A STUDY OF THE EFFECT OF POTASSIUM ON THE YIELD, DURATION OF STAND AND CHEMICAL COMPOSITION OF ALFALFA.

by

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INTRODUCTION

Potassium is a key element in the nutrition of plants. It is believed to have a very definite function in the formation of carbohydrates in plant tissue, and more recent evidence indicates that it has important uses in maintaining a balance with other basic elements in plant growth. The amount of potassium absorbed by a particular species of plants is to a large extent dependent on the amount available in the soil. In soils where the supply is more than ample, plants may absorb more potassium than is actually needed for healthy, vigorous growth. This increased uptake of potassium by plants has been referred to as luxury consumption (78).

Alfalfa is regarded generally as being a large user of potassium. Virginia's alfalfa production is increasing rapidly. In order to grow this alfalfa on a sustained basis, potassium is one of the important nutrients that must be supplied in large quantities. Many farmers in the state who have been growing alfalfa for some time are having difficulty in maintaining their stands. Experiments (88) indicate that the decline in stand is due in part to potassium starvation despite the rather heavy initial applications of this element.

The high potassium requirements of alfalfa and the rapidity of potassium absorption when the supply in available form is large, lessens the practicality of adding enough potassium at the time of seeding to last the crop through its probable life.

In this investigation, certain aspects of the use of potassium on alfalfa were studied using two experiments already established, one at Glade Spring, Virginia and the other at Culpeper, Virginia.

The objectives of this investigation were as follows:

1. To study the relationship of potassium in soil and plant conducive to a good stand of alfalfa.
2. To study the interaction of potassium uptake and the uptake of nitrogen, phosphorus, sodium, calcium and magnesium.

REVIEW OF LITERATURE

Literature dealing with the effects of fertilizers and soils on crops, particularly forage crops, is voluminous. Fertilizer experiments in the past, have been concerned for the most part with the study of yields. The problem dealing with the composition of the plant is a comparatively new one. It has been known since the earliest soil fertility studies were made that the composition of the plant is modified somewhat by the use of fertilizers. Plant composition has been used frequently as a guide for determining the nutrient status of the soil.

To understand the importance of potassium as a plant nutrient, we must know some of its functions in the plant. Carbohydrate formation is the particular role commonly assigned to potassium (3). This does not preclude, however, possible precursor service in the production of proteins, when these bear close structural resemblance to carbohydrates. Potassium has been found to play an essential role in regulating the nitrate reserves in the plant (65). In addition to its effect on absorption of nitrate, there is considerable evidence (35, 64, 77, 80, 81, 82, 89) to indicate that potassium is essential directly or indirectly for reduction of nitrate and perhaps for later stages of protein synthesis.

Russell (74) reports that potassium in its effect on plants is the counterpart of nitrogen and that the two elements are intimately linked in their action. Hepler and Kraybill (39) found that high potash fertilization delayed the date of blooming of tomatoes. These typical responses to a high level of potassium nutrition, when coupled with abundant nitrate, probably are correlated with a comparatively high rate of nitrate absorption and reduction and new protein synthesis. This, under some environmental influences, might lead to relatively low carbohydrate reserves and the characteristic plant responses noted.

Studies of inter-relationships of nutrient ions (35, 77, 80, 81, 82) have demonstrated that under some circumstances phosphate as well as nitrate favors absorption of potassium. Therefore, phosphate fertilization may be associated with increased intake of potassium.

Much work has been done on grains to determine influences of potassium on stiffness of straw. Plant descriptions in the literature on many different crops leave little doubt, however, that stiff straw is most frequently obtained when carbohydrates are abundant. Potassium is frequently recorded as favoring the development of thick cell walls and stiff straw, but in as many cases this element is reported as having the opposite effect (66).

Numerous data have been published regarding the effect of fertilizers on the yield and chemical composition of crops, particularly on the effect that increasing or decreasing one essential element has on the uptake of another essential element. Moser (58), for example, in pot tests in which he applied superphosphate at the rate of 600 pounds per acre to a Cecil sandy loam, was able to increase the phosphoric acid level in Austrian winter peas and lespedeza from .16 or .17 percent to only slightly over .20 percent. Larger quantities of phosphates did not result in any greater increase of phosphorus concentration in these forages. Similar results have been obtained in field tests by other investigators (12, 26, 31, 42, 52, 85, 92) where superphosphate alone has been applied to carpet grass, Kentucky bluegrass, lespedeza, Austrian winter peas, common vetch, wheat, potatoes and sugar beets. In pot work with the Gila clay in New Mexico, Hinkle (40) found that the phosphorus concentration in clover was not significantly altered as a result of applications of phosphates, even though the original amount in the clover, .17 percent, was relatively low for this plant. In the field tests he obtained a significant increase in the phosphorus concentration in alfalfa, although the highest level he obtained was well below the average reported in the literature. Other investigators, working with potato plants (48), alfalfa, oats and wheat hay (86) and cowpeas (5) found that applications of phosphates to the soil did not result in any significant increase of phosphorus in these plants.

