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Influence of Fertilizers On Four Legumes When Grown as Green Manures

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Influence of Fertilizers On Four Legumes When Grown as Green Manures

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THE ORGANIC MATTER content of Minnesota soils is declining. It is particularly difficult to maintain soil organic matter under cash-grain and corn-hog systems[2] of farming. Even with livestock systems, careful land and crop management is necessary to keep organic matter in the soil.

Plant nutrients can be returned to the land with commercial fertilizers; however, such fertilizers do not contribute to the maintenance of good soil structure or tilth. Soil organic matter is not only effective in maintaining good soil structure but also functions as a reservoir for plant nutrients which are released by the action of soil microorganisms. Maximum benefits from fertilizers are usually obtained when the soil is well supplied with organic matter.

On many farms the amount of manure produced is limited, and organic matter maintenance is largely dependent on the return of crop residues. Under any situation where organic matter maintenance is a problem, the use of green manure crops becomes increasingly important. These crops do not necessarily increase plant food, with the exception of nitrogen when a legume is used, but they do return substantial amounts of plant foods used in their growth which become available rather quickly. In addition they add organic matter which improves the physical condition of the soil.

With these benefits in mind this study was planned to determine which of four legumes is the greatest producer of tops and roots and which fertilizer elements or combination of elements produced the greatest yields under Minnesota conditions. The legumes tested were medium red clover, alfalfa, biennial white blossom sweet clover, and Hubam sweet clover.

RESULTS OF OTHER INVESTIGATIONS

A number of studies in Minnesota and elsewhere indicate that different legumes used as green manure crops vary in certain respects. Arny and McGinnis (*1*) found that under Minnesota conditions Hubam sweet clover produced 15 per cent more dry matter in tops than biennial white and 35 per cent more than biennial yellow blossom sweet clover. The biennials, however, far outyielded Hubam in root production.

In another Minnesota sweet clover investigation Dunham (*3*) reported that the maximum total weight of tops and roots was found in October of the year seeded when it was sown alone. One

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[2] Under the cash-grain system the land is largely used for corn, soybeans, small grain, and flax which are sold for cash. Under the corn-hog system a large proportion of the land is in corn which is fed to hogs. Such small grain as is grown is sold for cash. The number of livestock to consume roughage is limited in both cash-grain and corn-hog systems.

variety, Grundy County, was an exception.

Willard (9) in a study in Ohio obtained the results found in table 1.

Table 1. Dry Matter Per Acre in Legume Tops and Roots (9)

Crop	Tops	Roots	Total
		pounds	
Red clover	1,950	510	2,460
Alfalfa	1,700	1,380	3,080
Biennial white blossom sweet clover	2,360	2,320	4,680
Hubam sweet clover	3,840	360	4,200

Snider and Hein (7, 8) reported the greatest amount of total dry matter for sweet clover occurred between June 25 and July 21 of the second year in Illinois. However, the maximum root depth and bulk was in the fall of the first season with the maximum amount of tops in the second summer.

Data from Hutcheson (4) and Snider (6) demonstrate that legumes are heavy feeders of soil nutrients and if not returned directly or indirectly can remove large quantities of nutrients from the soil. Unless good soil management practices are followed these soil conserving crops can remove plant food more rapidly than the soil depleting crops.

That legumes respond to fertilization has been determined by many investigators. For example, red clover over a 24-year period on plots treated with phosphate, phosphate-potash, and with nitrogen, phosphate, and potash produced yields averaging 1.67, 2.03, and 2.14 tons per acre, respectively, as compared to 0.82 tons per acre on unfertilized land (4). In a Texas experiment (5) with vetch significant increases in dry matter of the tops were produced by phosphate, nitrogen-phosphate, and phosphate-potash applications. The root weight was increased 28, 34, and 33 per cent, respectively, by the three treatments.

In Minnesota, Burson, Harris, and Rost (2) found that fertilization with a readily available phosphate fertilizer increased both the yield and phosphorus content of alfalfa hay. The yield increase averaged 0.82 ton per acre and phosphorus content slightly more than 20 per cent. They found that phosphate fertilizer also tended to increase the protein content of the hay.

Ordinarily nitrogen applications are not considered necessary for legumes, except perhaps when seeding on a soil low in organic matter or for annual legumes.

