THE EFFECT OF FERTILIZERS ON THE PROTEIN, CALCIUM AND PHOSPHORUS CONTENT OF SOME CROPS GROWN ON THE DIFFERENT SOIL TYPES OF VIRGINIA

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by

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The soil has been an important subject of investigation for the agricultural chemist for a long time. The object of every investigation by agricultural chemists has been to determine the factors that limit crop production so that the farmer could produce the largest possible crops with the least expense; leaving the soil in a better condition and increasing its productive power at the same time.

The geological origin of a soil is an important factor and may give some indication of its fertility. Most Virginia soils are residual, that is, they were formed from bedrock in the position they now occupy and were not brought in by glaciers or water.

Geologically, the State is divided into the following general provinces: (1) The Coastal Plain, (2) The Piedmont Plateau, and (3) The Appalachia. Each geological division may have several distinct soil types and the fertilizer requirements may vary with each distinct type.

The Coastal Plain constitutes approximately one-fourth of the entire land area of the State. It is characterized by a broad, flat expanse of country, the elevation seldom ranging above 100 feet, and is intersected by numerous rivers, creeks and bays. The soils of this area are mostly sands and loams which are low in phosphorus,

nitrogen and potash. The soil is used as a seed bed and the plant food is supplied in the form of artificial fertilizers. This area is adapted to growing early vegetable crops and is known as the trucking section of Virginia.

The Piedmont Plateau extends from the Coastal Plain on the east to the Appalachia on the west. The soils of this area are red clays, silts and clay loams, which are fairly productive. These soils are adapted to growing almost all types of crops, grasses and fruits.

The Appalachia province embraces all the land area of the State from the eastern slope of the Blue Ridge Mountains to the western boundary of the State. In this area are found the Blue Ridge, Great Valley and Alleghany Ridges. All these areas have the Hagerstown series as the principal soil type and are productive soils, being particularly adapted to the production of grasses, grains and fruits.

These several soil types are widely different in their chemical and physical structure and characteristics. The claim is often made that plants show variations in their mineral elements and protein content, depending upon the character of the soil upon which they are grown. If this is true, then these variations could be corrected with fertilizer practices and would give some indication of the supply of available constituents in the soil. There seems to be a definite relation between the mineral elements in the plant and the available amounts of these minerals in the soil.

The soils of Virginia change as we pass from one part of the State to another, especially in the mountainous sections. We would naturally expect a change in the soil type to exert its influence upon the plants grown on this particular soil. It is a well-known fact that an abundance of plant food and the physical conditions of the soil exert a marked influence upon the growth and vigor of plants.

There are many factors which affect plant growth, such as the mineral content, the yield and the maturity. Water is a very important factor because all plant nutrients are absorbed in a soluble form. Reed (12) states that "The amount of moisture in the soil affects the concentration and osmotic pressure of cell sap; a low concentration seems to be associated with rapid growth, and a high concentration with slow growth and fruit bud formation." Shutt (14) records that "Wheat grown in newly cleared scrubland in parts of Northwest Canada is softer, more starchy and poorer in nitrogen than that grown on adjoining land which, through long cultivation, has lost some of its organic matter and, therefore, its capacity to hold moisture." Knight (10) and his coworkers have shown that altitude has a marked influence upon the maturity and mineral content of plants grown in Wyoming. Ellett (4) has shown that climatic conditions and soil type influence the protein content of bluegrass. However, the effect of fertilizer practices on the mineral content of plants is not clearly shown.

Investigations have shown that soils might be deficient in available phosphorus and calcium and these deficiencies are reflected in some cases in the plants grown on these soils. Forage crops have a lower calcium and phosphorus content on soils inadequately supplied with these elements than on soils adequately supplied. These elements play an important part in animal nutrition and a proper mineral metabolism is essential. The effect of phosphates in increasing the quality and feeding value of crops may be shown by their effect on the growth of animals.

The most nutritious pastures in England and the best dairy pastures in France are those whose soils are rich in phosphorus and calcium. This is also true in sections of the United States, soils derived from limestone produce nutritious pastures. The high phosphorus and calcium requirements of red clover which appear to be indicative of the requirements of other legumes, have made it difficult and frequently almost impossible to grow such crops without lime and phosphorus. On soils deficient in lime and possibly available phosphorus, non-legumes are grown and these crops are used as a forage almost entirely.