The following investigators (16, 73), however, reported definite increases in the content of phosphorus in pasture grasses when various phosphate fertilizers were applied to the soil. Hall and Hargrave (37) and Robinson and Pierre (73) reported an increased nitrogen, phosphorus and calcium content in pasture grasses produced on soils treated with phosphate fertilizers, either alone or with lime.

Several investigators (36, 75, 11) reported that phosphate fertilizers caused an increased percentage of phosphorus in alfalfa hay. Similar effects were noted for clover by McAllister (53). Grizzard (36) also obtained similar results from applications of a combination of phosphate and potash fertilizers. Millar (57) found that sweet clover and red clover, in which phosphorus content in the hay stage of maturity was more closely correlated with treatment, were more responsive to applications of phosphate fertilizers than was alfalfa. Snider and Hein (79) reported an increased phosphorus content in sweet clover hay from applications of phosphate fertilizer. Austin (6) indicated that phosphate and potash fertilizers resulted in increased concentrations of phosphorus and potassium in the plant sap. Adams, et al (2) reported that the phosphate in complete fertilizers used for soybeans appears to be the controlling factor in causing increased percentages of nitrogen, phosphorus and calcium in the hay. Adams (1) asserted that the amount of calcium supplied is the dominating influence exerted by complete fertilizers on the composition of soybeans.

Reports by Murphy (62) and Bayfield (7) show that the addition of phosphate fertilizer for wheat resulted in a larger percentage of phosphorus in the grain. The results of other investigators (33, 93) also indicate that this treatment resulted in a reduction of the protein content and had little or no effect upon the phosphorus content in the grain. McCalla and Woodford (55) found an increased nitrogen content in the grain when potash was added to a culture medium that was low in this element. In previous work, however, McCalla (54) observed that this treatment did not affect the composition of the grain, but resulted in a larger percentage of phosphorus and potassium in the straw.

It is recognized that liming practices tend to encourage the growth of species relatively high in calcium in both pasture and forages for hay. The growth of many legumes react markedly to limestone, rapidly displacing the nutritionally less desirable grasses. Since these legumes are higher in calcium than the species ordinarily constituting the native pastures, the calcium concentration in the forage as a whole is often greatly increased. Relatively small increases in calcium have been observed in carpet grass (13, 31) and Austrian winter peas (58), although increased yields were obtained as a result of liming. Vanderford (87) found that the yield of and concentration of calcium in soybeans, Korean lespedeza and sweet clover were higher on limed plots but that the increase of calcium was much greater in lespedeza than in the other species. Other workers have reported somewhat higher calcium levels in a number of vegetable crops (29), potato leaves (63) and alfalfa (44) as a result of increasing the calcium supply of the soil.

The most striking effects of limestone in relation to phosphorus appear to have been on yields rather than on the phosphorus concentration in the plant. Investigators working with forages (4, 14, 31, 85) in many parts of the country have not noted any change in the phosphorus concentration as a result of applying lime, although in most cases the yields were increased. Some others (13, 26, 44, 87, 92) noted a lower phosphorus concentration in several forage species as a result of liming. Sheets, et al (76) noted no change as a result of liming, in the phosphorus concentration in turnip greens grown on acid soils throughout the Southeast.

Many investigators have reported very slight or no change in the concentration of calcium in plants as a result of the use of superphosphate as a fertilizer (42, 58, 86, 92). In a few instances, superphosphate has been associated with higher percentages of calcium in carpet grass on certain soils but not on others (13). Sheets, et al (76) reported significantly less calcium concentration in turnip greens fertilized with superphosphate as compared with no superphosphate.

There seems to be general agreement that the phosphorus content of a plant to which potassium has been supplied as a fertilizer is either unchanged or lower than where it is omitted. Some investigators (13, 48, 85) have noted significantly smaller concentrations of phosphorus in forages, potato plants and cereals, while others (14, 31, 76) have reported no change associated with fertilizing with potassium.

