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WINTER PASTURAGE, HAY AND FERTILITY AFFORDED BY HAIRY VETCH.

By

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WINTER PASTURAGE, HAY AND FERTILITY AFFORDED BY HAIRY VETCH.

By J. F. Duggar.

SUMMARY.

Hairy vetch (*Vicia villosa*), sown in September or October, alone or with oats, affords nutritious pasturage during the following February, March, April and May. If not grazed too late it affords a cutting of hay from April 20 to May 10. Hairy vetch is disposed of as pasturage, hay or green manure in time for quick-growing summer crops, as cowpeas, sorghum, late corn, etc. It grows only from seed, but can be so managed as to reseed the ground continously.

Hairy vetch was cut for hay at four different stages; the yield of hay increased up to the time of full bloom, when the maximum yield of 5,789 pounds of hay per acre was obtained; chemical analysis showed that, at whatever stage this plant was cut, the hay was nutritious. Considering both quality and quantity of hay, it was concluded that the best time to cut vetch (growing alone) was three or four days before the period of full bloom.

Hairy vetch rapidly enriches the soil in nitrogen, if the plant is plowed in for green manure. It is able to draw this nitrogen from the air and add it the soil only when the roots of the vetch plant are supplied with enlargements of definite character, and known as root nodules or tubercles.

When sown in the usual way on most poor soils in Alabama the vetch plant does not have these "bumps" or nodules on the roots. If devoid of tubercles, hairy vetch does not enrich the soil, and fails completely if the land is poor.

Such soils can be made to produce vetch plants containing tubercles by sowing, along with the vetch seed, some of

the earth from a place where the English pea or the wild vetch has been grown for several years.

The process of employing suitable soil or other material containing definite kinds of tubercle-producing germs is called inoculation. Full directions for the inoculation and culture of hairy vetch are given in this bulletin.

With hairy vetch natural inoculation occurred during the second year that the plant was grown on the same land. Artificial inoculation, as described in this bulletin, caused the success of the first crop of vetch, whereas reliance on natural inoculation involved the failure of the first crop of vetch, or else the use of expensive nitrogenous fertilizers.

In order to have available for use in future years a supply of valuable inoculation material, it is important that prospective vetch growers should sow at least a small area of vetch this fall; the soil from this plot may be used for inoculating larger areas in subsequent years.

A very luxuriant crop of hairy vetch, in full bloom, contained in the roots, stubble, and vines growing on one acre, fully as much nitrogen as is contained in $1\frac{1}{4}$ tons of cotton seed meal. A large proportion of this came from the air.

By far the greater portion (at least four-fifths) of the fertilizing material in the vetch plant is in the top, or part cut for hay. However, there is considerable nitrogen in the stubble and roots, as shown here both by chemical analysis and by the satisfactory growth of corn on land where vetch stubble had been plowed in.

Our tests indicated a larger profit from feeding the vetch hay, plowing in only roots and stubble, than from turning under the entire plant for green manure.

Hairy vetch can be advantageously introduced as a "catch crop" into the ordinary rotations of the cotton farm, without reducing the usual area of cotton, corn, or small grain. Hairy vetch, if properly inoculated, is a profitable crop even if the farmer fails to utilize its food value and grows it only for soil improvement, which end it rapidly effects through prevention of leaching from the soil in winter and through the stores of nitrogen and vegetable matter added to the soil.

WHAT IS HAIRY VETCH?

In two previous bulletins (No. 87 and No. 96) of the Alabama Experiment Station, the writer has pointed out the great value of hairy vetch as a forage plant and as a means of improving the soil. As the editions of these bulletins are exhausted and as we have recently conducted other experiments with this plant, the present bulletin is issued with the hope of inducing many farmers to test hairy vetch, which we may safely say is one of the most promising plants for those who desire winter pastures, nutritious hay, or soil improvement.

Hairy vetch (*Vicia villosa*) is an annual plant. This implies that its growth is made in less than twelve months and that the plant does not spring from the roots, but that seed must be planted every year, or that the plants must be allowed to ripen sufficient seed for a "volunteer" crop the next season.

The introduction of hairy vetch into Central Europe is comparatively recent, while in the United States few tests of this plant were made before the present decade.

The plant forms numerous slender branches, which in thrifty plants are usually three to six feet long. These branches are too fine and slender to stand erect.

The leaflets are small. The entire plant is covered with a coat of fine hairs, hence the name hairy vetch. This plant is also called sand vetch. The flowers, which appear in dense clusters in April, are purplish, and a field of vetch in full bloom presents a beautiful appearance. The seed, of which several are borne in each pod, are black and about the size of okra seed. The seed pods readily burst open, throwing the seed to some distance. This makes it easy for the plant to reseed itself if not grazed too closely when the seeds are forming.

SPECIAL VALUE OF LEGUMINOUS PLANTS.

Hairy vetch, like the clovers, cowpeas, etc., belongs to the large order of plants known to the botanists as *Leguminosæ*. Hence we speak of members of this order as leguminous plants or legumes.

All the legumes with which we are concered might also properly be called soil-improving, or renovating, plants. They deserve this name because they have the power, not possessed by most other plants, to obtain *from the air* a large proportion of the fertilizing material that they need; and the nitrogen which they thus obtain, if given to the land by plowing in the legume, makes the soil rich in this valuable fertilizing material. Since nitrogen, if purchased in the form of cotton seed meal costs 10 or 12 cents per pound, the fertilizing value of legumes is self-evident.

The great value of legumes as soil improvers may be better realized by considering the figures which show the amount of nitrogen in the tops and roots of hairy vetch grown on this station in 1898–'9.

Analysis of samples of the vines and roots of hairy vetch cut May 2, 1899, when in full bloom, showed that the crop on one acre contained:

	Lbs. nitrogen per acre.
In the 5789 pounds of hay.....	159.2
In the 1052 pounds of roots and stubble.....	20.8
In the entire growth on one acre.....	180

This 180 pounds of nitrogen is equal to that contained in more than 2,500 pounds of cotton seed meal. Or, pricing the nitrogen at 10 cents per pound, a luxuriant growth of vetch on an acre represents nitrogen the market price of which is $18. Some of this comes from the soil, a large proportion from the air. If we assume that only half the nitrogen was obtained from the air, the soil would gain, by plowing in the entire vetch crop, nitrogen to the value of $9. Granting that some of this will be washed out from the soil before a succeeding crop can appropriate it, there is to counterbalance this the mechanical improvement of the soil, due to the incorporation of about three tons of vegetable matter per acre.