In as much as plants absorb minerals from the soil, we should expect that plants growing on soils would absorb and utilize these elements in some ratio to the relative amounts present.

If soil type and fertilizer practices affect or influence the composition of plants, forage crops that are deficient in phos-

phorus and calcium might influence the existence of malnutritional diseases among animals to which these crops are fed. These deficiencies may be improved by proper systems of soil management.

Object

The object of this investigation deals with the effects of soil type and fertilizer practices on the yield and composition of crops grown on the various soil types of Virginia and to compare these results with the averages obtained throughout the United States. In this way it is hoped that a contribution to the knowledge of Virginia-grown crops and their composition as affected by soil type and fertilizer practices may be made.

Review of Literature

Wiley (17) has shown that "Maize is the most invariable of cereals, maintaining under the most different conditions a most remarkable uniformity of composition."

Cooke (3) has found that "Nitrogenous fertilizers used alone increased the percentage of protein in the corn crops, but when used with potash, did not affect the composition; and when used with phosphoric acid, actually decreased the percentage of protein."

Thieler (16) states that "The lack of phosphorus in the ration fed to livestock could be directly traced through the plants grown to a phosphorus deficiency in the soil."

Elliot, Orr and Wood (5) have shown that the value of pasture grass is in direct proportion to the mineral constituents present; a high mineral content being associated with a high nutritive value.

Jessen (9) in studying the effects of nitrogenous fertilization of grass land on the proportion of grasses and clovers, states that "The application of sodium nitrate or other easily soluble nitrogen compounds to mixed growths of grasses and legumes, give the former the advantage owing to their greater transpiration rate and hence, more rapid assimilation. Where potassium and phosphoric acid are applied, while the grasses have the advantage at the start, the supply is ample for the legumes as well; and owing to the latter's simbiotic sources of nitrogen, they can compete more effectively with grasses."

McCarrison and Viswanath (11), studying the effect of fertilizing conditions on the nutritive and vitamine values of wheat, state that "The soil fertilized with farm yard manure yielded millet or wheat of higher nutritive value than the same soil fertilized with a complete commercial fertilizer on soil not fertilized for years. The difference seems to be in the vitamine content of the grain."

Hellriegel (6) has shown that when barley was grown in sand cultures and the nitrogen supply withheld, the grain was only two-thirds of the normal weight per individual. Also that the first addition of nitrates caused a marked rise in the weight per grain, but successive additions cause no further increase.

Hellriegel (7) has shown that varying the phosphate supply for barley grown in sand cultures to be materially affected. In absence of phosphates no grain was formed; when very little was added, grain formation proceeded normally, and the resulting grain was nearly full weight per individual; as the phosphate supply increased, the percentage of grain increased, but soon reached a maximum beyond which it would not go.

Hill, White and Jones (8) studying the effect of fertilization upon the composition of crops, have shown that corn from fertilized plats was richer in protein and potash than those from unfertilized plats. On plats which received bone meal the phosphorus content was high. Plats receiving superphosphate, tankage, nitrate and potash salts grew crops containing more ash and protein but less nitrogen-free extract than did plats receiving bone meal and potash salts. In general, this experiment shows that the composition of corn while slightly affected was not materially altered by fertilization.

Ames (1) states that "The composition of the wheat crop grown on unfertilized plats of two soils, containing different amounts of phosphorus, potash and nitrogen, is in accordance with the composition of these soils."

"The proportion of phosphorus, potassium and nitrogen in the wheat plant is increased by the addition of these elements to the soil."

"Phosphorus applied to soil, showing a deficiency of this element as measured by crop yields, increases the amount of phosphorus in the grain. Associated with this increased accumulation of phosphorus, there is an increased quantity of potassium and a decreased amount of nitrogen."

"The composition of wheat grown on the same soil, fertilized with different carriers of phosphorus, shows the phosphorus content to be higher on the barnyard manure plat."

Ames (2) in studying the effect of fertilizers on the composition of alfalfa hay has shown that "The phosphorus supply of the soil, as increased by the addition of acid phosphate, is reflected by the phosphorus content of the crop."

"When the fertilizer used contained both phosphorus and nitrogen, the increase in the amount of phosphorus over that found in the crop from unfertilized soils is not as great as where phosphorus without nitrogen was applied."

"The variations in the phosphorus content of the roughage are large, and these variations as affected by soil, fertilizer and climate, constitute factors of first-class practical importance to the breeder of livestock, especially as affecting the growth of bone."