The beneficial effects of lime on acid soils are so well known as to need little emphasis. Although generally considered a soil amendment and not a fertilizer, lime exerts a beneficial effect on legumes by reducing soil acidity and increasing nutrient calcium in soils. Lime is also of great benefit to the microorganisms of the soil for they have much the same nutrient and environmental requirements as higher forms of life.

MATERIALS AND METHODS

Yields of tops and roots of four legumes were obtained from six locations in Minnesota in the fall of the first growing season, with the exception of the Experiment Station, Rosemount. The roots were harvested to a depth of 6 inches. This was accepted as a sufficient depth for the necessary comparisons. It has been found that with biennial sweet clover, for example, by far the largest bulk of the root was in the first 7 inches of the soil (7). Willard (9) stated "we are so accustomed to talking of the 'deep root system' of sweet clover that it is a little surprising to find 3/5 to 2/3 of the total dry weight of the roots in the top 4 inches of the soil."

Fertilizer treatments included applications of nitrogen, phosphate, and potash either alone or in combination. The

Table 2. Yield Per Acre of Alfalfa, Biennial White Blossom Sweet Clover, and Hubam Sweet Clover Tops, Roots, and Total Dry Matter from Renville Field, 1948

Plant nutrients in pounds per acre	Average weight in pounds			Average gain in pounds		
	Tops	Roots	Total	Tops	Roots	Total
Alfalfa						
0-0-0	645	1368	2013	.....	.....	.....
0-50-0	1140	2424	3564	495	1056	1551
25-50-0	1635	2112	3747	990	744	1734
25-50-50	1440	1776	3216	795	408	1203
12-50-50	1290	1728	3018	645	360	1005
Biennial White Blossom Sweet Clover						
0-0-0	570	1056	1626	.....	.....	.....
0-50-0	2085	2592	4677	1515	1536	3051
25-50-0	2190	2448	4638	1620	1392	3012
25-50-50	1605	1512	3117	1035	456	1491
12-50-50	2580	2880	5460	2010	1824	3834
Hubam Sweet Clover						
0-0-0	855	456	1311	.....	.....	.....
0-50-0	2550	816	3366	1695	360	2055
25-50-0	2280	528	2808	1425	72	1497
25-50-50	1950	888	2838	1095	432	1527
12-50-50	2055	912	2967	1200	456	1656

treatments consisted principally of phosphate and phosphate-potash mixtures. When results are reported, the different treatments are expressed as pounds per acre of N, P_2O_5, and K_2O.

Three one-fourth-square-yard samples were taken from each plot, except the plots in Renville and Chippewa counties where four samples were taken, and at the Agricultural Experiment Station, Rosemount, where one-square-foot samples were taken.

No facilities were at hand in the field to wash the roots and therefore only that amount of soil necessary to place the roots in a paper bag was removed. In the laboratory roots were washed over a fine wire screen, the tops and roots were dried, and the air dry weight of the tops and roots of each sample was determined.

EXPERIMENTAL RESULTS

Renville County Field

These plots, harvested in the fall, 1948, were located on Webster silty clay loam soil and sown with alfalfa, biennial white blossom sweet clover, and Hubam sweet clover. The plots were not replicated and accordingly yield figures could not be analyzed statistically. Nevertheless the data obtained are of value and indicate trends in the response of the species to fertilization.

The amounts of tops and roots of the three legumes show extremely large gains as a result of the fertilizer treatments (table 2). The field had been cropped continuously to corn and oats from 1943 to 1946 and planted to soybeans in 1947. Of the fertilizers used the 0-50-0 had least effect on the yield of alfalfa tops. However, the roots showed the greatest response to this treatment with a gain of 1,056 pounds per acre. The greatest amount of total dry matter for alfalfa was obtained with the 25-50-0 treatment.

The 25-50-50 treatment resulted in a minimum gain, 1,035 pounds for the biennial white blossom sweet clover tops, and the 12-50-50 treatment a maximum of 2,010 pounds over the untreated plots. All of the gains in top growth were greater than 181 per cent. In root

production major gains occurred with the 0-50-0 treatment, with some additional gains when nitrogen and potash were added as in the 12-50-50 treatment. More than 5,000 pounds per acre of total dry matter were produced as a result of the 12-50-50 treatment compared to 1,626 pounds per acre on the unfertilized plots.

