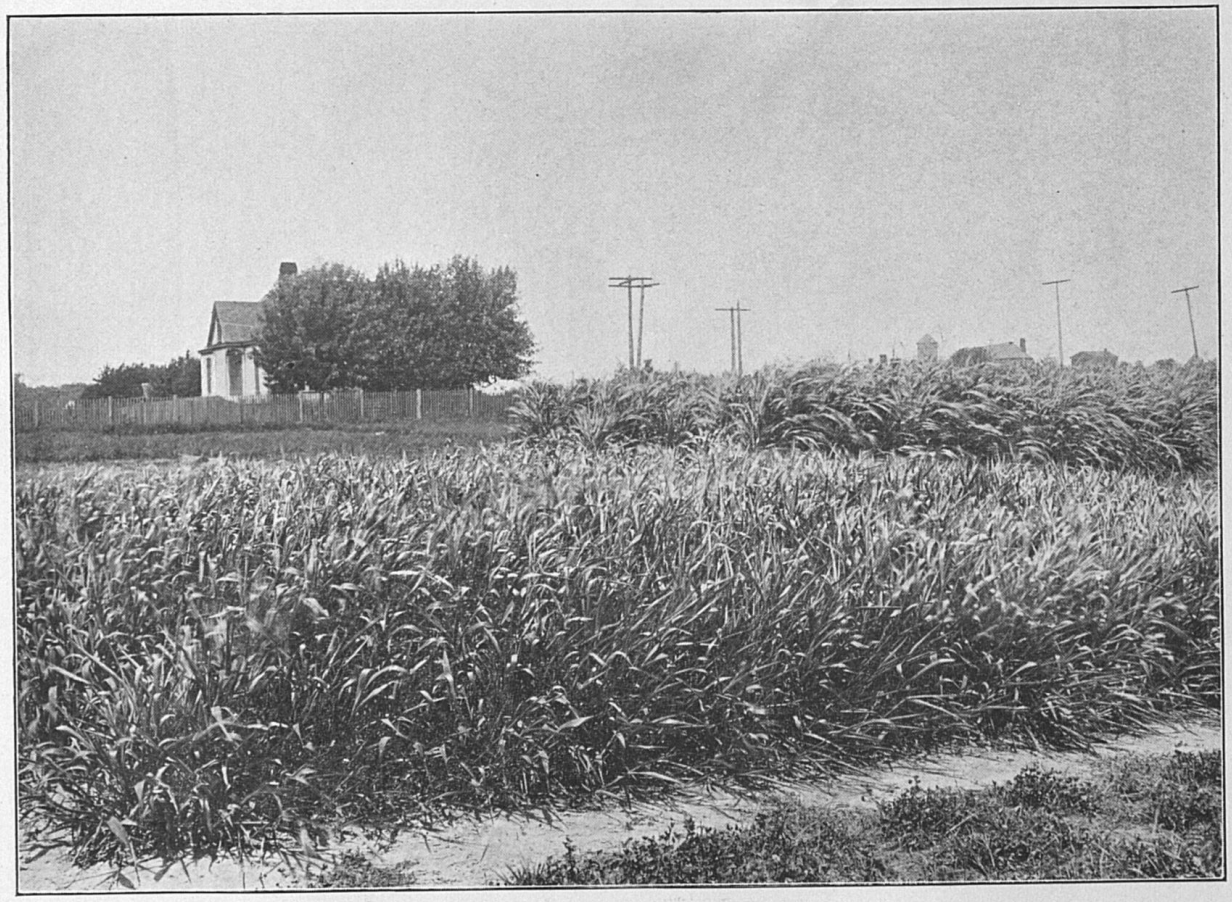

FIG. 14.—A Plot of Texas Millet, Aug. 9, 1901. Photographed by H. G.

FIG. 15.—A Plot of Pearl Millet, Aug. 24, 1901. Photographed by H. G.

FIG. 15.—A Plot of Pearl Millet, Aug. 24, 1901. Photographed by H. G.