Sievers and Holtz (15) state that "The total phosphorus content for all the soils in Washington State is very high and the available phosphorus very low as compared to similar soils from other sections of the country."

"The total calcium content of the same soils is high as compared to similar soils from other sections and none of the calcium is present in the carbonate form."

"The phosphorus and calcium content of oats grown on these soils is exceedingly low, averaging .138 and .09 per cent., respectively, as compared to about .30 and .38 per cent. for these crops as reported by other stations. For red clover the percentage for these elements for Washington was .15 and 1.55 while other stations reported about .20 and 1.75 per cent."

"In the sections where the forage crops were low in calcium and phosphorus, malnutritional disorders existed among the animals and it is thought that feeds containing small amounts of phosphorus may cause malnutritional diseases among animals."

Scott (13) has shown that many Montana grown forage crops contain much calcium but very little phosphorus in proportion. This condition produces a phosphorus deficiency and calcium excess in the matabolism of cattle fed upon them and gives rise to physiological disorders.

Forage crops from areas where cattle show bone chewing proclivities were analyzed and found to contain less phosphorus and more calcium than corresponding samples from unaffected areas. Soil samples from affected areas were high in calcium but apparently normal in phosphorus content. Since the crops grown upon them are phosphorus deficient, the soil's phosphorus is believed to be practically unavailable for plant assimilation.

Table No. 1.- Fertilizer Treatments of Samples Used in this Investigation.

County	Soil Type	Crop	Demonstration	Check	Yields in pounds per acre		
					Demonstration	Check	Difference
Rockbridge	Hagerstown Loam	Clover	133# 16% acid phosphate, 100# N. S.	No fertilizer	2500	2000	500
Pittsylvania	Cecil Loam	Clover	200# 16% acid phosphate, 100# N. S.	No fertilizer	1500	1500	----
Lunenburg	Cecil Loam	Timothy and Redtop	300# 16% acid phosphate,(S) 167# N. S.	300# 16% acid phos.(S)	3300	2000	1300
Buckingham	Iredell Loam	Redtop	200# 16% acid phosphate, 100# N. S.	No fertilizer	2500	1800	700
Amelia	Cecil Loam	Redtop	200# 16% acid phosphate, 100# N. S.	No fertilizer	2000	1000	1000
Rockingham	Hagerstown Loam	3rd.yr. Meadow Oat Grass.	133# 16% acid phosphate, 100# N. S.	No fertilizer	4000	3000	1000
Charlotte	Cecil Loam	Redtop	200# 16% acid phosphate,(S) 110# N. S.	200# 16% acid phos.(S)	2000	1400	600

(S) - Applied at planting time.

Note: All nitrate of soda applied as a topdressing.

Table No. 2.- Fertilizer Treatments of Samples Used in this Investigation.

County	Soil Type	Crop	Demonstration	Check	Yields in bushels per acre		
					Demonstration	Check	Difference
Charlotte	Cecil Clay	Corn	400# 16% acid phosphate, 50# M.P.(S) 200# N. S.	400# 16% acid phos., 50# M.P.(S)	28.00	21.00	7.00
King William	Norfolk Sandy Loam	Corn	167# N. S.	No fertilizer	33.33	30.00	3.33
Amelia	Cecil Clay	Corn	200# 16% acid phosphate, (S) 160# N.S.	200# 16% acid phos.(S)	36.65	28.30	8.35
Montgomery	Hagerstown loam	Corn	400# 16% acid phosphate, (S) 40# M.P.(S) 200# N.S.	400# 16% acid phos., 40# M.P.(S)	58.00	52.75	5.25
Stafford	Norfolk Sandy Loam	Corn	300# 16% acid phosphate, (S) 60# M.P.(S) 200# N.S.	No fertilizer	28.20	16.50	11.70
Botetourt	Hagerstown Clay Loam	Corn	400# 16% acid phosphate, (S) 50# M. P. 200# N. S.	400# 16% acid phos., (S) 50# M.P.+D	31.00	14.50	16.50
Prince Edward	Cecil Sandy Loam	Corn	333# 16% acid phosphate, (S) 33# M.P. 200# N. S.	300# 16% acid phos., (S) 33# M. P.	31.00	22.50	8.50
Appomattox	Davidson Clay	Corn	400# 16% acid phosphate, (S) 40# M.P., 200# N.S.	400# 16% acid Phos., (S) 40# M.P.+D	32.00	12.00	20.00
Halifax	Granville Sandy Loam	Corn	400# 16% acid phosphate, (S) 50# M.P., 200# N.S.	400# 16% acid phos., (S) 50# M.P.+D	45.00	40.00	5.00
Loudoun	Ashe Loam	Corn	300# 16% acid phosphate, (S) 40# M.P., 200# N.S.	No fertilizer	64.00	59.00	5.00

(S) - Applied at planting time.
Note: All nitrate of soda applied as a topdressing.