On poorer, sandier soil samples of hairy vetch taken May 7, '98, showed that the ton and a half of hay growing

on an acre contained 85½ pounds of nitrogen, and the roots and stubble 20 pounds, a total of 104½ pounds of nitrogen per acre. Numerous other figures obtained in experiments here might be given, all showing the superior value of hairy vetch and other legumes as fertilizers. For example, in this experiment just alluded to, rye, growing alongside the vetch, on similar soil and with identical fertilization, was able to obtain only one-fifth as much nitrogen as vetch, because the rye plant was limited to the supply of nitrogen in the soil, while the vetch plant drew from the unlimited store of nitrogen in the air as well as from the scant supply in the soil.

THE FUNCTION OF ROOT NODULES OR TUBERCLES.

The above figures and the experience of every observing farmer should raise the question, "Why can vetches, cow-peas, and other legumes, obtain nitrogen from the air while non-leguminous plants cannot?" Let us compare the roots of the cow-pea, or other legume with the roots of rye, corn, or other grass-like plant, and we will discover the essential point of difference between soil-improving and soil-exhausting plants. The legumes, or soil improvers, if thrifty and if examined at the proper time, say just before blooming, will be found to have little bumps or enlargements on the roots, slightly attached on the surface of the root. The soil exhausting plants—those which have not the power to take nitrogen from the air—have no such en-enlargements on the roots. These enlargements, root nodules, or tubercles, found on all normally developed soil-improving plants, are the means by which these plants are enabled to assimilate the gaseous nitrogen of the air. They are filled with minute vegetable organisms, germs, or bacteria, which convert the gaseous nitrogen into a form suitable for the use of the flowering plant.

In one sense, each tubercle or nodule is a fertilizer factory, peopled with great numbers of industrious vegetable operatives, working constantly and manufacturing nitrogenous fertilizer, which is floated off in the sap of the host plant to be utilized in building up the stem, roots, and leaves of the higher plant.

Hairy vetch begins its growth in September or October and occupies the ground during the winter months. It thus prevents in a large degree the leaching out in the winter rains of the nitrogen already in the soil. It retains what nitrogen is already in the soil by taking up through its roots the soluble soil nitrogen, which, if not thus utilized, would to a large extent be washed out and carried off in the drainage water, and thus utterly wasted. The nitrogen thus appropriated is restored to the soil when the plant, or its stubble, is incorporated with the soil a few months after winter ends. Soils of medium fertility in the South (as also rich soils) are more injured by leaching if left without growing vegetation during winter than they are by the fertilizing material removed in the crop. The richer the soil, the greater this loss. Leaching even occurs, in smaller measure, on the poorest of soils left bare of green vegetation in winter.

Hairy vetch checks leaching, but it is not alone in this valuable function. Rye, wheat, barley, and winter oats, in fact any crop filling the soil during winter with a tangle of live roots ready to take up the soluble nitrogen before it can escape in the drainage water, will serve to retain what fertility the soil already possesses. Often these crops, especially on rich land, save more than enough fertility in this way to pay cost of seed and labor expended in sowing them. Remember that nitrogen is worth 10 to 12 cents per pound, and that many pounds may be drained from an acre of bare soil each winter. The winter-growing small grain crops conserve present fertility, but they do not add to the supply of plant food, for when plowed in, they restore only what fertilizing materials they have obtained from the soil.

It is reserved for the winter-growing legumes to perform the double service of preventing leaching and of largely increasing the supply of nitrogen in the soil. They are both conservers and accumulators of fertility, and for this reason

are preferable to non-leguminous plants. Among these winter growing legumes, none promise greater usefulness to the cotton farmers of Alabama and to those who are turning their attention to live stock than hairy vetch. It requires the use of the land for only the cooler portion of the year, furnishes winter pasturage, nutritions hay, and a cheap fertilizer. The culture of hairy vetch is simple and the plant has adaptability to a wide class of soils, provided the farmer utilizes the results of recent discoveries relating to leguminous plants.

INCREASING THE YIELD OF RARELY-GROWN SOIL-IMPROVING PLANTS BY MEANS OF INOCULATION.

When a root nodule or tubercle decays the germs which it contain are left in the soil and distributed by cultivation and by the movement of drainage water. Hence the soil on which vetch has grown for several years has an abundant supply of that kind of germ found in the root nodules of the vetch plant. These germs are not dead but have the power of growing and of multiplying should they again come in contact with a succulent vetch root. If one of these germs becomes thus attached, a nodule is formed on the vetch root, and by the rapid multiplication of the original germ this tubercle becomes stocked with a multitude of nitrogen-storing bacteria, thus making available to the higher plant the great store of atmospheric nitrogen.

By an extension of the figure used in a preceding paragraph, we may say that a single one of these operatives (nodule bacteria) is able to organize a new fertilizer factory (nodule or tubercle) and in a few weeks or months to people it with the descendents of the founder. However, a germ from a vetch tubercle would be unable to cause the growth of a tubercle on any of the clovers, cowpeas, etc. In other words, nearly every kind (genus) of soil-improving legumes has its own exclusive variety of nodule-forming bacteria, which can cause the growth of tubercles only on this particular genus, or closely related genera, of plants.

As stated above, the growth of any given legume, say

cowpeas, stocks the soil with myriads of germs able to cause tubercles to develop on the next year's crop of cowpeas. The soil, thus germ laden, is blown about by the winds, stocking with the cowpea germs fields where cowpeas have never grown. Hence, we count on most Southern soils having a full supply of cowpea germs, because the cowpea has been so widely grown in the South. So in the North there is probably an ample supply of clover germs, distributed from the clover fields, which are so generally to be seen. Likewise in the West, where alfalfa fields are common, the supply of alfalfa germs, doubtless carried by winds and by irrigation water, seems ample.

But a very different condition prevails over large areas of the South as regards the supply of germs able to produce tubercles on clover, alfalfa, or vetch. Take vetch, for example. In Alabama there are comparatively few fields of either common or hairy vetch. Hence, even if all these fields were abundantly stocked with tubercles and vetch bacteria, there could be no general and adequate distribution of the germs.

Absence of "vetch germs" in many Alabama soils.—As a matter of fact, the writer has found, in examination of vetch plants from dozens of localities in Alabama, that when first grown, vetch fails to produce tubercles, or else has so few tubercles that they are inadequate for soil improvement. Hence we infer the absence or inadequate supply of vetch germs from the majority of soils of the extreme South.