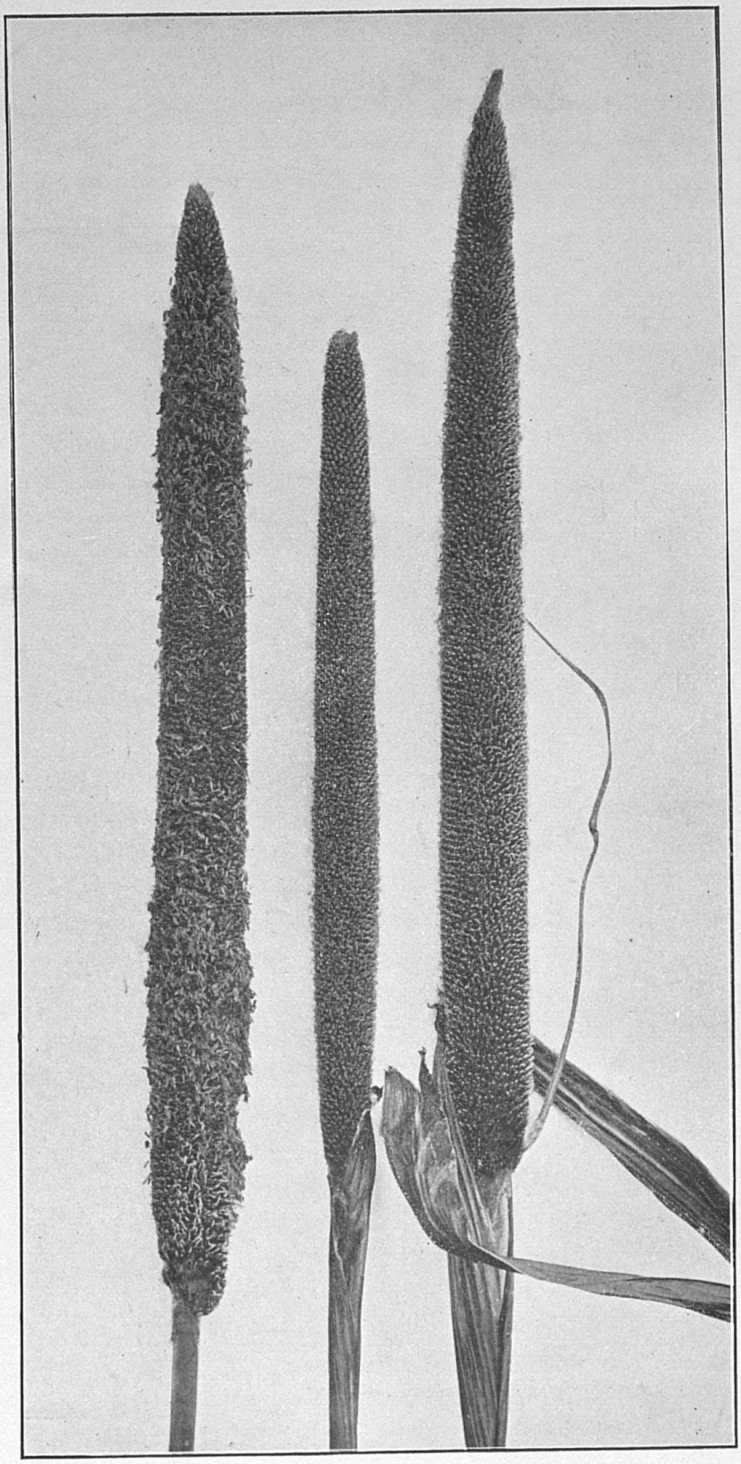

FIG. 16.—Heads or Spikes of Pearl Millet, from Plot, Sept. 20, 1901. Reduced to about one-half natural size. Photographed by H. G.

spike-like head, somewhat like that of timothy, but reaching a length of 1 foot and a diameter of 1 inch. Two cuttings can be obtained from it during a season.

A half plot cut July 17, 1901, produced at the rate of 20.8 tons of fresh fodder per acre, which dried to 7.2 tons. The second cutting from the same plants, Sep. 26, 1901, gave a yield of 19.36 tons of fresh fodder per acre and 9.2 tons of dry fodder. This half plot thus produced at the rate of 40.16 tons of fresh fodder and 16.4 tons of dry fodder per acre. It was planted in drills, 3 feet apart.

Phalaris arundinacea (REED CANARY-GRASS).—Planted April 14, 1900. Cut June 19, 1901: Weight, fresh, 8.08 tons per acre; weight, dry, 4.16 tons per acre.

Phleum pratense (TIMOTHY).—Planted April 12, 1900. Cut July 2, 1901: Weight, fresh, 7.12 tons per acre; weight, dry, 3.68 tons per acre.

Poa compressa (CANADA BLUE-GRASS).—Planted April 12, 1900. Cut June 19, 1901: Weight, fresh, 2.64 tons per acre; weight, dry, 1.6 ton per acre.