The greatest gain for Hubam sweet clover tops was obtained with the 0-50-50 treatment, and yields declined with the addition of nitrogen and potash. Unlike the tops, the roots responded best to the nitgrogen-phosphate-potash combinations, while the nitrogen-phosphate treatment resulted in the minimum gain of only 72 pounds per acre. The combined tops and roots produced a total of 3,366 pounds of dry matter with the 0-50-0 treatment or an increase of approximately 157 per cent.

Nicollet County Field

This field was located on a broad upland plain of Webster silty clay loam. The plots were set up in 1947 as a part of a long-time rotation fertility experiment and consist of a series of 10 different treatments. Roots and tops were harvested from series V plots in 1948, series II in 1949, and series I, VI, and X in 1950. The series V, VI, and X rotation was grain, hay, corn, corn; the series I and II crop sequence was grain seeded to biennial white blossom sweet clover followed by corn. Before planting the legume the pH of these plots was series I, 6.1; series II, 7.47; series V, 6.75; series VI, 6.1; and series X, 5.6. The legume-grass mixture on series V, VI, and X consisted of a mixture of red clover, alsike, and timothy with the predominant crop being red clover.

On series V there was a significant gain in top growth of red clover from the 20-40-40 fertilizer combination (table 3). The 0-60-0 treatment was the only one which failed to produce a highly significant gain in root production. A gain of more than one-half ton in total dry matter was obtained with the 20-40-40 treatment.

The series VI red clover tops responded most to the 0-60-0 treatment with a significant gain of 1,024 pounds per acre. The phosphate treatments of 0-40-0 and 0-60-0 resulted in significant root increases of 328 and 550 pounds per acre, respectively. Only the 0-60-0 treatment showed a significant gain for total dry matter.

On series X, as on series VI, the largest yields of red clover tops, roots, and total dry matter were obtained with the phosphate treatment and no apparent benefit was derived from the addition of potash.

On series II the biennial white blossom sweet clover tops showed very little effect from fertilization, and, as with the tops, the use of nitrogen alone resulted in decreased root production. The 0-40-0 treatment gave a statistically significant increase in root production.

The series I plots of biennial white blossom sweet clover showed the greatest response to the 0-40-0 treatment, which was highly significant for the tops. This treatment also produced the greatest quantity of roots as well as total dry matter. The two nitrogen treatments, 20-0-0 and 20-40-0, resulted in negligible root gains.

Chippewa County Field

The plots from which the samples were taken in 1949 were located on Flom silty clay loam, which is a member of the Barnes-Parnell soil association. Biennial white blossom sweet clover was sown on all plots.

The biennial white blossom sweet clover tops in this experiment showed a great response to the 0-80-0, 40-80-0, and 40-80-80 treatments (table 4). A gain of more than 3,000 pounds of roots was produced as a result of the 0-80-0

Table 3. Yield Per Acre of Red Clover and Biennial White Blossom Sweet Clover Tops, Roots, and Total Dry Matter from Series I, II, V, VI, and X Plots from Nicollet Field, 1948, 1949, and 1950

Plant nutrients in pounds per acre	Average weight in pounds			Average gain in pounds		
N-P_2O_5-K_2O	Tops	Roots	Total	Tops	Roots	Total
Red Clover—Series V—1948						
0-0-0	799	381	1181	.....	.....	.....
0-40-0	1322	613	1935	523	232**	754
0-60-0	1055	507	1561	256	126	380
0-40-40	1371	683	2054	572	302**	873
20-40-0	1215	607	1823	416	226**	642
20-40-40	1703	693	2395	904*	312**	1214*
**L.S.D. 1%				1274	185	1607
*L.S.D. 5%				812	138	1025
Red Clover—Series VI—1950						
0-0-0	1259	661	1920	.....	.....	.....
0-40-0	1749	989	2738	490	328*	818
0-60-0	2283	1211	3494	1024*	550**	1574**
0-40-40	1731	777	2508	472	116	588
**L.S.D. 1%				1090	352	1353
*L.S.D. 5%				796	257	988
Red Clover—Series X—1950						
0-0-0	1646	1119	2765	.....	.....	.....
0-60-0	2223	1375	3598	577	256	833
0-60-60	1984	1297	3281	338	178	516
**L.S.D. 1%				1030	514	1501
*L.S.D. 5%				740	369	1078
Biennial White Blossom Sweet Clover—Series II—1949						
0-0-0	2080	2290	4370	.....	.....	.....
20-0-0	2040	2042	4082	—40	—248	—288
0-40-0	2040	2819	4859	—40	529*	489
20-40-0	2160	2662	4822	80	372	452
20-40-40	2100	2639	4739	20	349	369
**L.S.D. 1%				758	679	1575
*L.S.D. 5%				521	509	1083
Biennial White Blossom Sweet Clover—Series I—1950						
0-0-0	934	2036	2970	.....	.....	.....
20-0-0	1046	2042	3088	112	6	118
0-40-0	1304	2390	3964	370**	354	724
20-40-0	1088	2039	3127	154	3	157
20-40-40	1055	2205	3260	121	169	290
**L.S.D. 1%				356	691	1019
*L.S.D. 5%				265	515	760