This fact has a very practical bearing. For a vetch or other leguminous plant without tubercles is cut off from the store of atmospheric nitrogen, cannot improve the soil, and cannot make a luxuriant growth except on rich land or by the use of high priced nitrogenous fertilizers. Moreover, the absence of tubercles lowers the quality of the forage, decreasing the valuable nitrogenous food materials, as well as greatly diminishing the yield. (See Ala. Expt. Sta. Bul. No. 96, p. 206).

Leguminous plants have no proper place on the farm unless their roots are well supplied with tubercles. Yet such

rarely-grown legumes as vetch, clover and alfalfa on many Southern soils fail to form tubercles the first year. It is the farmer's business to make them form tubercles. He can do this by supplying to his field where he wishes to sow clover, alfalfa, or vetch, the appropriate germ. This process of supplying the requisite germ is called *inoculation.*

Inoculation by use of suitable earth.—For instance, the farmer wishing to grow vetch, should, if a patch of hairy vetch or of common vetch growing wild is to be had in his vicinity, examine these vetch plants. If they have tubercles, he should obtain some of the soil from the upper three inches of this old vetch field, taking the soil from near the roots of the old vetch plants or from spots where there was a thick stand of vetch.

However, as not many will be able to find a vetch field from which to get soil, a substitute can be had in the soil from a portion of the garden where English peas grew last season, *and where they developed an abundant growth of tubercles.*

Having the soil from the old vetch field or gard en spot proceed as follows :

If the supply of inoculating soil is limited in proportion to the area to be sown with vetch, place the soil in a bucket, tub or tight barrel and add such an amount of water as will thoroughly saturate the soil and in addition will leave, after the settling of the soil, sufficient water to wet the amount of vetch seed to be sown. After adding the water, stir soil and water together very thoroughly. Then allow settling to occur and pour off the water on the vetch seed, stirring the seed to make sure that every seed becomes wet. Sow the seed promptly after this treatment, avoiding as far as practicable exposure to light. Cover the seed promptly.

A more thorough inoculation can be secured, when there is available sufficient inoculating soil, by proceeding as above, and in addition, sowing broadcast one or two tons per acre of the unmoistened inoculating soil, harrowing it

in promptly and repeatedly, so as to thoroughly distribute the inoculating earth through the soil.*

Commercial germ fertilizer, or Nitragin.—There is a prepared inoculating material, called germ fertilizer, or Nitragin, imported from Germany by Victor Koechl & Co., 79 Murray St., New York. There is a different brand for clover, alfalfa, vetch, etc. All brands cost about $1.25 per bottle (sufficient for $\frac{5}{8}$ acre), the cost with express, amounting to about $2.25 per acre. Directions for use accompany each bottle.

The following extract from Bulletin No. 93 of this station indicates that there are practical limitations to the *extensive* use of Nitragin, its best use being as a "starter" for inoculating a small area; the soil from this small plot, may, in future years, be used to inoculate extensive areas:

"The greatest obstacle to the general use of Nitragin in certain 'cloverless' regions is the fact that this valuable material is perishable. It loses its inoculating property if long exposed to light, or if subjected to much heat, or if kept for more than two or three months. It endures longer in a cool than in a warm temperature. Nitragin shipped from Germany early enough to reach the Southern farmer in time for use on fall-sown seed runs great risk of being exposed to a temperature sufficiently high to cause fermentation, and consequent death, of the germs which it contains.

"So many bottles of Nitragin ordered in time for use in our fall experiments have reached us in a worthless or dead condition that we would advise those who may wish to obtain a few bottles of Nitragin as a "starter," to order the shipment made from Germany about the first of February, so that the Nitragin will arrive in time for use on seed sown in March. While we have found to be dead some of the Nitragin imported in winter, the losses have been less at this season than with importations in the early fall."

* As inoculation material for crimson clover, earth from roots of vetch or English peas will not answer. For this purpose use earth from about the roots of the little white clovers often found in spring in old pastures and lawns or from the roots of any of the true clovers (*Trifolium*)

NATURAL INOCULATION.

As stated above there are two means of artificial inoculation, (1) by use of soil from a field on which has been grown for several years, *with abundant supply of tubercles*, the same kind of legume that it is desired to inoculate, and (2) by the use of Nitragin or germ fertilizer, a concentrated commercial preparation, which is exceedingly perishable.

Artificial inoculation pays, but it is not absolutely necessary to final success with vetch and similar rarely-grown legumes. Nature may do the work of inoculation, if given time enough. Artificial inoculation, with material sufficiently stocked with the proper germs, practically insures immediate success, or the success of the crop the first year. To wait for nature to so modify the germs now in the soil of "vetchless" regions as to cause nodule formation on the vetch plant, involves on poor land the failure of at least the first crop of vetch, or else it necessitates sowing vetch seed on rich land or the use of the expensive nitrogenous fertilizer for the proper growth of the first crop of vetch.

Two experiments recently made by the writer suggest that with the vetch plant we can expect natural or spontaneous inoculation to occur the second season, when vetch grows during two years in succession on the land.

On recently cleared land where hairy vetch grew in the spring of 1898 without artificial inoculation and without tubercles, vetch seed were again sown in the fall of 1898. The resulting plants become fairly well supplied with tubercles.

Likewise on a fairly good upland loam soil, where in the season of 1897-'98 diligent and repeated search failed to discover a single tubercle on the roots of hairy vetch, the vetch plants of 1898-'99, produced by self seeding or shattering, had developed tubercles on about two-thirds of the plants as early as December 7, 1898. Later, the supply of tubercles was adequate.

In both cases the location of the plots was such as to render it highly improbable that wind or drainage water

was responsible for the introduction of the requisite number of vetch germs. It seemed to be rather a case of a change in the germs already in the soil, by which they adapted themselves to the vetch plant. Experiments with other leguminous plants in one of the same fields further strengthen this conclusion.

The practical importance of these results is apparent, if this conclusion is sustained by further investigation. They suggest a means by which any farmer, who may be unable to obtain suitable inoculating material or unwilling to take the pains necessary for artificial inoculation, may, by persistent planting of vetch after vetch, crimson clover after clover, alfalfa after alfalfa, and so on, in the second or third year grow vetch, clover, or alfalfa plants amply stocked with root nodules.

Moreover these results explain the success that a few have already met with in growing vetch and other unusual legumes before practically anything was known about the advantages of inoculating such plants on certain soils.

For those who decide to dispense with artificial inoculation and to wait for nature to do this work, failure of the first crop can be avoided by sowing vetch seed on (1) land naturally rich, or (2) on poorer land where the stubble or vines of cowpeas have recently been plowed in, or (3) by the use of nitrogenous fertilizers, especially stable manure, or even cotton seed meal.