Poa pratensis (KENTUCKY BLUE-GRASS).—Planted April 14, 1900. Cut June 11, 1901: Weight, fresh, 4.08 tons per acre; weight, dry, 1.68 ton per acre.

The proper time to gather blue-grass seeds. Mr. Edgar Brown, of the Seed Laboratory, U. S. Department of Agriculture, spent some time at this Station last June, and in conjunction with the Station had gathered on the Farm blue-grass seeds at fourteen different dates, covering the period when the seed is at its best and also at its worst. It has seemed to some of us who have been watching the work of harvesting blue-grass seed that it is often gathered before it is sufficiently ripe, and that this, together with the excessive heat to which it is at times subjected during the curing process, explains the poor quality of some seed shipped out of Blue-grass Kentucky. The seed gathered under Mr. Brown's direction has recently been tested in the Vivarium of my Division, and the results presented below indicate that seeds gathered either very early or very late in June are likely to show a low per cent. of germination, and that from about June 12 to June 20 is the best time to gather seeds.

Blue-grass Seed Gathered on Kentucky Experiment Station Farm in June, 1901. Tested by Planting in Benches in Vivarium in Fall of Same Year.

Date of Gathering Seed	Plot 1.—Equal bulks of seed. Planted Sept. 29, 1901. Examined Nov. 8, 1901.	Plot 2.—Equal bulks of seed. Planted Oct. 11, 1901. Examined Nov. 27, 1901.	Plot 3—Equal bulks of seed. Planted Oct. 14, 1901. Examined Nov. 27, 1901.	Plot 4.—500 seeds of each. Planted Nov. 11, 1901. Examined Dec. 2, 1901.	
	Plants produced.	Plants produced.	Plants produced.	Plants produced.	Per cent. germinated.
June 8	294	192	125	225	45
10	290	182	112	195	39
12	398	270	148	.....	....
14	600	284	172	316	63.2
15	484	296	157	.....	.....
17	632	335	163	310	62
18	620	263	165	.....	.....
19	553	247	140	.....	.....
20	427	260	134	.....	.....
21	453	236	130	.....	.....
22	397	204	142	.....	....
24	430	245	150	.. ..	.....
25	387	233	147	312	62.4
26	412	216	132	191	38.2

3. Analyses of Forage Plants from the Plots

By A. M. PETER, Chemist.

In the following tables will be found analyses of a number of the forage plants grown on the experimental plots, not including what have been published in Bulletin 87, but including a few analyses of material obtained from other sources. The analyses were made at different times by different members of the chemical force; the later ones by Messrs. La Bach, Averitt and Beatty, and the older ones by Messrs. Frazer, Curtis and Peter. The methods used were those adopted by the Association of Official Agricultural Chemists.

Wherever not otherwise indicated in the tables, the samples were taken from the plots by cutting off the plants two or three inches above the ground as they would be cut for hay. The material was then brought to the laboratory as quickly as possible and weighed, then well dried in a warm room, weighed again, ground to powder and analyzed. The results printed in the table of analyses represent the composition of this room dried material, which is usually somewhat dryer than the same material would have been if dried in the field as in making hay. Besides the substances which are usually determined in the analysis of feed stuffs, we have also given the phosphoric acid, nitrogen and potash, as these are important in judging the value of a forage plant as a manure-maker, or for enriching the soil. A large part of these constituents of fertilizers passes into the manure, when the material is fed to stock, and the richer the food is in these the more valuable the manure is likely to be.

In the following tables the first column contains the number of the sample and the second the common name of the plant. After this follows the analysis, calculated upon the dry material prepared by drying in the air of a warm room; next is a column showing the time of cutting, and lastly the number of the sample is repeated.