Table No. 3.- Fertilizer Treatments of Samples Used in this Investigation.

County	Soil Type	Crop	Demonstration	Check	Yields in bushels per acre		
					Demonstration	Check	Difference
Loudoun	Iredell Clay Loam	Wheat	300# 3-12-3, 100# N. S.	300# 3-12-3	28.40	26.80	1.60
Rappahannock	Cecil Clay	Rye	200# 16% acid phos.(S),200# 16% acid phos*	200# 16% acid phos.(S),200# 16% acid phos*	23.60	10.90	12.70
Prince William	Iredell Clay Loam	Wheat	200# 0-13-30 L.P.(S),167# N. S.	200# 0-13-30 L.P.(S)	20.33	14.00	6.33
Rockingham	Iredell Clay Loam	Wheat	350# 16% acid phos.(S),100# 16% acid phos* 100# N. S.	350# 16% acid phos.(S),100# acid phos*	22.00	14.00	8.00
Rockbridge	Hagerstown Loam	Wheat	200# 16% acid phos.(S), 50# 16% acid phos* 167# N. S.	200# 16% acid phos.(S), 50# acid phos.*	24.33	19.50	4.83
Grayson	Ashe Loam	Wheat	200# 16% acid phos.(S),100# N. S.	200# 16% acid phos.(S)	20.75	17.00	3.75
Botetourt	Hagerstown Loam	Wheat	200# 16% acid phos.(S),167# N. S.	200# 16% acid phos.(S)	23.10	14.60	8.50
Shenandoah	Hagerstown Loam	Wheat	350# 1½-8-4, (S),167# N. S.	350# 1½-8-4,(S)	23.00	19.00	4.00
Stafford	Chester Loam	Wheat	250# 16% acid phos.(S),222# 16% acid phos* 100# N. S.	250# 16% acid phos.(S)	23.33	14.62	8.71
Rockingham	Dekalb Loam	Wheat	300# 2-12-2, (S),167# N.S.	300# 2-12-2,(S)	22.20	15.20	7.00

Note: All nitrate of soda applied as a topdressing.

* - Applied as topdressing with nitrate of soda.

L.P. - Lime Phosphate.

(S) - Applied at Seeding time.

With the view of carrying out this experiment as outlined, the demonstration fertilizer plats of the Department of Agronomy of the Extension Division were selected, because they represented some of the soil types in different sections of Virginia where applications of fertilizers were made with different crops and the effect of these applications could be measured, by comparing the yields obtained, on adjacent plats, where no fertilizers were applied.

Tables 1, 2 and 3 show the fertilizer treatments, soil types, and yields with different crops.

The Hagerstown soils are the principal soils of the limestone valleys and uplands of Virginia. These soils are found extensively in Rockbridge, Rockingham, Botetourt, Montgomery and Shenandoah Counties. They are among the most fertile of eastern soils, being particularly adapted to the production of grasses, grains and fruits.

The application of superphosphate and nitrate of soda in early spring as a topdressing, considerably increased the yields of clover hay in Rockbridge County. In Rockingham, with the same fertilizer treatment, the yield of Meadow Oat Grass was greatly increased.

In Montgomery County the yield of corn was very high and shows a small increase from superphosphate and muriate of potash applied at seeding and nitrate of soda as a topdressing. Whereas, in Botetourt the yield was considerably smaller but a very large increase was obtained from the same treatment as in Montgomery.

The yield of wheat was considerably increased in Rockbridge

County by the application of superphosphate at seeding, and with superphosphate and nitrate of soda applied in early spring as a top-dressing.

The Shenandoah plats show a good increase when a complete fertilizer and nitrate of soda were applied in early spring as a top-dressing. Botetourt plats show the greatest increase for wheat from the application of superphosphate and nitrate of soda applied in early spring as a topdressing.