Either of the above courses should insure a fair crop of forage the first year and this fertilization with nitrogenous material need not be repeated when on the same land vetch is grown for the second or third year, the presence of tubercles then rendering the plant independent of the nitrogen of fertilizers.

The soil of a field where vetch tubercles have been thus caused to develop in numbers can subsequently be used as inoculating material for the remainder of the farm.

Artificial inoculation is important, but it is more important to get started *at once* a patch of this valuable plant, no matter how small the area. By sowing a plat this fall, the

farmer will have in one to three years soil filled with vetch germs, which soil can then be used as a germ fertilizer for vetch on larger areas of poor land, needing upbuilding.

Where to get seed.—Our supply of seed of hairy vetch was bought this summer from T. W. Wood & Sons, Richmond, Va., at $3.25 per bushel. A few years ago we bought of Peter Henderson & Co., New York City. Prices are apt to advance somewhat after mid-summer. At the usual catalogue prices for small amounts, a quart of hairy vetch seed, weighing 1½ pounds, would cost, including postage, about 25 cents. A better investment could scarcely be made except in a larger quantity of the same seed.

Nearly every extensive dealer in field seeds can supply hairy vetch. Do not accept just any kind of vetch seed the seedsman may offer, but insist on having hairy or sand vetch (*Vicia villosa.*) If the stock is exhausted, common vetch (*Vicia sativa*), though less valuable, is worth sowing as a means of obtaining inoculating material for use in future years. The earth from around the roots of common vetch supplied with tubercles is suitable inoculating material for hairy vetch.

MAKING A START WITH HAIRY VETCH.

Artificial inoculation is important. But whether or not it is convenient to inoculate vetch at this time, every provident farmer should at once take steps to have home-made inoculating material available for use in future years. Sow a plot of vetch this fall, no matter how limited the area, so as to be able in future to use the soil from this plot as inoculating material. A lot sown now *with thorough inoculation* should afford a supply of inoculating earth for use on the vetch seed to be sown in the fall of 1900. If the present sowing is made *without* inoculation, and vetch is grown on the same area each winter, the soil should naturally become sufficiently stocked with vetch germs for use as inoculating material for the seed which will be sown in the fall of 1901 and 1902.

A very small plot runs the risk of injury by rabbits,

chickens, and insects. However, it is better to sow a quart this fall (on a square about 33 feet each way) than to wait until a larger area can be sown. Inoculate this small area if practicabe. If not, or if doubtful about the character of the earth used as inoculating material, use for this first sowing a moderate application of stable manure or about 200 pounds per acre of cotton seed meal in addition to acid phosphate and kainit or wood ashes. This little plot will be worth something when its soil becomes abundantly stocked with "vetch germs."

DOES INOCULATION OF HAIRY VETCH PAY?

Experiments already reported in Bulletins Nos. 87 and 96 of this Station show that in a poor sandy field vetch seed, inoculated by dipping the seed in a soil-extract prepared from the earth of a patch of wild vetch, afforded more than a ton of hay per acre in excess of seed sown the same day alongside, but without inoculation. The next year, by use of Nitragin, the commercial germ fertilizer, the yield of hay in another sandy field was increased by more than a ton and a quarter per acre.

These results answer very plainly the above question, and show that under such conditions we were several times repaid for the pains or expense incurred in inoculating the seed or the soil.

USES OF HAIRY VETCH.

This plant is valuable for winter pasturage, for hay, and for soil improvement.

For winter pasturage.—Hairy vetch, coming up as a volunteer crop in the early part of September, 1898, was large enough to afford pasturage by the first of January. Another field, where a mixture of turf oats and hairy vetch was sown as late as October 24, 1898, was ready for grazing by March 1, in spite of the unprecedented cold weather in February. This field was grazed by a sow and pigs from April 1 until May 26. Moreover, the portions of the field grazed in April made a second growth, affording 1,041 to 1,633 pounds of hay per acre. It seems safe to count on

getting moderate grazing by February 1 and good grazing by March 1, when hairy vetch alone, or hairy vetch and turf oats are sown in September. As a pasture plant, hairy vetch is relished by all classes of farm animals.

For hay.—Hay from hairy vetch is ready for cutting from April 20 to May 10. The hay of all the hay-producing legumes is rich in protein or nitrogenous matter, the so-called "muscle forming" nutrients. Vetch is especially rich in this valuable ingredient. The absence of coarse stems is another point of superiority with vetch hay.

As the branches of hairy vetch are slender they need the support afforded by sowing with the vetch seed one of the small grains. For this purpose turf or grazing oats are most generally used. Without such support heavy rains beat the vetch plant down, reducing the yield and injuring the quality of the hay. The mixed vetch and oat hay is of excellent quality, though less rich in protein than unmixed vetch hay. The mixture is cut when the vetch is in bloom, before the oat heads have filled and before the oat stems have become very woody.

Best stage for hay.—The experiment described below was recently made here to determine the best stage for cutting vetch hay, grown without the support of any small grain or other admixture. Samples carefully taken under the writer's direction and analyzed by Mr. C. L. Hare, of the Chemical Department of this Station, show the composition of hairy vetch hay when cut at different dates. For comparison, average analyses of corn blades or "fodder" and of hay from Johnson grass, cowpeas, and red clover are inserted.

Composition of hairy vetch hay cut at different dates.

Date and stage when cut (1899.)	Composition of hay.					
	Moisture.	Crude protein.	Carbohydrates.	Fats.	Crude Fiber.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*	
April 19; just before blooming	20.72	23 45	26.25	2.22	20 24	7.12
April 26; 5% of blooms showing	22.83	18.97	29.06	2.11	20.44	6 59
May 2; in full bloom	20 30	17.15	32·12	2.14	22 50	5 79
May 9; seed pods formed, but not filled	22 48	18 71	29.50	2.35	19 92	7.04
* Johnson grass hay	9 64	6.08	42.23	1.79	32 80	6.46
* Red Clover hay	13.14	12.28	38.66	3 22	25.34	6 99
* Cowpea hay	10 46	14 77	39 34	3.07	24.35	8 01
*Corn blades ("fodder.")	14.09	10.86	42.59	2 65	21.16	8.74

In judging of the nutritive value of hay by its chemical composition, it should be remembered that protein (nitrogenous material) is the most valuable nutrient, carbohydrates and fats next in value, that ash may be left out of consideration, and that the larger the proportion of fiber (woody matter) the coarser the hay.