Station Number.	NAME OF PLANT.	In the air-dry sample, per cent.				
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.
3570	Alfalfa	8.07	8.41	15.25	27.59	39.40
3571	"	8.69	6.58	12.94	30.48	40.16
3585	"	9.13	7.08	12.50	25.82	44.04
3608	"	9.44	8.33	19.31	29.08	32.58
9265	" Samarcand	6.20	10.76	18.31	29.93	31.79
3572	Alsike clover	9.51	9.06	15.81	26.70	37.44
3573	" "	9.42	7.74	13.88	26.90	40.46
5704	" "	9.09	9.84	18.72	17.14	43.16
7686	Australian salt bush	7.26	15.93	18.93	24.63	31.45
7726	" " "	6.33	15.96	17.68	23.85	34.66
5701	Black medick	9.15	12.21	20.94	18.99	36.56
3569	Bush clover, native	8.25	5.22	9.19	36.68	38.64
5712	Canada blue-grass	8.44	4.20	5.28	26.75	52.83
5710	Canary reed-grass	8.41	7.16	7.69	27.07	47.74
7787	Cheat	6.35	6.90	9.68	32.46	42.53
5727	Cowpeas, whippoorwill, whole plant	9.55	8.28	14.31	25.02	40.82
9254	" " " "	7.36	19.21	26.19	22.32	22.84
9249	" wonderful " "	8.25	16.84	26.37	20.70	25.59
9250	" lady " "	6.84	19.79	27.25	24.08	20.02
9251	" ex. early bl'keyed, whole plant	7.43	17.41	25.81	21.75	25.52
9252	" large blackeyed, whole plant	7.19	19.89	26.44	18.03	26.26
9253	" red ripper " "	7.45	18.94	29.44	17.86	23.90
9255	" calico " "	8.19	18.42	26.31	19.83	25.45
9256	" Clay " "	7.89	18.20	26.87	23.19	22.02
9257	" Taylor " "	8.35	19.09	26.75	18.60	25.23
9258	" black " "	8.19	18.24	27.75	18.17	25.88
9259	" unknown " "	8.05	18.77	27.25	19.59	22.65
9297	" roots, not bearing tubercles	5.40	.....	11.31	.....	.....
9298	" " bearing tubercles	5.56	11.28	16.87	.....	.....
9400	" whippoorwill, seeds	11.46	3.58	25.63	4.06	54.35
9397	" extra early blackeyed, seeds	10.69	3.57	25.12	2.61	56.76
9398	" large blackeyed, seeds	9.45	3.55	25.12	3.83	57.06
9399	" red ripper "	9.18	3.19	23.19	4.48	58.92
9401	" calico "	9.40	3.60	24.69	4.60	56.77
9402	" Clay "	10.69	3.50	25.31	4.98	54.56
9403	" Taylor "	11.34	3.16	23.06	3.77	57.62
9404	" black "	10.80	3.25	23.44	4.16	57.32
9405	" unknown "	9.40	3.38	25.50	4.57	56.27
5700	Crimson clover	9.66	8.57	16.69	25.48	37.77

In the air-dry sample per cent.				WHEN GATHERED.		STATION NUMBER.
Fat.	Phosphoric Acid.	Nitrogen.	Potash.			
1.28	0.64	2.44	0.98	June 12, 1893.		3570
1.15	0.66	2.07	1.46	June 28, 1893.		3571
1.43	0.55	2.00	0.93	" 22, 1894.	In bloom	3585
1.26	0.75	3.09	1.03	May 24, 1895.		3608
3.01	0.68	2.93	3.12	" 24, 1901.	Beginning to bloom	9265
1.48	0.97	2.53	1.35	June 14, 1893.		3572
1.60	0.99	2.22	0.96	" 28, 1893.		3573
2.05	0.94	2.99	0.94	" 5, 1897.		5704
1.80	1.66	3.02	6.39	[illegible]		[illegible]

ERRATUM.

Analyses Nos. 9297 and 9298 on pp. 52 and 53 are of roots of soy bean, not cowpeas, and should have been printed on pp. 56 and 57.

1.98	0.99	4.28	4.00	" " "		9257
1.77	1.03	4.44	4.25	" " "		9258
3.69	1.14	4.36	5.15	" " "	Same as 9249	9259
.....	.....	1.81	.....		Exclusive of the tap root	9297
.....	1.04	2.70	1.38		" " " " "	9298
0.92	1.19	4.10	1.61	Sept. 21, 1901.		9400
1.25	1.30	4.02	1.60	Aug. 20, "		9397
0.99	1.34	4.02	1.55	Sept. 19, "		9398
1.04	1.01	3.71	1.49	Oct. 22, "		9399
0.94	1.17	3.95	1.57	" " "		9401
0.96	1.18	4.05	1.57	" " "		9402
1.05	0.74	3.69	1.53	" " "		9403
1.03	1.15	3.75	1.52	" " "		9404
0.88	1.24	4.08	1.60	" " "		9405
1.83	0.84	2.67	0.95	May 19, 1897.		5700