The Cecil soils occupy a large area in middle and southern Virginia. The sandy types are grayish; the loam, yellowish; and the clay loam, reddish. The chief crops grown on this soil in Virginia are tobacco, small grains, corn and clovers. These soils usually respond to fertilizer treatment and are easily improved and maintained.

The yield of clover hay was not increased by an application of superphosphate and nitrate of soda in early spring as a topdressing on the Pittsylvania plats. This was probably due to the exceptionally dry season. In Lunenburg the yield of timothy and redtop was greatly increased when superphosphate was applied at seeding and nitrate of soda applied in early spring as a topdressing. The yield of redtop was doubled on Amelia plats by the application of superphosphate and nitrate of soda in early spring as a topdressing, while on the Charlotte plats with the same treatments the increase was small.

The yield of corn was considerably increased by the appli-

cation of superphosphate at seeding and nitrate of soda applied as a topdressing on the Amelia and Charlotte plats. The Prince Edward plats received the same treatments as Amelia with the addition of muriate of potash added with the topdressing. The yield was considerably increased.

The yield of rye was increased three times by the application of superphosphate at seeding and in early spring as a topdressing in Rappahannock County.

The Iredell soils are found in the Piedmont Plateau of Virginia. These soils are light brown to black in color. The subsoil is a heavy waxy clay which makes them very sensitive to seasonal conditions. Cotton, tobacco, small grains and hays are grown on this soil type. These soils respond readily to potash treatments which usually prevent the rusting of cotton.

Timothy and Redtop show a considerable increase in yield of hay per acre from the application of superphosphate and nitrate of soda applied in early spring as a topdressing on the Buckingham plats.

The yield of the wheat crop was greatly increased on the Prince William plats by the application of 0-13-30 lime phosphate at seeding and nitrate of soda applied in early spring as a topdressing. The Rockingham plats show a large increase in the yield of wheat per acre by the application of superphosphate at seeding and superphosphate and nitrate of soda applied in early spring as a topdress-

ing. Whereas, on Loudoun plats by the application of a complete fertilizer and nitrate of soda applied in early spring the increase in yield of the wheat was very small.

The Norfolk soils are light-colored sands with yellow friable subsoils and are the most extensive and important soils of the Coastal Plain region. These soils are adapted to a wide range of crops, but they are of rather low natural productivity. Therefore, liberal applications of manures or fertilizers are required for good yields of nearly all crops.

The yield of corn was increased very little by the application of nitrate of soda as a topdressing in King William County. In Stafford County the yield was almost doubled by the application of acid phosphate and muriate of potash at seeding and topdressed with nitrate of soda.

Davidson soils are brown and reddish surface soils with stiff clay subsoils. These soils are productive, being adapted to cotton, corn, clovers and wheat.

The yield of the corn crop was increased almost three times in Appomattox County when acid phosphate was applied at seeding and topdressed with muriate of potash and nitrate of soda.

Granville soils are very similar in color and structure to the Norfolk soils. These soils are used principally for the production of bright tobacco, cotton, corn, peanuts and wheat. Moderately heavy additions of manure or fertilizers high in nitrogen and potash are necessary for good yields.

The increase in yield of corn was small but the yield was large on the Halifax plats when superphosphate was applied at seeding and top dressed with muriate of potash and nitrate of soda.

The Ashe soils are brownish mountain soils with yellow subsoils and are very rich. Stock raising and general farming comprise most of the tillage practices.

The application of superphosphate at seeding and topdressing with muriate of potash and nitrate of soda gave a small increase in the yield of the corn crop on the plats in Loudoun County but a very high yield was obtained.

A small increase in the yield of wheat was obtained on the Grayson County plats when superphosphate was applied at seeding and top dressed with nitrate of soda in early spring.

The Chester soils have grayish brown surface soils with gritty clay subsoils. These soils are the most extensive soils in Northern Piedmont. They are rich and are used for general farming, the production of corn, wheat, clovers and fruits.

There was a large increase in the yield of wheat on the Stafford plats by the addition of superphosphate at seeding and again with nitrate of soda as a topdressing.

The Dekalb soils predominate throughout the Cumberland-Alleghany Plateau and in the ridges lying east of the Plateau and west of the Blue Ridge region. These soils are pale gray and yellow with yellow subsoils. The soils are rich and used for the produc-

tion of small grains, corn and general farming.

