XVI. STUDIES ON THE NITROGEN CONTENT OF WEEDS AND THEIR RELATION TO SOIL FERTILITY.

Horace J. Harper and Henry F. Murphy, Oklahoma Agricultural Experiment Station.

Ever since man emerged from the savage state and began to develop a higher state of civilization, he has been confronted with the problem of soil fertility. The Chinese have been struggling with this problem for over four thousand years and have developed many desirable practices as a result of their long period of experiences. In the United States the problem of soil fertility has been studied from many angles and methods of maintaining soil fertility have been worked out which are applicable to many localities, but the maintenance of soil fertility in the region of marginal and submarginal land still remains an unsolved problem. In most of the soils which are now classified as marginal land, the potential fertility was low before the land was brought under cultivation but the availability of much of the plant food which was present was usually high. As a result large yields were produced and little attention was given toward the maintenance of the crop producing power of the soil. Now we have a lot of poor land which is being farmed by poor people and some inexpensive system is needed which can be used to build up and keep on building up the impoverished soils which we find in our fields today.

Are we on the right track in our soil building program? This is a vital question and is one that will need considerable investigation before it can be answered satisfactorily.

At the present time most of the investigators are recommending that the farmer should grow more legumes in order to build up his soil. Now just how do legumes build up soil fertility? Legumes require minerals for their metabolism just the same as nonlegumes and these minerals are taken from the soil. If the legumes are removed from the land, which is the usual custom, a large amount of mineral plant food is lost and the land is made poorer, not better. Besides mineral plant food the legumes need nitrogen as do all other green plants. The only difference between legumes and nonlegumes from the standpoint of metabolism is that the legume plant is capable of assimilating free nitrogen from the air by the aid of certain bacteria (*Rhizobium leguminosarum*) which grow on their roots. On the other hand there is another group of micro-organisms called Azotobacter which are capable of assimilating atmospheric nitrogen without the aid of growing plants, consequently our problem is to determine whether or not the nonsymbiotic group of bacteria can fix enough nitrogen to satisfy a profitable cropping system as compared with the nitrogen fixed by symbitotic bacteria growing on the roots of legumes. It may be that a combination of the two systems is preferable. We cannot check the fixation of nitrogen by the nonsymbiotic organisms although it has been shown that their activities are greater in soils low in available nitrogen than when the nitrogen availability is high. However, there is one more point for consideration. The legume crop secures a considerable part of its nitrogen from the soil even though its roots are well inoculated with nitrogen fixing bacteria. The legume crop is planted at a considerable cost for seed and labor. Also in the process of growth cultivation is necessary especially in cases of row crops and cultivation results in the rapid destruction of organic matter in the soil due to increased aeration, which may in many cases amount to nearly as much as the organic matter produced by the growing crop. Under such conditions the soil is not benefitted appreciabily even though the whole legume crop is returned to the land. Another problem on our poor lands is inoculation. Many of our legume crops are poorly inoculated and consequently much of the nitrogen used by the legume plants must come from the soil. In other words, legume plants may be of little more benefit than non-leguminous plants under present conditions where farmers have been taught to grow legumes for feed rather than to plow under for soil improvement because in most cases the tops of the legumes are cut and hauled from the land.

Everyone is familiar with the fact that if a soil which has been farmed at some previous time, has been allowed to lie idle and grow up to weeds, that such soil is more productive when brought under cultivation again than it was when the last crops were grown provided erosion has not entered into the problem. Why is this true? Has the plant food been increased? Has the organic matter content been raised? The farmer doesn't worry about the question. He knows that the land produces more than it did before. The problem then is this, can weeds with the aid of azotobacter be used to maintain the nitrogen and organic matter content of marginal land as satisfactorily as can be done by means of legume crops?

A close examination of land which has been allowed to lie idle will reveal a marked difference in the types of vegetation which are present on various fields. Clean cultivation tends to eliminate many weeds and this is especially true in case of the native legumes. However since fixation of nitrogen is not dependent on the presence of legume plants, it is entirely possible that the transfer of the seed of easily eradicated weeds to so-called worn out land might be the most practical method of building up the organic matter and nitrogen content of the soil so that the land could again be utilized for the production of agricultural crops.

In order to secure more information on this subject let us examine the data which are given in Table I on the nitrogen content of certain weeds and cultivated crops.