Fudge and Fraps (32) and Daniel and Harper (25) reported positive correlations between the nitrogen, phosphorus and calcium content in certain grasses and the available supply of these constituents in the soil. Pugsley and McKibbin (70) noted that grasses produced on highly calcareous soils contained more calcium than average values for the same plants grown on other soils. Perkins, et al (68) found that the phosphorus content of wheat grown on acid soils in Kansas was roughly proportional to the solubility of phosphorus in the soil.

Daniel and Harper (24) correlated mineral content of alfalfa and native grass with seasonal rainfall. During periods when the rainfall was high, the calcium content of the plants decreased and the phosphorus content increased. When the rainfall was low, the calcium content increased and the phosphorus content decreased.

Daniel (23), reporting on the magnesium content of several grasses and legumes, found the average magnesium content of the grasses to be .156 percent, while that of the legumes was .379 percent. The legumes contained, therefore, about 2.43 times as much magnesium as the grasses.

This same investigator (23), reporting on the magnesium content of several legumes at different stages of growth, found that the magnesium content decreased as the plant matured.

Prince, et al (69), working with forage crops, reported that the most important factor influencing magnesium uptake is the quantity of available potassium in the soils. If an abundance of potassium is at the plant's disposal, its magnesium content will be low. In work with potatoes, however, Carolus (20) observed that magnesium absorption was facilitated by the presence of potassium and calcium in the substrata but strongly depressed by the presence of sodium. From the standpoint of magnesium nutrition, therefore, the work suggests that large amounts of sodium salts should not be used in combination with magnesium salts for correction of magnesium deficiency.

McMurtrey (56), working with tobacco, found marked deficiency symptoms when the leaf contained .15 percent magnesium, whereas leaves containing .25 percent magnesium were generally free of symptoms. It is also commonly agreed that magnesium deficiency is most evident on light sandy soils and following periods of excessive rainfall. Zimmerman (95) concluded that at low fertility levels plant uptake of magnesium is closely related to the available supplies in the soil, whereas at higher fertility levels the cation ratios play a more dominant role.

Lehr (49), working with sodium as a plant nutrient, found a distinct relationship between yield response to sodium and capacity to absorb the element. Fodder beet, with an almost unlimited capacity for absorbing sodium, ranked first, followed by turnips, lupines, oats and ryegrass in that order. Increasing the supply of potassium to ryegrass was accompanied by considerable decrease in sodium uptake. Lehr (49), working with the previously mentioned crops, and Mullison, et al (60), with barley, noted that in the absence of both sodium and potassium, deficiency symptoms appeared much earlier and were much more severe than when sodium was present. The latter investigators also observed that the partial replacement of potassium by sodium for wheat at the heading stage resulted in a marked increase in yield.

Harmer and Benne (38) classified several crops according to sodium response as follows:

1. None to very slight benefit: buckwheat, corn, lettuce, onion, potato, rye, soybean, spinach, strawberry, bean.
2. Slight to medium benefit: asparagus, barley, carrot, cotton, oat, pea, tomato, wheat.
3. Medium to large benefit: cabbage, kale, mustard, radish.
4. Large benefit: celery, mangel, Swiss chard, turnip, table beet, sugar beet.

It is generally agreed among investigators that the sodium content of plants is very low in comparison with their potassium content. Wallace, Toth and Bear (90) found that the average sodium content of some grasses was .04 percent. The sedge plants were found to be sodium accumulators. Of the legumes analyzed, only ladino clover, red clover and white clover were sodium accumulators. Alfalfa was not a sodium accumulator. The sodium content of the legumes tended to be a little higher than the grasses.

In further studies with alfalfa, Wallace, Toth and Bear (91) reported that yields were improved with sodium applications in sand cultures. In field experiments, however, sodium did not improve alfalfa yields, even though sodium content of the plants from the sodium plots was increased. Similar results were reported by Dorph-Petersen and Steenbjerg (27). These investigators noted that beets were the only crop that responded to sodium application in field experiments, while several crops responded to sodium in pot experiments. Furthermore, they concluded that crops with a large potassium consumption are more likely to show a response to sodium, while crops with a small potassium consumption do not respond to sodium.

Investigators (15, 28, 30, 41, 48, 52, 85, 92), using a wide variety of plants and soils, are almost unanimous in their conclusions that applications of potassium result in a depressed absorption of calcium by the plant accompanied by a lower concentration of the element in most instances. On the other hand it has been observed (31, 85) that where no increase in yield occurred, the calcium concentration in some forage crops has not been materially affected. Hunter (43) reported a marked increase in the concentration of calcium in alfalfa as a result of increasing the calcium supply and decreasing the potassium supply in a Dutchess loam soil.