The percentage of protein ("muscle formers") in vetch hay is higher than in the other leguminous hays, red clover and cowpea vines, which are usually taken as standards in this respect, and much higher than in corn blades or "fodder;" vetch hay contains three times as much of these "muscle formers" as Johnson grass hay.

As regards the percentage of carbohydrates or carbonaceous material, samples of vetch hay rank below the other hays named.

Vetch hay, cut at whatever stage, was highly nutritious. The several samples did not differ widely except that the hay of the earliest cutting was richest in nitrogenous material and poorest in starchy matter.

The following table shows the results in a more practical

* McBryde; Tenn. Expt. Sta., Bul. Vol ix, No. 3

shape, and gives for each cutting the yield per acre of hay, of dry matter, and of the most important food constituents in the hay.

Yield of hay and principal nutrients per acre from hairy vetch.

Date and stage when cut.	Yield per acre.			
	Hay.	Dry matter.	Crude protein.	Carbohydrates and fat.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
April 19; just before blooming..	3117	2471	731	887
April 26; 5% of blooms showing.	3705	2859	707	1154
May 2; in full bloom.....	5789	4614	993	1983
May 9; seed pods formed, but not filled.....	5463	4235	1022	1740

The yield of hay was over 1½ tons per acre before the plants bloomed; during the next six days and up to the time when only a few blooms had appeared, it increased by nearly a third of a ton per acre. In the week immediately preceding full bloom there was an increase of nearly a ton per acre. In the week between full bloom and the formation of pods there was a slight decrease in the yield of hay, many leaves and blooms having fallen.

The total amount of dry matter produced varied in about the same proportion as the hay, the maximum of 4,614 pounds of dry matter per acre being reached May 2, when the plants were in full bloom. There was a rapid increase of crude protein (or nitrogenous material) in the week preceding full bloom, after which there was practically no increase.

The two most important carbonaceous nutrients, or "fat formers," carbohydrates and fat, increased during each period until the time of full bloom, after which there was a decline. The most rapid gain was in the week preceding full bloom, during which week these nutrients increased 62 per cent. or 729 pounds per acre.

The figures indicate that, of the four dates chosen for cutting the hay, best results were obtained from thecutting made

May 2 when the plants were in full bloom, this date giving the maximum amount of hay, of dry motter, and of carbohydrates and fat, with practically no sacrifice of nitrogeneous material.

Judging the hay by appearances alone, the plants in full bloom were slightly too mature for hay of best color, the lower leaves having turned yellow. Judging the hay by looks alone, before chemical analyses were made, and also having regard to yield of hay, the writer deemed April 30, or the period when one-half or two-thirds of the blooms were showing, the best time for cutting the crop.

Hairy vetch for green manuring, or soil improvement.

The superiority of the legumes over other plants for green manuring has already been referred to. In the South, the cowpea is the standard for green manure or soil improvement. Hairy vetch seems the equal of the cowpea and has the advantage of growing in the winter, thus preventing leaching of fertilizing material from the soil, and displacing no summer crop.

In an experiment which will be detailed in another bulletin, corn was planted in May and June, 1898, on adjacent plots where a few days before had been plowed in, on different plots, either the stubble of hairy vetch, the entire growth of vetch, the stubble of rye, or the entire growth of nearly mature rye plants. The yield of corn in 1898 was at least 50 per cent. and in some instances 100 per cent. greater on the plots where vetch or vetch stubble had been plowed in than on the plots where rye had grown.

The same plots, uniformly fertilized, were again planted in corn in the spring of 1899. The present appearance of the crop (August, 1899), indicates that the superiority as fertilizers of vetch stubble or vines is still maintained.

Still more strikingly has a crop of silage corn, planted a few days after plowing in vetch or vetch stubble, shown the great value of hairy vetch as a fertilizer or green manure, these causing nearly the quadrupling or trebling of the yield of corn on an adjoining plot.

In both of these experiments, here only briefly alluded to, the entire vetch plant was compared with the roots and stubble as fertilizer. With corn, the yield of grain was scarcely different, whether the entire vetch plant or only the stubble had been plowed in. With silage corn, the yield of green material per acre grown on the vetch stubble plot was $2\frac{3}{4}$ tons less than on the plot where vetch vines, stubble and roots had been plowed in. This superior yield of silage corn resulting from the plowing in of the entire growth of vetch was more than offset by the 3,600 pounds of hay per acre obtained from the vetch-stubble plot. This hay contained a greater amount of dry matter of better quality than that in the $2\frac{3}{4}$ tons of silage corn.

Fertilizing materials in hairy vetch.—The experiment to ascertain the best time to cut hairy vetch for hay,—which has been reported on a preceding page,—had also another aim, viz., to determine the stage of growth when hairy vetch is most valuable as a green manure.

By the use of a frame, six feet square, samples of tops (or hay) and of the stubble and roots were carefully taken. The roots to a depth of six inches were collected, the earth being separated from the roots by sifting. The loss of a small weight of the finer roots was unavoidable, but the error thus involved was inconsiderable and nearly constant for all samples. The stubble, two to three inches long, was collected with the roots, except on May 9, when roots were separated from stubble and fallen leaves.

The following table shows the composition,from the standpoint of fertilizer value, of tops and roots and stubble of hairy vetch at different stages of growth, and for comparison, the composition of the corresponding parts of the rye plant:

Analyses of vines and roots and stubble of hairy vetch harvested at different dates.

Material analyzed (by C. L. Hare.)	Date (1899) and stage when cut	Fertilizing materials.		
		Nitrogen.	Phosphoric acid. (P_2O_5).	Potash. (K_2O).
		Per cent.	*Per cent.*	*Per cent.*
Tops; hairy vetch....	April 19; just before bloom.....	3.75	.81	2.18
Tops; " "	April 26; 5% of blooms showing.	3.03	.78	2.14
Tops; " "	May 2; in full bloom	2.75	.79	2.21
Tops; " "	May 9; seed pods formed, but not filled.	2.99	.74	2.68
Roots and stubble; hairy vetch.....	April 19; just before bloom.....	2.36	.49	1.23
Roots and stubble; hairy vetch.....	April 26; 5% of blooms showing.	2.03	.48	.88
Roots and stubble; hairy vetch.. ...	May 2; in full bloom.	1.97	.48	.88
Roots alone; hairy vetch.....	May 9; seed pods formed.....	2.19	.43	.96
Stubble & fallen leaves and blooms; hairy vetch	May 9; seed pods formed.....	2.07	.42	1.14
Rye tops.....	May 7, 1898; in dough stage.....	.52		
Rye roots and stubble.	May 7, 1898; in dough stage.....	.35		

It should be noted that the tops of the hairy vetch plant are about six times as rich in nitrogen as the corresponding portion of the nearly mature rye plant, and that the roots and stubble of vetch are also about six times as rich in nitrogen as those of rye.