treatment. The 0-80-0 and 40-80-80 treatments resulted in a total dry matter production of more than 7,700 and 6,700 pounds per acre, respectively.

When nitrogen and potash were each combined with phosphate it is interesting to note that nitrogen-phosphate produced the better result in the production of tops while phosphate-potash was very slightly better for root growth.

Due to the presence of free lime carbonate the *p*H of the soil of these plots was 7.8. As a result the phosphate applications were very beneficial, since much of the soil phosphorus was probably in the very slowly available tricalcium phosphate form.

Table 4. Yield Per Acre of Biennial White Blossom Sweet Clover Tops, Roots, and Total Dry Matter from Chippewa Field, 1949

Plant nutrients in pounds per acre	Average weight in pounds			Average gain in pounds		
	Tops	Roots	Total	Tops	Roots	Total
N-P_2O_5-K_2O						
0-0-0	1830	1629	3459	.....	.....	.....
40-0-0	2040	1619	3659	210	—10	200
0-80-0	2700	5058	7758	870*	3429**	4299**
0-0-80	1980	1938	3918	150	309	459
40-80-0	2550	3213	5763	720*	1584**	2304
40-0-80	1860	1948	3808	30	319	349
0-80-80	2340	3216	5556	510	1587**	2097
40-80-80	2790	3977	6767	960**	2348**	3308*
**L.S.D. 1%				898	1571	4095
*L.S.D. 5%				605	1179	2761

Cottonwood County Field

These plots located near Mountain Lake on a Clarion silt loam soil, at the beginning of the experiment had a pH of 5.7. Tops and roots of the four legumes—medium red clover, alfalfa, biennial white blossom sweet clover, and Hubam sweet clover—were harvested in the fall of 1950.

The 0-60-0 treatment resulted in a significant gain in red clover top growth of 248 pounds, which was exactly twice that of the 0-60-60 combination (table

Table 5. Yield Per Acre of Red Clover, Biennial White Blossom Sweet Clover, Alfalfa, and Hubam Sweet Clover Tops, Roots, and Total Dry Matter from Cottonwood Field, 1950

Plant nutrients in pounds per acre	Average weight in pounds			Average gain in pounds		
	Tops	Roots	Total	Tops	Roots	Total
N-P_2O_5-K_2O						
			Red Clover			
0-0-0	281	348	629	.....	.....	.....
0-60-0	529	489	1018	248*	141	389*
0-60-60	405	536	941	124	188	312
**L.S.D. 1%				253	326	521
*L.S.D. 5%				182	234	374
			Alfalfa			
0-0-0	303	316	619	.....	.....	.....
0-60-0	483	480	963	180**	164	344**
0-60-60	489	463	952	186**	147	333**
**L.S.D. 1%				164	240	328
*L.S.D 5%				118	172	236
			Biennial White Blossom Sweet Clover			
0-0-0	666	759	1425	.....	.....	.....
0-60-0	621	715	1336	—45	—44	—89
0-60-60	779	949	1728	113	190	303
**L.S.D. 1%				326	355	666
*L.S.D. 5%				234	255	478
			Hubam Sweet Clover			
0-0-0	1174	251	1425	.....	.....	.....
0-60-0	1205	265	1470	31	14	45
0-60-60	1658	357	2015	484*	106	590*
**L.S.D. 1%				575	157	720
*L.S.D. 5%				413	112	517

5). The 0-60-60 treatment, however, proved to be the more effective one for the red clover roots.