Calcium concentration in the plant tends to be inversely proportional to the supply of potassium in the nutrient solution (10, 21). It is generally agreed (10, 51, 59) that the calcium concentration in plants will increase with increase in the calcium supply of nutrient solutions. Tiedjens and Wall (83) grew tomato plants in culture solution with 20 p.p.m. calcium, but varying amounts of potassium (4, 8, 20, 40, 80, 160, 320 p.p.m.). Those plants at the first three levels showed potassium deficiency, but little or no calcium deficiency. Plants receiving the last two levels showed extreme injury due to calcium deficiency. However, when the calcium level was increased to 40 p.p.m., the plants showed no calcium deficiency even at the highest potassium level.

Van Itallie (45) in studies with ryegrass, and Richards (72) with alfalfa, concluded that potassium exerts the greatest depressive action on ion uptake followed by sodium, magnesium and calcium in that order.

Wood (94) observed a seasonal variation in potash content of raspberry leaves. It was found that the potassium content of the leaves was greatly influenced by potassium fertilization and stage of growth. Passing through growth stages of pre-blossom, blossom, fruiting and post-harvest, leaves showed wide variations in potassium content. The potassium content was highest in the blossom stage and lowest in the post-harvest stage. Lilleland and Brown (50) analysed leaves of prune trees in June, July, August, September and October. The potassium content increased from June to July, then decreased progressively the rest of the year. On the other hand, the calcium and magnesium content increased slightly throughout the season.

In experiments with alfalfa, Bear and Wallace (9) reported that neither 60 nor 120 pounds per acre annual rate of potash supplied sufficient potassium when applied all at one time. They concluded that an application of 60 pounds of potash per acre after each cutting would produce better results than one single large application. These investigators also found that where the available soil potassium was low, crabgrass and other weeds were able to grow vigorously.

Under conditions in which all the fertilizer was applied before seeding, Bear and Prince (8) noted that alfalfa accumulated large amounts of potassium in the first few crops. The potassium in the alfalfa tended to decrease from the second to the eighth crop, whereas calcium and magnesium increased. The sum of calcium, magnesium and potassium tended to remain constant.

Munsell, in Connecticut (61), found that the rate and frequency of potassium treatments had considerable effect on the chemical composition of alfalfa. A single, heavy application of potassium before seeding depressed the calcium content of alfalfa markedly in the first and second cuttings. The effect of a single, heavy application of potassium before seeding gave an increase in potassium content for the first three cuttings. Dividing the potassium treatments into three times per year applications gave a more uniform content of both calcium and potassium for all six cuttings.

MATERIALS AND METHODS

Field Methods

The alfalfa for these investigations was grown at Glade Spring, Virginia on the farm of the late W. P. Buchanan and at Culpeper, Virginia on the E. T. Willis farm (88). There were two experiments at Culpeper, both identical in plan, and designated as locations A and B. Location A was on a soil moderately high in fertility and location B was on a soil low in fertility. The soil used for the experiment at Glade Spring is Dunmore silt loam and at Culpeper is Davidson clay loam.

Table 1 shows the crop history and soil fertilization of the two locations at Culpeper from 1945 to 1949. Table 2 shows the results of chemical analyses of four composite soil samples from each of the two locations, taken prior to the beginning of the experiment. Similar information on the soil from the Glade Spring experiment is not available. However, it is known that the soil was heavily and frequently limed for many years prior to the beginning of the experiment and that phosphorus and potassium fertilization probably had been somewhat limited.

In the spring of 1949 at both Glade Spring and Culpeper, fertilizer treatments were topdressed on established stands of alfalfa two years old. These topdressings were repeated in 1950 and 1951 immediately following the first cutting in early spring. The fertilizer materials and rates at Glade Spring were made as follows:

Table 1. Soil Analyses of Four Composite Soil Samples from Each of Two Locations on the E. T. Willis Farm, Culpeper, Virginia.