Although the table does not contain a very complete list of the weeds found in the state it does contain most of the common weeds found growing in cultivated fields. One of the most outstanding facts which appears in the table is the high percentage of nitrogen which is found in most of the weeds analyzed. The samples were all mature when secured unless otherwise designated and the high values are not due to imature plants which usually contain a higher percentage of total nitrogen than mature plants.

Canadensis (*Erigeron canadensis*) is a very common weed in Oklahoma and the average of several analyses of this plant gave a nitrogen content of 1.813%. This is almost as high as the average for the soybean (*Soja max*) plant which was 1.899%. The crab grass

(*Digitaria sanguinalis*) which grow in our fields oftentimes after the cultivated crop has matured or has been harvested, performs a good function. It utilizes the nitrogen that is made available later in the season and which might otherwise be lost by leaching out of the soil. This plant is high in nitrogen, the two samples analyzed containing 1.676% and 2.189% of this valuable plant food. The rosin weed (*Aplopappus sciliatus*) is another weed that is quite common and seems to grow quite well on poor soils. This plant also is high in total nitrogen and like many other weeds apparently has a low coefficient of evaporation, and as a result makes a good growth with a limited supply of moisture.

The ragweeds (*Ambrosia artemisiaefolia* and *Ambrosia psilostacha*) and sunflower (*Helianthus annus*) both contain considerable amounts of nitrogen. An interesting relationship occurred in case of the sunflowers. One sample grew without competition from other plants while the other sample was secured from a very thick stand of plants which had long stems and few leaves. The taller sample contained only one-half as much nitrogen as the sample which grew without competition. Campbel.* in his study of the nitrogen content of weeds found that the stems contained less nitrogen than the leaves, consequently plants having a high percentage of stem would be lower in nitrogen content than similar plants having a high percentage of leaves. Other references on the nitrogen content of weed are North Dakota Bulletin No. 115 and Minnesota Bulletin No. 101.

The weed which contained the lowest amount of total nitrogen was coreopsis (*Coreopsis tinctoria*). This plant grows very abundantly in cultivated fields, especially in seasons of high rainfall or on poorly drained land. It grew so luxuriantly in northern Oklahoma during the past season that many fields of wheat were smothered and the crop was not harvested. This plant is rather low in total nitrogen and although it would produce quite a large amount of organic matter, it has been found rather recently that the organic matter of plant tissue low in total nitrogen, has very little effect in increasing soil organic matter because the carbohydrate materials are easily oxidized an dleave no residues in the soil.

The average nitrogen content of twenty-five samples of straw was .519 percent. There was a wide variation in these analyses. One sample of oat straw grown on land which had previouslybeen in alfalfa analyzed 1.21% nitrogen while one sample of wheat straw grown on very poor land analyzed only .283% nitrogen. From these analyses it is very evident that weeds are far more valuable than straw from the standpoint of their nitrogen content.

The highest content of nitrogen found in this study occurred in immature hairy vetch plants. On April 21, 1926, young vetch grown on the Oklahoma Agricultural Experiment Station farm contained 4.1% nitrogen. The percentage of nitrogen decreased as the plants matured and was about 2.67% when the plant was mature. Austrian winter peas contained about the same amount of total nitrogen as the hairy vetch. These two crops are promising winter cover crops

*Botanical Gazette v. 78 (1924) p. 103-115.

and grow during a season when most weeds and cultivated crops are dormant. Rye also grows during this period but the nitrogen content of the rye at the time the heads begin to emerge is just about the same as that of the weeds studied.

Sweet clover which is a rank growing plant and has a very extensive root system does not contain very much more nitrogen than the weeds studied.

The yield of the weed growth has not been determined very carefully for many of the different plants but it is not unusual to secure a ton of dry material due to weed growth on relatively poor land. This compares favorably with the yield of cultivated crops under similar conditions.

Much opposition would undoubtedly be encountered if such a program were recommended for marginal land but there is on economic problem which must be solved and that is, "By what method or methods can the marginal farmer increase his yields most easily and most economically? Can he afford to buy legume seed, and plow, plant and cultivate his fields in order to produce a crop of organic matter to plow under which may not exceed in total tonnage that which could have been produced by the weed growth occuring on the idle land.