Both the 0-60-0 and 0-60-60 treatments resulted in highly significant gains of alfalfa tops. The gains in root production due to the two treatments were nearly equal, but were not large enough to be statistically significant.

For the biennial white blossom sweet clover tops and roots the 0-60-60 treatment was the only one which was effective.

The top and root gains of Hubam sweet clover were very minor for the 0-60-0 treatment, while the 0-60-60 combination resulted in increases amounting to 484 and 106 pounds per acre, or 41 and 42 per cent gains over the unfertilized plots, for the tops and roots, respectively.

The low yields of the four legumes were probably due to the weather, since the rainfall averaged 0.74 inch less than normal each month at Mountain Lake, and the timothy planted on the boarders of the plots did not become visible until a week before the legumes were harvested.

Redwood County Field

These plots were treated exactly the same as those in Cottonwood County. The soil type was Webster silty clay loam with a surface soil *p*H of 6.2.

The 0-60-0 treatment resulted in the greater gains for both the red clover tops and roots, and the root gains were highly significant (table 6).

In contrast to the red clover the 0-60-60 combination produced the higher yields of both tops and roots for alfalfa, biennial white blossom sweet clover, and Hubam sweet clover.

Table 6. Yield Per Acre of Red Clover, Alfalfa, Biennial White Blossom Sweet Clover, and Hubam Sweet Clover Tops, Roots, and Total Dry Matter from Redwood Field, 1950

Plant nutrients in pounds per acre	Average weight in pounds			Average gain in pounds		
N-P_2O_5-K_2O	Tops	Roots	Total	Tops	Roots	Total
		Red Clover				
0-0-0	672	421	1093	.....	.....	.....
0-60-0	1050	781	1831	378*	360**	738**
0-60-60	965	732	1697	293	311*	604*
**L.S.D. 1%				419	324	720
*L.S.D. 5%				301	233	517
		Alfalfa				
0-0-0	391	427	817	.....	.....	.....
0-60-0	512	544	1056	121	117	239
0-60-60	734	811	1545	343*	384**	728*
**L.S.D. 1%				409	383	775
*L.S.D. 5%				294	275	556
		Biennial White Blossom Sweet Clover				
0-0-0	527	1153	1680	.....	.....	.....
0-60-0	641	1259	1900	114	106	220
0-60-60	665	1428	2093	138	275	413
**L.S.D. 1%				309	623	913
*L.S.D. 5%				222	448	655
		Hubam Sweet Clover				
0-0-0	1239	283	1522	.....	.....	.....
0-60-0	1061	207	1268	—178	—76	—254
0-60-60	1469	363	1832	230	80	310
**L.S.D. 1%				832	319	1063
*L.S.D. 5%				597	229	763

Experiment Station, Rosemount, Dakota County

The plan of this series of plots called for the plowing down of certain legumes as green manures in the season following seeding. Accordingly plots were sampled in the first week of July, 1950, just prior to plowing down the legume. This was the only field not sampled at the end of the first growing season. The soil of these plots is Vermillion silt loam, derived from loess, and had a pH of 5.6. The plots were sown to red clover, alfalfa, and biennial white blossom sweet clover. The plots were limed when the experiment was started.

Highly significant increases in red clover tops and roots were obtained as a result of fertilization (table 7).

The biennial white blossom sweet clover tops and roots failed to show any gain from the 0-60-0 treatment. However, the gains due to the 0-60-60 combination were significant at the 5 per cent level for both tops and roots.

The results obtained at the Experiment Station, Rosemount, differed from those of the other fields in that both red clover and alfalfa exceeded biennial white blossom sweet clover in root production. The lower amount of sweet clover roots was probably due to the midseason harvest in the second year when a biennial is drawing upon its root reserves.

EFFECT OF FERTILIZERS ON STANDS AND DRY MATTER PRODUCTION

Plant counts were made of all the legumes harvested in 1950 except on plots on the Experiment Station, Rosemount. These counts were made to determine whether the fertilization under field conditions actually increased the weight of each plant or merely increased the number of plants per unit area.