Location - A

Replicate	pH	Organic Matter %	Truog Phosphorus Lbs./Acre	Exchangeable Cations m.e. per 100 Grams of Soil K	Ca	Mg	H
1	6.78	3.09	98	.19	11.90	2.52	7.98
2	6.90	2.69	139	.20	12.10	2.55	7.15
3	6.95	2.77	104	.18	11.24	2.18	6.74
4	6.95	2.77	104	.18	11.24	2.18	6.74

Location - B

Replicate	pH	Organic Matter %	Truog Phosphorus Lbs./Acre	K	Ca	Mg	H
1	6.90	2.24	102	.16	9.12	2.10	4.34
2	6.95	2.47	100	.14	12.07	2.17	5.23
3	7.22	2.64	125	.12	10.33	3.17	4.42
4	7.12	2.38	75	.10	9.96	3.36	4.81

Table 2. Crop History and Fertilization from 1945 Through 1949 on the E. T. Willis Farm, Culpeper, Virginia.

Location - A

Year	Crop	Fertilization	Lime
1945	Soybeans	500 Lbs./Acre of 0-14-7	None
1946	Barley	600 Lbs./Acre of 3-12-6	None
1947	Corn	600 Lbs./Acre of 3-12-6	None
1948	Barley (Alfalfa in September)	1500 Lbs./Acre of 0-12-12 Borax	2 Tons/Acre
1949	Alfalfa	None	2 Tons/Acre

Location - B

Year	Crop	Fertilization	Lime
1945	Corn	500 Lbs./Acre of 3-12-6	None
1946	Barley	600 Lbs./Acre of 3-12-6	None
1947	Barley (Alfalfa in September)	1000 Lbs./Acre of 0-12-12	3 Tons/Acre
1948	Alfalfa	500 Lbs./Acre of 0-12-12 Borax	None
1949	Alfalfa	500 Lbs./Acre of 0-12-12 Borax	None

Treatment[1/]	1,000 Lbs./Acre of Indicated Analysis	Na_2CO_3 Lbs./Acre	Minor Elements[2/] Lbs./Acre
1	2-12-12	100	30
2	2-12-12	0	30
3	2-12-12	100	0
4	2-12-24	100	30
5	2-12-0	100	30
6	2-24-24	100	30

The fertilizer treatments on a per acre basis at Culpeper were made as follows in 1949:

1. Check.
2. 800 Lbs. 0-12-12.
3. 800 Lbs. 0-12-12 and 30 Lbs. Minor Elements[2/]
4. 800 Lbs. 0-12-12 and 100 Lbs. Na_2CO_3.
5. 800 Lbs. 0-12-12 and 120 Lbs. K_2O.

An explanation of the rates of fertilization used at Culpeper in 1950 is necessary to interpret the results. The farmer topdressed the entire alfalfa field in February 1950, with 1,000 Lbs. per acre of 0-10-20 and, due to a misunderstanding, included the experimental area in this topdressing. The regular experimental topdressings were then

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$

superimposed over this application on the plots. Consequently, the rate of P_2O_5 becomes 196 pounds per acre and the rate of K_2O becomes 296 and 416 pounds per acre.

The plots at Glade Spring and Culpeper were laid out in a randomized block design with four replications. Each plot was 10 x 21.78 feet or 1/200 acre.

Yields of air dry hay at each cutting were determined by taking a six-foot length of a five-foot mower swath through the center of each plot at cutting time, which was usually at about 1/4 bloom stage. The forage in this 30 square feet of area was carefully raked and bagged while green and pliable. The material was placed in previously weighed cotton bags, and dried in forced, hot air driers until the stems were brittle and snapped readily. It was then removed from the drier, allowed to come to equilibrium with the atmosphere and weighed.

The dried hay was ground in a hammer mill, after which it was thoroughly mixed and a small sub-sample taken. This smaller sample was then ground further in a Wiley mill, placed in small bottles and taken to the laboratory for analysis. The chemical composition was expressed on an oven dry basis.

Composite soil samples from each plot were taken near the end of the experiments in 1951. A tube sampler was used to extract a soil core at 20 to 30 locations within each plot. Topsoil samples were taken to a depth of about 8 inches and subsoil samples from about 9 to 16 inches. These samples were air dried, crushed to pass a 20-mesh screen, thoroughly mixed, and placed in ice cream cartons for storage until processed in the laboratory.

Laboratory Procedures

Plants: A one-gram sample of plant material, for all determinations except nitrogen, was dry ashed, using a temperature of 400° C. The ash was dissolved in 1.5 N HNO_3, diluted to volume with water and the determination made from the solution. Sodium and potassium were determined on a Perkin-Elmer flame photometer (17). Calcium and magnesium were determined on a Beckman spectrophotometer (18).

Total phosphorus in the plant material was determined by the molybdivanadophosphoric acid method described by Kitson and Mellon (47). Nitrogen was determined by the nesslerization of ammonia according to the procedure described by Kelly, Hunter, and Stergis (46).