Weeds as a rule are considered as an enemy of the farmer, but there are many places in Oklahoma and elsewhere where weeds can not be considered as an enemy but must be considered as an aid in helping to maintain the fertility of the soil. The feeding power of weeds deserves considerable attention, because any plant which will produce a good growth on poor land and is not too difficult to eradicate will be of value in helping to solve the problem of soil fertility on our marginal land. The botanist is in an excellent position to help with this problem and can render a valuable service by studying the growth of native vegetation including both legumes and nonlegumes on abandoned land. More research is needed, and it is hoped that in the near future other research workers can add to the meager bit of information which has been accumulated in this investigation.

Table I. A comparison of the nitrogen content of certain weeds and cultivated plants.

No.	Plant	Location	Percent of Nitrogen
1.	Canadensis	Estill Farm, Carrier, Okla.	1.882
2.	"	Station Farm, Stillwater, Okla.	2.445
3.	"	5 mi. SE. Stillwater, Okla.	2.225
4.	"	East of Buffalo, Okla.	2.023
5.	"	Quinlan, Okla.	1.538
6.	"	Glencoe, Okla.	1.188
7.	"	Chandler, Okla.	1,393
		Average	1.813
8.	Sunflower	East of Orlando, Okla.	1.225
9.	"	5 mi. SE. Stillwater, Okla.	2.310
10.	Annual Ragweed	Glencoe, Okla.	1.653
11.	" "	O. A. M. C. Campus	2.222
12.	" " (Tops)	Hastings Farm, Perkins, Okla.	1.739
13.	" " (Roots)	" " " "	534
14.	Perennial Ragweed	Enid, Okla.	1.673
15.	" "	Stillwater, Okla.	1.802
16.	Rosin Weed	Okeene, Okla.	1.688
17.	" "	Buffalo, Okla.	1.734
18.	" "	Estill Farm, Carrier, Okla.	1,320

19.		5 mi. SE. Stillwater, Okla.	1.765
		Average	1.627
20.	Coreopsis (Mature)	Carrier, Okla.	0.913
21.	" (Green)	" "	1,256
22.	" "	Enid, Okla.	1.071
23.	Wild Lettuce	Buffalo, Okla.	1.133
24.	" "	Goodwell, Okla.	2.112
25.	" "	Near Yost Lake, Stillwater Ok.	1.955
26.	Cockleburr (Tops)	Hasting's Farm, Perkins, Okla.	2,309
27.	" (Roots)	" " " "	.798
28.	Crab Grass	Stillwater, Okla.	1.676
29.	" "		2.189
30.	Poor Land Weed	Chandler, Okla.	1,123
31.	Black-Eyed Susan	" "	.932
32	Water Hemp (Large)	Enid, Okla.	2,037
33.	" " (Small)	" "	1.517
34.	" " (Roots)	" "	1.134
35.	Russian Thistle	Buffalo, Okla.	.1311
36.	Bermuda Grass (Seed stage)	Stillwater, Okla.	2,065
37.	Oat Straw (Max. N. Cont.)	Carrier, Okla.	1.210
38.	Wheat straw (Min. " ")	Sterling, Kan.	.283
39.	Straw (Av. of 25 samples)		.519
40.	Soybeans (Av. of 9 samples)		1.899
41.	Cowpeas	Stillwater, Okla.	2.360
42.	Hairy Vetch Apr. 21, 1926	Stillwater, Okla.	4,100
43.	" " in rye " " "	" "	3.430
44.	" " Apr. 11, 1927	" "	3.700
45.	" " Apr. 16, 927	" "	3.550
46.	" " Apr. 30, 1927 (Full Bloom)	" "	2.700
47.	" " May 26, 1927 (green pod stage)	" "	2.670
48.	Austrian Winter Peas (April 16, 1927)	" "	3.240
49	Austrian Winter Peas May 26, 1927 (pod stage)	" "	2,760
50.	Sweet Clover Ave. 2 samples (1st yrs. growth)	" "	2.530
51.	Sweet Clover (2nd yrs. growth) unlimed plot	" "	1.610
52.	Sweet Clover (2nd yrs. growth) limed plot	" "	1.960
53.	Cotton Burrs (1926)	" "	1.160
54.	Sesbania (Tops)	" "	2.660
55.	" (Roots)	" "	1.960
56.	Rye (Apr. 30, 1927) unfertilized	" "	1.750
57.	Rye (Apr. 30, 1927) fertilized	" "	1.483
58.	Rye in Hairy Vetch (Apr. 21, 1926)	" "	2.080