Table 8 indicates that although the number of plants per unit area was greater on the fertilized than on the unfertilized plots the gains were not significant. Fertilization also generally increased the top, root, and total weight per plant. It was especially effective on

Table 7. Yield Per Acre of Red Clover, Alfalfa, and Biennial White Blossom Sweet Clover Tops, Roots, and Total Dry Matter from Rosemount Experimental Farm, 1950

Plant nutrients in pounds per acre	Average weight in pounds			Average gain in pounds		
	Tops	Roots	Total	Tops	Roots	Total
N-P_2O_5-K_2O						
		Red Clover				
0-0-0	1699	1137	2836	.....	.....	.....
0-60-0	3381	1473	4856	1682**	336*	2020**
0-60-60	3077	1622	4699	1378**	485**	1863**
**L.S.D. 1%				1040	477	1371
*L.S.D. 5%				687	315	906
		Alfalfa				
0-0-0	3115	1572	4687	.....	.....	.....
0-60-0	4705	2009	6714	1590**	437*	2027**
0-60-60	4237	1865	6102	1122**	293	1415**
**L.S.D. 1%				1101	463	1411
*L.S.D. 5%				727	306	931
		Biennial White Blossom Sweet Clover				
0-0-0	4060	803	4863	.....	.....	.....
0-60-0	3431	759	4190	—629	—44	—673
0-60-60	5919	1268	7183	1855*	465*	2320*
**L.S.D. 1%				2277	548	2721
*L.S.D. 5%				1503	362	1798

Table 8. Average Number of Plants Per One-Quarter Square Yard, and the Average Top, Root, and Total Weight Per Plant of Four Legumes

Plant nutrients in pounds per acre	Number of plants	Average top weight	Average root weight	Average total weight
$N\text{-}P_2O_5\text{-}K_2O$		grams	grams	grams
		Red Clover (4 fields)		
0-0-0	66.0	0.43	0.27	0.70
0-60-0	77.4	0.62**	0.36**	0.98**
0-60-60	77.9	0.50	0.31*	0.81
**L.S.D. 1%	21.3	0.12	0.06	0.15
*L.S.D. 5%	16.0	0.09	0.04	0.12
		Alfalfa (2 fields)		
0-0-0	72.9	0.12	0.13	0.25
0-60-0	80.3	0.18*	0.17*	0.35*
0-60-60	76.5	0.20**	0.19**	0.39**
**L.S.D. 1%	43.4	0.08	0.06	0.14
*L.S.D. 5%	31.8	0.06	0.04	0.10
		Biennial White Blossom Sweet Clover (2 fields)		
0-0-0	91.1	0.19	0.26	0.45
0-60-0	93.2	0.21	0.28	0.49
0-60-60	97.7	0.18	0.29	0.47
**L.S.D. 1%	39.2	0.07	0.09	0.16
*L.S.D. 5%	28.8	0.05	0.07	0.12
		Hubam Sweet Clover (2 fields)		
0-0-0	99.8	0.29	0.06	0.35
0-60-0	110.2	0.27	0.06	0.33
0-60-60	120.1	0.36	0.11	0.47
**L.S.D. 1%	47.5	0.18	0.12	0.29
*L.S.D. 5%	34.9	0.13	0.08	0.21

red clover and alfalfa. With red clover the 0-60-0 treatment produced highly significant gains for the roots and total weight per plant. The phosphate-potash treatment resulted in highly significant gains for the alfalfa tops, roots, and total weight per plant. There appeared to be a greater effect on the Hubam sweet clover with the 0-60-60 than with the 0-60-0 treatment.

Nitrogen alone or in combination exerted little effect upon the number of plants per unit area or the size of biennial white blossom sweet clover roots on the Nicollet County field (table 9). The phosphate treatment produced a significant gain in top production of sweet clover and greater gains for both root and total dry matter than any other treatment.

Table 9. Average Number of Biennial White Bossom Sweet Clover Plants Per One-Quarter Square Yard, and the Average Top, Root, and Total Weight Per Plant on Nicollet Field Series I Plots

Plant nutrients in pounds per acre	Number of plants	Average top weight	Average root weight	Average total weight
$N\text{-}P_2O_5\text{-}K_2O$		grams	grams	grams
0-0-0	90.9	0.26	0.55	0.81
20-0-0	85.8	0.29	0.56	0.85
0-40-0	88.0	0.35*	0.65	1.00
20-40-0	92.7	0.28	0.54	0.82
30-40-40	92.8	0.27	0.58	0.85
*L.S.D. 5%	18.0	0.07	0.12	0.22

Table 10. Effect of Fertilizer on the Average Yields of Legume Tops, Roots, and Total Dry Matter, 1948-50