The yield of wheat was considerably increased on the Rockingham plats by the addition of a complete fertilizer at seeding and topdressing with nitrate of soda.

Table No. 4.- The effect of fertilizers on the percentages of crude protein, lime & phosphoric acid in plants grown on Virginia soil types.

Soil Type	Date of cutting	With fertilizers			Without fertilizers		
		Crude protein	CaO	P_2O_5	Crude protein	CaO	P_2O_5
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Clover Hay							
Hagerstown Loam	June 7	17.81	2.20	.76	19.63	2.70	.63
Hagerstown Loam	June 7	17.94	2.41	.69	19.88	2.52	.63
Cecil Loam	June 15	18.50	1.93	.82	19.56	2.32	.57
Cecil Loam	June 25	17.00	2.52	.86	14.81	2.34	.46
Redtop							
Cecil Loam	June 18	10.00	.70	.79	9.00	.85	.82
Iredell Loam	June 25	7.75	.69	.75	5.88	.48	.54
Iredell Loam	June 25	6.31	.58	.62	6.25	.79	.63
Cecil Loam	June 19	13.00	.72	.87	9.56	.58	.67
Cecil Loam	June 26	10.38	.73	.74	8.19	.68	.70
Meadow Oat Grass							
Hagerstown Loam	May 30	9.44	.66	.79	9.88	.69	.79
Hagerstown Loam	May 30	7.19	.58	.80	7.38	.53	.83
Timothy Hay							
Cecil Loam	June 6	10.81	.77	.60	10.60	.62	.56
Cecil Loam	June 19	9.31	.43	.54	6.25	.67	.39
Corn Fodder and Shuck							
Iredell Loam	Late Fall	4.63	.43	.18			
Cecil Loam	Late Fall	5.19	.59	.23			
Hagerstown Loam	Late Fall	5.19	.50	.19			
Hagerstown Loam	Late Fall	5.25	.48	.14			

Table 4 shows the effect of fertilizers on the percentages of crude protein, calcium and phosphoric acid in plants grown on Virginia soil types.

The percentages of crude protein in clover hay on two different soil types with the same fertilizer treatments are very uniform and are slightly higher on the untreated plats, with one exception, which is considerably lower on the check plat. This sample was taken late and the hay was very near maturity. As hays become mature the percentages of carbohydrates and fibers increase and crude proteins decrease. This probably explains why the untreated plats have a slightly higher protein content and why the low protein content in one instance on the untreated plats.

Redtop shows a marked variation in crude protein content for samples cut at a late date and on different soil types. The samples grown on Cecil Loam were higher in protein content and cut earlier than the samples grown on the Iredell Loams. In all cases the protein content was higher on the treated plats.

Meadow Oat Grass shows a very slight increase in protein content on the check plats.

Timothy hay shows one variation in crude protein content, which was probably due to cutting at maturity.

Corn stalk and shucks show no variation between the percentages of crude protein in samples from different soil types.

There is no marked variation in the calcium content of

clover hay grown on treated and untreated plats. Redtop shows a marked uniformity of calcium content from different soil types on treated and check plats. Timothy hay shows no variation in the calcium content from treated and untreated plats. The same is true for Meadow Oat Grass and corn stalks and fodder.

The phosphoric acid content of clover was slightly higher on the treated plats, although there were no marked variations.

Redtop does not show any outstanding variations in the phosphoric acid content between different soil types and fertilizer treatments. Timothy hay, Meadow Oat Grass and corn stalks and fodder show no variation between samples from different soil types and fertilized plats.

Table No. 5.- The effect of fertilizers on the percentages of crude protein, lime and phosphoric acid in corn and wheat grain grown on Virginia soil types.

With fertilizers			Without fertilizers		
Crude protein	CaO	P_2O_5	Crude protein	CaO	P_2O_5
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Corn					
9.63	.02	1.53	9.31	.02	1.16
10.25	.02	1.44	8.50	.02	1.24
9.94	.02	1.57	9.94	.02	1.68
9.56	.05	1.12	8.19	.02	1.00
9.50	.02	1.08	9.25	.02	.96
8.44	.02	1.09	8.75	.02	1.03
7.75	.02	.91	7.19	.02	.89
10.44	.02	1.46	11.13	.02	1.42
8.38	.02	1.10	6.06	.02	.70
9.69	.02	1.26	9.31	.02	1.20
Wheat					
11.19	.063	.66	10.69	.034	.74
10.86	.060	.51	10.69	.033	.70
10.75	.130	.74	10.88	.063	.77
11.10	.040	.53	9.81	.056	.51
11.44	.079	.97	11.31	.056	.89
14.00	.081	.79	12.88	.045	.90
10.63	.089	.66	12.00	.033	.78
11.88	.062	1.04	10.81	.067	1.08
10.25	.022	.81	11.25	.045	.85
* 7.88	.020	.65	8.75	.034	.67

* - Rye.