The practical points are more clearly brought out in the following table, which shows the number of pounds of nitrogen, phosphoric acid, and potash contained in the vetch crop on one acre:

Pounds of fertilizing material per acre in hairy vetch cut at different dates.

Date when cut.	Pounds per acre.			
	Air dry material.	Nitrogen.	Phosphoric acid.	Potash.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
April 19; vines	3117	117.0	25.2	70.0
April 19; roots and stubble	850	20 0	4.2	10.5
April 19; total	**3967**	**137.0**	**29.4**	**80.5**
April 26; vines	3705	112.3	28.9	79.3
April 26; roots and stubble	870	17.7	4.2	7.7
April 27; total	**4575**	**130.0**	**33.1**	**87.0**
May 2; vines	5789	159.2	45.6	127.9
May 2; roots and stubble	1054	20.8	5.1	9.2
May 2; total	**6843**	**180.0**	**50.7**	**137.1**
May 9; vines	5463	173.3	40.4	156.4
May 9; roots alone	346	7.0	1.5	3.4
May 9; stubble and fallen material	1061	22.0	4.5	12.1
May 9; total	**6870**	**202.8**	**46.4**	**171.9**

The total amount of air dry vines, roots, and stubble increased at first slowly, and later rapidly, up to the time of full bloom, after which there was no increase. The maximum amount of air dry material was nearly $3\frac{1}{2}$ tons. This was on a stiff, reddish upland loam, thoroughly supplied with root nodule bacteria through the artificial inoculation of the preceding crop of hairy vetch.

The amount of phosphoric acid attained its maximum at the time of full bloom, while the quantity of potash appropriated increased rapidly as the plant grew older.

IS HAIRY VETCH OR COTTON SEED MEAL THE CHEAPEST NITROGENOUS FERTILIZER?

Of greatest importance are the figures showing the amount of nitrogen in the crop of vetch hay and in the roots and stubble.

As early as April 19, and before a single bloom could be seen, the entire plant contained per acre 137 pounds of nitrogen, or as much nitrogenous fertilizer as is contained in 1,957 pounds of cotton seed meal (7 per cent. nitrogen). The failure of the nitrogen to increase during the next week is only apparent and probably due to inequalities in sampling. In the week elapsing between the stages of early bloom and of full bloom (April 26 to May 2) the nitrogen increased very rapidly. When the plants were in full bloom the hay contained 159.2 pounds of nitrogen, and the roots and stubble 20.8 pounds per acre, the nitrogen in the hay alone being equivalent to that in 2274 pounds of cotton seed meal and the nitrogen in the roots and stubble to that in 297 pounds of cotton seed meal.

A still further increase in nitrogen took place during the week following the period of full bloom, bringing up the nitrogen in the hay to 173.3 pounds and in the roots, stubble and fallen leaves and blooms to 29.5 pounds. The nitrogen equivalent for these maximum figures would be respectively 2,475 and 421 pounds of cotton seed meal, or nearly as much nitrogen in the entire vetch plant growing on an acre (202.8 pounds nitrogen) as is contained in one and one-half tons of cotton seed meal.

Not all of this nitrogen is clear gain, for an undetermined proportion of it comes from the soil. But, as the soil is not rich and as non-leguminous crops are able to obtain only a fraction of this amount of nitrogen, it seems safe to assume that much more than half of the nitrogen contained in this heavy growth of vetch was obtained from the air, and thus was a clear gain to the soil when the vetch plant was plowed in.

Proportion of nitrogen in tops and roots.—Of the total amount of nitrogen in the entire plant the roots, short stubble and fallen material contained 14.6 per cent. just before the blooms appeared, 13.6 per cent. in the earliest blooming stage, 11.6 per cent. at the period of full bloom, and 14.6 per cent. in the pod-bearing stage.

Thus analysis found in roots, stubble and fallen material less than one-sixth of the total nitrogen. The real proportion was somewhat greater, as, in taking the samples, portions of the finest roots were unavoidably left in the soil. Moreover the stubble was much shorter than that left by the mowing machine, stems being cut by hand two or three inches from the ground. In view of these two facts we will not be far wrong in assuming that the portion of the vetch plant used for hay contains about four-fifths of the nitrogen, and that what is left on the ground contains about one-fifth. This agrees with results of 1898, given in Bulletin No. 96, when vetch roots and stubble contained 19 per cent. of the total nitrogen. This fifth of nitrogen itself represents considerable fertilizing material, as the different samples of roots and stubble contained as much nitrogen per acre as is found in from 253 to 421 pounds of cotton seed meal, and enough to insure a good growth of crops following vetch stubble.

These experiments teach: (1) That hairy vetch when stocked with an abundance of root nodules, is able to accumulate exceedingly large quantities of nitrogen from the air; (2) That when the entire growth is to be turned in as a green manure, the plowing should be postponed as late in the life of the plant as practicable; (3) That the greater portion of the fertilizing material is in the vines or tops, although the roots and stubble often contain sufficient nitrogen for the needs of the succeeding crop; (The high value of the hay and the richness of the manure made from this hay, make it usually advisable to cut the hay and use only the stubble as green manure).

DIRECTIONS FOR SOWING HAIRY VETCH.

Time to sow.— September is the best month in this latitude. October 15th is not too late for the Southern half of the State, though earlier sowing is preferred. In one instance we sowed as late as November 4th, with success. Most of our November sowings have partially or completely failed. Seed sown here between October 1 and October 15

has usually given satisfactory results. On land not liable to severe injury from drought, August sowing, though risky, is permissible, especially when this date coincides with the last working of sorghum, late corn, etc.

Preparation of land.—If the land is weedy, plow it as for wheat or oats. Having inoculated the seed, sow them broadcast. Sow acid phosphate or some potash fertilizer, or both, if the land is poor or needs either or both. Cover seed and fertilizers with any deep working harrow, or with cultivator, or with any other implement that will cover the seed 1 to 3 inches deep.

If the land is in cotton, very late corn, or drilled forage plants, sow vetch seed broadcast without breaking the land. Work the seed and mineral fertilizer in with cultivator or one horse harrow. This will not materially injure the cotton if the cotton rows are as wide as they should be and if the cultivator, with short single-tree, is used immediately after the first or second picking.