Treatment	Tops	Gain over check	Roots	Gain over check	Tops plus roots	Gain over check
0-0-0	1311	.....	751	.....	2061	.....
0-P-0	1707	396*	1134	383*	2842	781**
0-P-K	1855	544*	1091	340*	2946	885**
**L.S.D. 1%	.....	436	.....	440	.....	719
*L.S.D. 5%	.....	323	.....	327	.....	534

All legumes, regardless of species, which were grown in experiments that included check, phosphate, and phosphate-potash treatments, were averaged and the results analyzed statistically. From the results (table 10) some generalizations can be offered: first, that the most top growth occurred with the phosphate-potash treatment; second, that the maximum root growth was with the phosphate treatment, although for both treatments yield increases were significant at the 5 per cent level; and third, that the total dry matter production was higher with the phosphate-potash treatment.

COMPARISON OF LEGUMES

Similarly an effort was made to determine which of the four legumes, regardless of treatments, was superior in top production, root production, and the production of total dry matter. However, only at Redwood and Cottonwood fields were all four legumes grown together in the same experiment. As a result of this, and because it is only one year's data, the generalizations cannot be as inclusive as with the fertilizer treatments. With these limitations in mind it can be stated that Hubam sweet clover was the superior producer of tops, with red clover and biennial white blossom sweet clover equal and ranking second, and alfalfa third (table 11). Biennial white blossom sweet clover produced the greatest amount of roots and also total dry matter. Hubam sweet clover was a poor fourth in root production but was nearly equal to biennial white blossom sweet clover in total dry matter produced. Since this data comes from a first season harvest it is not surprising that alfalfa, a long-lived perennial, ranked lowest in total dry matter production.

SUMMARY

This study consisted of field experiments in Chippewa, Cottonwood, Dakota, Nicollet, Redwood, and Renville counties, Minnesota. The Chippewa field was on Flom silty clay loam, a soil high in free lime carbonate. Renville, Redwood, Cottonwood, and Nicollet fields were on soils of the Clarion-Webster soil association. The soil on Experiment Station, Rosemount in Dakota County

Table 11. Average Yields of Tops, Roots, and Total Dry Matter in Pounds Per Acre on the Cottonwood and Redwood Fields, 1950

Legume	Tops	Roots	Total
Red Clover	650	551	1201
Alfalfa	485	507	992
Biennial white blossom sweet clover	650	1044	1694
Hubam sweet clover	1301	288	1589

is a loessial silt loam, classified as Vermillion silt loam. The legumes studied were red clover, alfalfa, biennial white blossom sweet clover, and Hubam sweet clover grown under various fertilizer treatments. The legume roots were harvested to a depth of 6 inches, and these were collected, with one exception, at the end of the first growing season. The weights of the air-dried tops, roots, and total dry matter were obtained in addition to stand counts on some of the 1950 fields. The material was collected over a three-year period, although only in Nicollet County did the data cover a continuous three-year period.

The fertilizer treatments used were principally phosphate and phosphate-potash, since there is little evidence that profitable responses occur when nitrogen is applied to legumes. Nitrogen alone and in combination was used in some of the experiments though not extensively, as one of the reasons for growing legumes is to supply the soil with additional nitrogen. Various rates of fertilizer application were used in the experiments although 300 pounds per acre of 0-20-0 and 0-20-20 was the general one.

CONCLUSIONS

The following conclusions may be drawn from the results of this study:

1. Biennial white blossom sweet clover, with the exception of the second growing season harvest, supplied the most root and total dry matter.
2. Hubam sweet clover supplied the most tops but was lowest in root production.
3. Red clover and alfalfa were about equal in top and root production and only in the second year did they equal biennial white blossom sweet clover in root and total dry matter production.
4. Phosphate with a few exceptions was the most beneficial fertilizer treatment.
5. Nitrogen alone had no appreciable effect and when in a complete fertilizer seldom exceeded the results obtained from phosphate or a phosphate-potash mixture.
6. The top and total dry matter production for the legumes as a whole was highest with the phosphate-potash combination, but the root production was slightly greater with the phosphate treatment.
7. The phosphate-potash combination proved to be the superior treatment in a majority of the cases for biennial white blossom sweet clover and for Hubam sweet clover top and root production.
8. Fertilization generally increased the number of plants growing within a unit area and also the weight of individual plants.

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