In the air-dry sample per cent.				WHEN GATHERED.		Station Number.
Fat.	Phosphoric Acid.	Nitrogen.	Potash.			
1.28	0.64	2.44	0.98	June 12, 1893.		3570
1.15	0.66	2.07	1.46	June 28, 1893.		3571
1.43	0.55	2.00	0.93	" 22, 1894.	In bloom	3585
1.26	0.75	3.09	1.03	May 24, 1895.		3608
3.01	0.68	2.93	3.12	" 24, 1901.	Beginning to bloom	9265
1.48	0.97	2.53	1.35	June 14, 1893.		3572
1.60	0.99	2.22	0.96	" 28, 1893.		3573
2.05	0.94	2.99	0.94	" 5, 1897.		5704
1.80	1.66	3.03	6.32	Nov. 2, 1899.	From vivarium	7686
1.52	1.05	2.83	4.96	Oct. 6, 1900.		7726
2.15	0.75	3.35	0.68	May 19, 1897.		5701
2.02	0.21	1.47	1.25	July 19, 1895.	Wild growth, Louisa, Ky.	3569
2.50	0.48	0.84	1.46	" 1, 1897.		5712
1.93	0.53	1.23	1.91	" 1, 1897.		5710
2.08	0.68	1.55	1.82	June 9, 1900.	College campus	7787
2.05	0.71	2.29	2.05	Aug. 26, 1898.		5727
2.08	1.36	4.19	6.07	July 2, 1901.		9254
2.25	0.97	4.22	4.55	" " "	Same as 9405	9249
2.02	0.94	4.36	5.20	" " "		9250
2.08	0.99	4.13	4.73	" " "		9251
2.19	1.07	4.23	5.57	" " "		9252
2.41	1.35	4.71	5.71	" " "		9253
1.80	1.08	4.21	4.81	" " "		9255
1.83	1.16	4.30	5.22	" " "		9256
1.98	0.99	4.28	4.00	" " "		9257
1.77	1.03	4.44	4.25	" " "		9258
3.69	1.14	4.36	5.15	" " "	Same as 9249	9259
.....	.....	1.81	.....		Exclusive of the tap root	9297
.....	1.04	2.70	1.38		" " " " "	9298
0.92	1.19	4.10	1.61	Sept. 21, 1901.		9400
1.25	1.30	4.02	1.60	Aug. 20, "		9397
0.99	1.34	4.02	1.55	Sept. 19, "		9398
1.04	1.01	3.71	1.49	Oct. 22, "		9399
0.94	1.17	3.95	1.57	" " "		9401
0.96	1.18	4.05	1.57	" " "		9402
1.05	0.74	3.69	1.53	" " "		9403
1.03	1.15	3.75	1.52	" " "		9404
0.88	1.24	4.08	1.60	" " "		9405
1.83	0.84	2.67	0.95	May 19, 1897.		5700

Station Number.	NAME OF PLANT.	In the air-dry sample; per cent.				
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.
9267	Crimson clover	7.52	12.06	14.44	24.54	38.56
7690	Egyptian clover	6.93	10.70	16.81	23.68	38.10
5711	English blue-grass	9.00	6.58	7.81	30.80	43.78
5713	" "	9.13	6.09	11.87	30.00	40.69
5732	Fenugreek	10.03	12.41	20.13	20.96	34.92
7689	"	6.90	11.20	21.93	19.49	37.99
5709	Fiorin	8.51	5.53	6.19	28.16	49.64
9248	Flat pea, whole plant	8.13	6.18	23.60	27.48	32.02
3616	Florida beggar, weed	11.20	18.14	22.13	14.50	32.03
3620	" " "	8.43	7.98	7.31	29.81	45.08
3632	" " "	8.01	7.78	14.50	28.41	39.41
7790	Furze	5.47	6.96	11.62	38.56	35.43
3629	Japan clover	7.71	8.74	16.94	27.01	37.00
5716	Johnson grass	8.29	5.38	4.00	33.12	47.77
5717	" " root	9.89	8.19	3.81	25.93	50.99
3578	Kidney vetch	8.59	12.99	7.69	28.02	41.54
5699	" "	9.59	13.17	16.00	18.46	40.76
5733	" "	10.00	11.98	13.56	26.00	36.62
5734	" " roots	9.17	15.12	10.81	27.18	36.35
5735	" "	10.36	6.72	11.31	33.47	36.67
5708	Low hop clover	11.18	7.40	12.75	25.25	41.79
3574	Mammoth clover	9.19	8.37	15.31	26.37	39.24
3575	" "	8.76	7.53	12.69	32.71	36.85
7786	Oats	6.13	11.69	14.50	25.21	39.51
7791	"	6.63	8.27	10.31	26.35	45.63
5703	Orchard grass	8.17	5.99	7.00	32.25	44.43
5707	Rape, dwarf Essex	9.91	16.45	23.94	10.91	35.71
5714	" " "	11.01	13.39	12.62	14.08	45.44
5715	" " "	10.00	11.33	11.50	13.60	51.22
5718	" " "	10.92	18.18	24.56	11.35	31.93
231	Red clover	10.00	7.04	13.78	19.41	46.43
242	" "	10.00	6.15	13.65	19.97	47.71
5724	Rostow sugar pea	10.24	6.54	16.00	25.84	38.89
5725	Russian field pea	10.41	5.84	16.69	25.66	38.58
5726	" " "	10.03	6.75	15.13	28.78	37.22
5728	Russian vetch	9.31	7.82	25.31	22.37	32.80
5729	" "	10.65	6.12	19.56	28.92	32.96
5730	" "	10.49	5.70	19.38	20.26	41.35
5731	" "	11.62	9.83	27.00	23.16	26.32