Amount of seed.—If hairy vetch is sown alone or with only a few pecks of oats to support the vines, one bushel of vetch seed per acre will be needed for a full crop of hay. On large areas, especially where the farmer is doubtful about his ability to thoroughly inoculate the seed, it is safer to sow nearly or quite the usual amount of fall oats, adding as many vetch seed as the pocketbook permits, from one gallon to one-half bushel per acre. The greater the proportion of vetch seed the greater the quantity of hay or pasturage, the richer its quality, and the greater the improvement of the soil. At least one peck of vetch seed per acre is desirable. For hay or pasturage, or both, this may be sown with 1½ to 2½ bushels of turf oats, or if only pasturage is wanted it may be sown with 1½ bushels of rye per acre.

Red rust proof, or Texas, oats may be used where hay or grain, is desired, rather than pasturage and in localities where September and October sowings of this variety of oat usually escape winter killing. On soils of fair fertility the turf oat is preferable for hay as well as on account of its

superior hardiness and suitability for grazing. On very poor soils we have found the turf oat almost too late for cutting when vetch is at its best. Our Southern rye ripens too early for cutting with heavy vetch.

A more promising oat for sowing with vetch is Hatchett's Black, which, though never sown here with vetch, has, when sown alone, proved hardy here; its advantages over the red oat are its hardiness and length of straw and over the Myers turf oat, its earlier maturity. Our seed were obtained from T. W. Wood & Sons, Richmond, Va.

Hairy vetch has been successfully grown for winter pasturage on Bermuda sod. To insure the germination of the vetch seed it is desirable to scarrify the Bermuda sod every fall. For this purpose we have used a narrow scooter plow, but probably a heavily weighted disk harrow might be used for this purpose with greater convenience and reduced cost. Of course stock must be removed for at least a few weeks at the time when vetch seed are being formed to insure annual reseeding of the pasture.

FERTILIZERS FOR HAIRY VETCH AND OTHER LEGUMES.

The legumes, if supplied with tubercles, that is, if thoroughly inoculated either naturally or artificially, need no nitrogenous fertilizers,—no stable manure, cotton seed, cotton seed meal, or ammoniated guano. By the aid of root nodule bacteria they can get their nitrogen from the air.

But they are entirely dependent on the soil or the fertilizer for mineral fertilizers, that is, for phosphoric acid and potash. The table given on page —— shows that the hay from an acre of hairy vetch plants in full bloom removed from the soil as much phosphoric acid as is contained in 365 pounds of ordinary (12½ per cent.) acid phosphate, and as much potash as would be supplied by 1,097 pounds of kainit containing 12½ per cent. of potash.

Although this was an exceptionally heavy crop and an unusual draft on the soil, the figures suggest that even an ordinary crop of vetch hay (indeed, of any hay), removes

a large amount of phosphates and potash from the soil. To grow vetch hay for several years without supplying these mineral fertilizers will exhaust the phosphates and potash in poor or medium soils and will result in reduced yields of vetch. Vetch used exclusively for pasturage or soil improvement would not thus rapidly exhaust the phosphates and potash of the soil.

On the sandy and loamy soils of this vicinity we have found it profitable to use 240 pounds of acid phosphate and forty pounds of muriate of potash per acre. If kainit is used instead of the muriate, 150 to 200 pounds per acre are employed. The phosphate alone will doubtless be sufficient on many soils, especially if the vetch is used for pasturage or for soil improvement and if no hay is removed from the field. Of course, some of the soils of Alabama need no commercial fertilizer for an occasional crop of hay, but the removal of many successive crops of any kind of hay will, on almost any upland soil, finally necessitate the use of fertilizers for both leguminous and other crops.

As elsewhere stated, the farmer whose land is not already supplied with "vetch germs," and who cannot or will not make use of artificial inoculation, must, on ordinary soils, go to the additional expense of applying nitrogenous fertilizers on his first crop of vetch. He may use, in addition to above-mentioned mineral fertilizers, say 200 pounds of cotton seed meal per acre, or a liberal application of stable manure, or he may sow vetch on land recently enriched in nitrogen by a crop of cowpeas.

THE WEED QUESTION.

That farmer is wise who, before introducing a new plant on his farm, asks whether there is danger of its becoming a troublesome weed. The writer has never heard or read any complaint of vetch as a weed. There is a probability that if carelessly managed on a wheat farm hairy vetch might give trouble through possible admixture of early ripening of vetch seed with late ripening wheat, The grains could not be separated on the farm, and the writer does not

know whether they could be separated at the flouring mills. This mixture is conjectural only. Even if the seasons of maturing of wheat and vetch should occasionally thus overlap, careful management could avoid the danger by cutting vetch hay early, or by plowing in vetch before the seeds form, on any fields where wheat is to be sown the following fall. If the wheat field were terraced, care would be necessary to prevent the vetch plants on the terrace bank from seeding.

Hairy vetch is strictly an annual, and hence if kept from seeding it will not re-appear. The admixture of vetch seed with oats is not objectionable in oats fed on the farm, as vetch seed has been successfully used as a grain food.

ENEMIES OF VETCH.

It is not intended to give a list of the diseases and insects that injure vetch.

Hairy vetch is hardy as regards cold. Sowing in October or earlier, it withstood the exceptional cold of the past winter when the thermometer in February showed the phenominally low record of degrees Fahreinheit below zero. Younger plants were injured, and the stand thinned, but not killed out entirely.

The most serious trouble with vetch on the Station Farm at Auburn is the nematode worm, with which our fields, and gardens and orchards in many parts of the State, are infested. It is because of the presence of this pest in the soils of this Station that we are not justified in shipping our soil for use as inoculating material. Whoever uses garden soil as inoculating material for vetch should first endeavor to make sure that this pest is not in the soil of his garden.

The presence of the nematode worm, microscopic in size, may be known by the enlargements or galls which it causes on nearly all plants with tender succulent roots, especially on cabbages, turnips, beets, celery, okra, tomatoes, most legumes, and even cotton.

The nematode gall, which is the result of an injury to the

root by a minute worm, may be distinguished from the beneficial root nodule or tubercle found on thrifty leguminous plants, by the following differences:

(1) The desirable nodules are usually but slightly attached to the root, occupying a position on the side of the root, while the nematode gall, in its early stages, is usually concentric with the root; the root seems to grow through the center of the little spindle-shaped gall, the shape and location of which on the root may be compared to a sweet potato. The gall has only the diameter of a knitting needle or wheat straw; later, when the gall becomes corky or begins to rot it loses all constancy of shape and greatly enlarges;

(3) The presence of enlargements on the roots of cabbage, squash, okra, tomatoes, or related plants indicates the presence of the nematode pest, for tubercles are never found on the roots of the non-leguminous plants of the farm and garden.