Table 5 shows the effect of fertilizers on the percentages of crude protein, lime and phosphoric acid in corn and wheat grown on Virginia soil types.

The percentage of crude protein in the corn grain grown on Virginia soil types does not show but one marked variation. This instance the crude protein was 6.06, the sample was from a check plat on Norfolk Sandy Loam. The small variations may be due to varietial differences and not to soil type and nitrate of soda applied as a topdressing.

The percentage of crude protein in wheat grain grown on several Virginia soil types does not show any marked variations.

The calcium content of corn was very constant and was not influenced by soil type and fertilizer practices while for wheat one outstanding instance and this sample was taken from plats on Iredell soils. The treated samples were slightly higher in most cases than untreated plats.

Corn shows a slight increase in phosphoric acid content on treated plats but no marked variation. Wheat shows a slightly higher phosphoric acid content in the untreated samples, although no outstanding variations were noted.

Table No. 6.- A comparison of the percentages of crude protein, calcium, and phosphoric acid in plants grown in Virginia with analyses with the averages for the United States as given by Henry and Morrison.

Crop	Per cent.of Crude Protein	Per cent. of CaO	Per cent. of P205	No. of analyses
Henry and Morrison				
Red clover	14.70	1.60	.39	
Redtop	8.20	*	*	
Meadow Oat Grass	9.07	*	*	
Timothy	7.01	.25	.31	
Dent Corn	11.27	.02	.69	
Wheat	13.83	.06	.86	
Corn stalks	5.95	.66	.45	
Virginia				
Red clover	18.12	2.37	.67	8
Redtop	8.63	.68	.71	10
Meadow Oat Grass	8.47	.61	.80	6
Timothy	9.24	.62	.54	8
Dent Corn	9.06	.02	1.19	40
Wheat	11.11	.06	.78	38
Corn stalks	5.07	.50	.19	8

* - Not given by Henry and Morrison.

Note - All analyses given on dry basis.

The percentages of crude protein, calcium and phosphoric acid is considerably higher in red clover grown in Virginia than the analysis given by Henry and Morrison. Redtop shows a slightly higher percentage of protein, meadow oat grass, slightly less protein for these crops grown in Virginia as given by Henry and Morrison. In both Redtop and Oat Grass the mineral content was high. Virginia-grown timothy hay shows a striking increase in protein, calcium and phosphoric acid in comparison with analyses from other states. The percentage of protein is considerably less in Virginia-grown corn, the calcium content being the same and the phosphoric acid showing an outstanding increase in comparison with analysis given by Henry and Morrison.

Wheat shows slightly less protein and phosphoric acid for Virginia soils than analyses by Henry and Morrison.

The mineral elements in most every case were higher or about equal to analyses given by other states for the same crops, thus showing that the Virginia-grown grasses and grains are not deficient in calcium and phosphoric acid.

Summary and Conclusions

The yield with hay crops were increased with one exception by the addition of acid phosphate and top dressings of nitrate of soda.

The crude protein, calcium and phosphoric acid content of

the Virginia-grown hay crops were higher than the averages given for these crops grown in the United States with only one exception. Meadow Oat Grass had a slightly lower protein content.

Corn stover grown in Virginia closely approaches the averages of protein, calcium and phosphoric acid content given by Henry and Morrison.

The wheat and corn analyzed from Virginia soils has a lower protein content than the general average for the United States.

The calcium content of these crops agree with the averages.

The phosphoric acid content of the wheat samples grown in Virginia is slightly less than the averages but no marked differences occur.

The phosphoric acid content of the corn analyzed shows a higher average than those given for the United States.

From these analyses, it might be inferred that no mineral deficiency exists in the crops studied in this investigation. No deficiency diseases should result from feeding animals rations of different crops grown in Virginia.

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