In the air-dry sample; per cent.				WHEN GATHERED.		STATION NUMBER.
Fat.	Phosphoric Acid.	Nitrogen.	Potash.			
2.88	0.63	2.31	2.73	May 24, 1901.	In full bloom	9267
2.78	0.63	2.69	2.48	June 18, 1900.		7690
2.03	0.57	1.25	2.19	July 1, 1897.	Festuca elatior	5711
2.23	0.66	1.90	1.75	" 1, "	" pratensis	5713
1.55	0.74	3.22	4.49	June 2, 1899.	From Vivarium	5732
2.49	0.75	3.51	4.96	June 13, 1900.		7689
1.97	0.54	0.99	1.66	" 29, 1897.		5709
2.59	0.80	3.69	2.94	July 2, 1901.		9248
2.00	1.27	3.54	4.51	May 28, 1896.		3616
1.39	0.95	1.17	2.76	July 18, 1896.		3620
1.91	0.59	2.32	1.10	Sept. 8, 1896.		3632
1.96	0.65	1.86	2.44	June 8, 1900.		7790
2.60	1.08	2.71	2.17	July 31, 1896.	From Vivarium	3629
1.44	0.43	0.64	1.15	" 31, 1897		5716
1.19	1.05	0.61	4.26	Aug. 6, 1897.		5717
1.18	1.79	1.23	2.09	June 28, 1893.		3578
2.02	0.48	2.56	1.08	May 19, 1897.	In bloom	5699
1.84	0.67	2.17	1.03	June 3, 1899.		5733
1.37	1.15	1.73	0.59	" 3, "		5734
1.47	0.61	1.81	1.16	" 17, "		5735
1.63	0.73	2.04	2.08	June 11, 1897.	Wild growth, Danville, Ky.	5708
1.52	0.78	2.45	1.11	" 21, "	Beginning to bloom	3574
1.46	0.62	2.03	0.84	" 28, "		3575
2.96	1.34	2.32	5.66	June 19, 1900.		7786
2.81	0.92	1.65	3.60	July 16, 1900.		7791
2.16	0.54	1.12	1.88	June 5, 1897.	In bloom	5703
3.08	1.44	3.83	5.72	" 22, "		5707
3.46	1.40	2.02	4.86	July 8, "		5714
2.35	1.23	1.84	3.17	" 31, "		5715
3.06	1.01	3.93	5.12	Nov. 4, "	Second growth	5718
3.34	.....	.....	.....	May 28, 1887.	In bloom—College Campus	231
2.52	....	.....	.....	June 13, 1887.	" " " "	242
2.49	0.73	2.56	1.27	July 23, 1898.		5724
2.76	0.74	2.67	1.17	" " "		5725
2.09	0.76	2.42	1.26	Aug. 6, "		5726
2.39	1.26	4.05	1.99	July 19, 1898.		5728
1.79	1.06	3.13	1.74	Sept. 15, "	Some seeds ripe	5729
2.82	0.93	3.10	1.49	Nov. 16, "		5730
2.07	1.37	4.32	3.45	May 8, 1899.	Spontaneous growth	5731