It is not meant to say that the presence of the nematode pest prevents the growth of vetch. Doubtless the yield of vetch is greatly reduced by the presence of the nematode galls, but we have obtained heavy crops of hairy vetch hay from a loam soil badly infested with nematodes. One failure of vetch on deep white sandy soil on this farm was attributed to the joint effects of nematode injuries and late sowing. Nematodes are more often found and more injurious in light sandy soils than in those containing a fair proportion of clay.

Mention must also be made here of the destruction of the green seeds of vetch, which occurred here for the first time during the past May and June. On certain small, isolated areas, the destruction of seed by one or more unidentified insects was so great that not enough seed matured to re-seed the land. This injury was felt, but was less serious, on larger areas of vetch.

SUGGESTIONS ABOUT THE RESEEDING OF HAIRY VETCH.

One of the reasons for giving preference to hairy vetch as compared with crimson clover is because of the ease with which the former reseeds the land. When the ripe seed pods burst open they scatter the seed to considerable distances. These seed do not ordinarily germinate until the latter part of summer, so that it has been recommended to sow cowpeas on fields where hairy vetch has shed its seed in June. Sometimes the cowpeas are sown in drills and cultivated. But if the summer is wet, causing the early germination of the vetch seed, the cultivation of the peas may be at the expense of the stand of vetch. By omitting the cultivation of the cowpeas when vetch plants have come up, or by sowing the cowpeas broadcast, this danger may be avoided.

Hairy vetch used as pasturage will reseed the land if stock are removed a few weeks before the time of seed formation, On the Mississippi Agricultural College farm hairy vetch and turf oats are cut for the grain crop at such a late stage as to insure the shattering of enough seed of both vetch and oats to reseed the land,—invariably with vetch, and generally with oats.

By sowing hairy vetch with red oats sown early in the fall for grain, reseeding will sometimes occur by leaving a long stubble including considerable of the lower portion of the vetch plant, with attached seed.

Here, by cutting *quite early* a mixture of vetch and oats, we have obtained a hay crop of best quality, and the vetch stubble has afterwards (in favorable seasons) made sufficient growth to reseed the land. If vetch is expected to make enough second growth to insure the reseeding of the land, cutting should occur when the plants are in the early blooming stage.

Or by pursuing exactly the opposite course, cutting the vetch after some pods have matured, hay can be made from hairy vetch without interfering with reseeding. Such

hay is not of good quality and not marketable, but may be fairly nutritious.

ADAPTING VETCH TO ORDINARY ROTATIONS.

From what has just preceded it may be inferred that the self-seeding of vetch is comparatively easy in a rotation where vetch is every year the principal crop and where the intervening summer crops are those that occupy the land but a few months. Among the crops suitable for such use are cowpeas, sorghum, late-planted corn for grain or for the silo, Spanish peanuts, and a number of quickly maturing forage crops.

However, it is still an open question whether hairy vetch can be so managed as to annually reseed itself when the rotation is one suitable for an ordinary cotton farm, needing relatively little forage. Possibly those who work terraced land, especially where the terraces are near together, may be able to effect this by having vetch on the otherwise unoccupied terrace banks and allowing it to grow there continuously, expecting it, with or without the farmer's help, to distribute its seed into the cultivated land on either side.

It is certain that the cotton farmer needs hairy vetch in his rotation, since it will pay in soil improvement alone, leaving out of consideration the forage incidentally produced. He will have no difficulty in utilizing hairy vetch in rotation with cotton if he will sow vetch seed each fall, either purchasing or saving the seed.

Let us take for example a rotation, which, even without vetch, is one of the best and most practicable for cotton farms maintaining some live stock in addition to work teams:

First year, cotton;

Second year, corn, with cowpeas between rows;

Third year, fall-sown small grain, followed next June by cowpeas, which in turn is followed by cotton the next year.

The introduction of hairy vetch (or of crimson clover) as a catch crop to occupy the land in winter would certainly

improve this rotation. Is its introduction practicable? It is, as may be seen by the following example of one means of utilizing vetch in a three year rotation of cotton, corn and oats:

First year:—Cotton, with vetch seed worked in during September immediately after first or second picking; the vetch to be turned under in March, or if to be followed by late corn, plowing may take place later when the fertilizer value of the vetch will have increased.

Second year:—Corn; the corn to be harvested in time for breaking the land in latter part of September or October for a mixture of oats and vetch.

Third year:—Oats and vetch sown together; the harvesting (for hay or grain) to occur at such a time as to insure the self seeding of the vetch; broadcast cowpeas to be grown during the summer and cut for hay in time for the volunteer vetch plants to occupy the ground. This vetch should afford grazing in February and March and be plowed under in time for cotton to be planted in April of the fourth year, thus beginning again the same rotation.

The amount of vetch seed required during the entire period of rotation would be as follows for each acre:

For sowing after cotton	1 bushel
For sowing with oats after cotton	$\frac{1}{4}$ to $\frac{1}{2}$ "
For volunteer vetch crop after above	0
Total amount of seed for 1 acre for 3 years	$1\frac{1}{2}$ bushel
Average annual amt. seed per acre thus cropped	$\frac{1}{2}$ "

In return for this outlay for seed and for the cost or working in the seed among the growing cotton plants, there would be obtained from vetch the following benefits:

(1) *In food;* (a) February and March grazing during two seasons and (b) the vetch hay harvested with the oats;

(2) *In soil improvement;* (a) The nitrogen that is obtained from the air by two crops of immature vetch grazed and turned in;

(b) The air-derived nitrogen of the half crop of vetch (with oats) stored up during an entire season, part of this fertility being represented by the vetch stubble and part by the hay or by the manure obtained from feeding this hay;

(c) The soluble soil nitrogen whose escape in the drainage water of winter has been prevented by winter-growing vetch;

(d) The mechanical improvement and increased ability to withstand drought, due to the incorporation of the vegetable matter contained in the several crops of vetch.

In view of these gains from sowing hairy vetch can there be any question as to whether the annual outlay for a half bushel of seed (say $1.50 per acre) is a profitable investment? These benefits are conditional upon the presence of root nodules, whether these occur as the result of natural or of artificial inoculation.