Station Number.	NAME OF PLANT.	In the air-dry Sample, per cent.				
		Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.
9296	Russian vetch	6.90	12.76	22.19	27.64	26.79
3584	Serradella	8.99	15.29	18.56	16.86	38.55
2023	"	9.47	11.78	12.50	25.50	38.64
7727	Smooth brome grass	5.77	5.87	5.56	32.91	47.82
7725	Soy bean, whole plant	6.99	8.25	16.87	23.78	42.52
7760	" " " "	8.26	8.61	21.05	26.32	32.67
9244	" " " "	7.93	13.43	24.06	21.96	31.04
7687	" " best white, 4913, whole plant	7.03	8.07	13.68	22.59	45.82
7688	" " best green, 4914, " "	7.42	9.39	17.68	25.38	37.74
7761	" " " " " " "	7.02	10.44	14.93	26.08	37.24
9246	" " " " " imported seed	8.40	12.99	26.81	18.53	31.72
9247	" " " " " homegrown "	7.28	13.61	25.19	20.25	32.41
7762	" " 4912	7.32	9.40	25.25	12.33	33.41
9245	" " "	6.85	13.69	23.56	22.28	32.49
9360	" " seeds	8.66	5.41	36.56	.....	.....
9361	" " "	8.97	5.32	36.62	.....	.....
7757	" " 4913, ripe seeds	7.11	5.71	37.31	4.63	26.84
7758	" " 4914, " "	6.57	5.64	34.68	4.66	29.60
7759	" " 4912, " "	7.03	5.89	35.56	4.89	26.14
2020	Spurry, entire plant	8.69	12.65	12.81	22.14	40.38
3577	Sweet clover	8.01	4.81	11.38	34.65	40.03
3607	" "	9.41	7.73	19.13	26.89	35.13
2053	" "	9.69	6.58	19.31	16.44	44.78
3627	" "	8.42	6.47	18.44	24.96	39.97
3628	" "	8.54	5.29	15.25	29.40	39.63
5702	" "	8.91	8.31	16.19	23.61	40.81
7724	Teff	6.23	9.21	11.87	26.22	44.38
7723	Teosinte	6.50	12.29	7.93	27.12	44.54
7691	Velvet bean	6.54	8.94	20.12	25.14	36.13
7789	Virginia wild rye	6.17	7.64	9.37	31.07	44.41
7728	White lupine	6.73	12.82	20.56	20.16	37.15

In the air-dry sample, per cent.				WHEN GATHERED.		STATION NUMBER.
Fat.	Phosphoric Acid.	Nitrogen.	Potash.			
3.72	1.04	3.55	4.17	Aug 24, 1901.	.....	9296
1.75	1.04	2.97	1.52	June 22, 1894.	In bloom	3584
2.11	.....	.....	.....	Aug. 24, 1892.	Through blooming	2023
2.07	0.43	0.89	2.23	" 19, 1900.	.....	7727
1.59	0.73	2.70	2.23	" 1, "	.....	7725
3.09	0.69	3.37	2.74	Sept. 17, 1900.	.....	7760
1.58	0.95	3.85	3.84	July 3, 1901.	.....	9244
2.81	0.75	2.19	2.46	Aug. 1, 1900.	.....	7687
2.39	0.72	2.83	2.85	" 1, "	.....	7688
4.29	0.88	2.39	2.09	Sept. 17, "	.....	7761
1.55	0.85	4.29	3.42	July 3, 1901.	.....	9246
1.26	0.85	4.03	3.48	" 3, "	.....	9247
12.29	1.18	4.04	2.37	Sept. 17, 1900.	.....	7762
1.13	0.88	3.77	3.80	July 3, 1901.	.....	9245
.....	1.69	5.85	1.79	Oct. 1, 1901.	From plantswithout tubercles	9360
.....	1.65	5.86	1.96	Oct. 1, 1901.	From plants with tubercles	9361
18.40	1.63	5.97	2.67	Sept. 8, 1900.	.....	7757
18.85	1.78	5.55	2.54	Oct. 10, "	.....	7758
20.49	1.61	5.69	2.50	Sept. 20, "	.....	7759
3.33	.....	.....	.....	June 14, 1892.	In full bloom	2020
1.12	0.53	1.20	0.66	June 28, 1893.	.....	3577
1.71	0.82	3.06	1.02	May 24, 1895.	.....	3607
3.20	.....	.....	.....	Oct. 5, 1892.	First year	2053
1.74	0.79	2.95	1.45	July 30, 1896.	" "	3627
1.89	0.77	2.44	1.04	Aug. 25, "	" "	3628
2.17	0.96	2.59	1.45	May 22, 1897.	Second year	5702
2.09	0.80	1.90	2.34	Aug. 2, 1900.	.....	7724
1.62	0.88	1.27	6.21	" 2, "	.....	7723
3.23	0.61	3.22	2.55	Oct. 5, 1900.	.....	7691
1.34	0.66	1.50	2.05	June 24, "	.....	7789
2.58	1.17	3.29	4.52	June 8, 1900,	.....	7728

It may not be out of place here to repeat from Bulletin 87 a brief statement explanatory of the nature of the substances into which a feed stuff is usually separated by analysis.

Water is contained in all feed stuffs and its amount varies greatly, being usually largest in the young plant, becoming less as the plant becomes more woody. In dried materials like hay it may be about 10 per cent., but is quite different in different materials, and varies in the same material with the moisture of the air in which it is kept.

Ash is the mineral matter which is left when the feed stuff is burned. It usually consists mainly of carbonates and phosphates of lime and potash. The ash of grasses usually contains also a large proportion of silica. Besides the mineral substances which are actually contained in the vegetable matter itself, the ash usually contains more or less sand or soil that has adhered to the plant in the form of dust. Animals derive the phosphates of their bones from the ash constituents of their food, but the phosphates and potash are only partly used up in this way, the rest going to enrich the manure.

Protein is the name for a class of substances containing nitrogen. This is one of the most important constituents of feed stuffs, as it is the one which furnishes the material for making flesh, blood, muscles, &c. Protein is often divided by analysis into *albuminoids*, or substances similar to albumin or white of egg, considered very valuable as food, and *amids*, which are considered less valuable. In very young, tender grasses the proportion of amids is apt to be large.

Fiber is the woody part of plants and is the least digestible constituent of feed stuffs. A part of it, however is usually capable of being digested and serves a similar purpose in the food to the nitrogen-free extract.

Nitrogen-free extract is the starchy part of the feed stuff, including, besides starch, the sugars, gums, &c., and is an important part of a food. As grasses become ripe the proportion of nitrogen-free extract largely increases.

Fat is that part of the feed stuff that is soluble in ether and includes, besides true fat or oil, the wax and green coloring matter of plants. The fat of food may be stored up in the

body as fat, or burned to keep up the heat and energy of the animal.

Some general ideas of the relative value of different forage plants as food may be had from a comparison of their analyses, but a correct estimate can only be made when the proportion of each constituent that is digestible—that is, the co efficient of digestibility—is known.

Below are given the co-efficients of digestibility of some dried forage plants, taken from Prof. W. A. Henry's "Feeds and Feeding" 2nd edition, 1900. Most of these figures were determined by the American Experiment Stations, but a few are from foreign sources. The co-efficients of digestibility show how many parts in each 100 of each constituent were found to be digestible. Thus, in the first line of the table, opposite "Alfalfa hay," we find, in the column headed "Protein," the number 74, which means that seventy-four hundredths of all the protein in alfalfa hay was digestible. If alfalfa hay contains 15.25 per cent. of protein, the digestible protein in the hay will be seventy-four hundreths of this amount, or 11.28 per cent. The digestibility as well as the composition of forage plants varies considerably at different stages of growth as well as in different years.

Average Digestion Co-efficients of Some Forage Plants.

MATERIAL.	Dry Matter.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Alfalfa hay	60.	74.	43.	66.	39.
Alsike clover hay	62.	66.	53.	71.	50.
Cowpea-vine hay	59.	65.	43.	71.	50.
Crimson clover hay	62.	69.	45.	62.	44.
Hungarian grass hay	65.	60.	68.	67.	64.
Johnson grass hay	55.	45.	58.	64.	39.
Orchard grass hay	56.	60.	61.	62.	51.
Red clover hay, cut in bloom	61.	62.	49.	69.	62.
Redtop hay	60.	61.	61.	62.	51.
Serradella hay, cut in bloom	62.	75.	50.	63.	65
Soja bean hay	62.	71.	61.	69.	29.
" " meal	79.	87.	.. ..	73.	85.
Timothy hay, all trials	57.	48.	52.	63.	57.
" " cut in bloom	60.	56.	58.	63.	57.
" " " soon after bloom	53.	45.	47.	60.	53.
Vetch "	65.	76.	54.	66.	60.

INDEX TO COMMON NAMES.