Soils: The soil samples were prepared for analysis according to the method of Peech, et al (67). Exchangeable sodium and potassium were determined on a Perkin-Elmer flame photometer (17), and calcium and magnesium on a Beckman spectrophotometer (34). Available phosphorus was determined by the method outlined by Truog (84). Exchangeable hydrogen was determined by the triethanolamine method described by Peech, et al (67). pH was determined with a Beckman pH meter, using a glass electrode, a 1:1 soil-water ratio, and a standing time of 30 minutes (67).

RESULTS

Yield data at Glade Spring for 1949 are presented in Tables 3, 4, 5 and 6. Without exception, the highest yields were obtained where the topdressing was 2-24-24. In the last two cuttings, the lowest yields were obtained from a 2-12-0 treatment with sodium, while in the first cutting, the lowest yield resulted from the 2-12-12 treatment without sodium. However, these yield differences were insignificant as analysed statistically. The only significant yield increase for 1949 occurred in the third cutting with the first increment of potash, as shown by an analysis of variance (Table 5). The second increment of potash gave a still slightly higher, but insignificant yield.

The minor elements appear to have no appreciable effect on yields. In fact, Tables 4 and 5 show that the plots not receiving minor elements produced slightly higher yields than those receiving minor elements. An extra addition of phosphorus did not produce a significant yield response, although small increases in yield were obtained.

No significant yield response was obtained with sodium, yet yields from the no-sodium treatments were among the lowest obtained.

It is noticed from Table 5 that the yields in October were very low. This may be due to lack of sufficient moisture, since the rainfall was not ample over the two-thirds of the 1949 growing season.

Tables 7 through 10 give the 1949 yield results from Location A at Culpeper and Tables 12 through 15 give yield results from Location B. Tables 11 and 16 summarize the data from the four cuttings made at Location A and B, respectively. It is noted from Tables 11 and 16 that a

Table 3. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, Sampled on July 12, 1949.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre Replications				
	1	2	3	4	Average
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2] 100 Lbs. Na_2CO_3	1,200	1,456	1,320	1,096	1,268
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	1,280	912	1,024	1,096	1,078
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	1,488	1,072	936	912	1,102
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,136	1,072	1,072	1,216	1,124
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,472	1,000	1,064	800	1,084
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,384	1,064	1,216	1,024	1,172

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 4. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, Sampled on August 24, 1949.

Treatment 1/ Lbs./Acre	Dry Weight in Lbs./Acre Replications 1	2	3	4	Average
1000 Lbs. 2-12-12 30 Lbs. Minor Elements 2/ 100 Lbs. Na_2CO_3	2,603	2,831	2,287	2,330	2,513
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	2,091	2,232	2,744	2,243	2,327
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	2,276	4,040	2,178	2,178	2,668
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	2,505	2,309	2,712	3,114	2,660
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	2,222	2,004	2,309	1,808	2,086
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	2,679	2,810	3,093	2,679	2,815

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 5. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, Sampled on October 27, 1949.

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre				
	Replications				
	1	2	3	4	Average
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2/] 100 Lbs. Na_2CO_3	724	466	618	614	605
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	494	496	490	652	533
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	626	788	616	600	657
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	608	688	578	780	663
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	526	332	462	440	440
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	880	576	834	680	742

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	8,421	.80	Phosphorus	79
Treats.	5	45,976	4.49*	Minor Elements	52
Error	15	10,229		Sodium	72
Total	23			2-12-0 vs 2-12-12	165
				2-12-12 vs 2-12-24	58

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.

Table 6. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia in 1949. (A Summary of Three Cuttings).

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre Cuttings			
	1	2	3	Total
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2/] 100 Lbs. Na_2CO_3	1,268	2,513	605	4,396
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	1,078	2,327	523	3,938
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	1,102	2,668	657	4,427
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,124	2,660	663	4,447
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,084	2,086	440	3,610
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,172	2,815	742	4,729

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 7. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on May 9, 1949. Location - A.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre				
	Replications				
	1	2	3	4	Average
Check	2,856	2,685	2,907	3,061	2,877
800 Lbs. 0-12-12	3,215	3,078	3,146	2,787	3,056
800 Lbs. 0-12-12 30 Lbs. Minor Elements[2]	3,317	3,249	3,266	3,471	3,326
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	3,488	3,078	3,420	3,164	3,288
800 Lbs. 0-12-12 120 Lbs. K_2O	3,352	3,283	3,317	3,574	3,382

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.[3]
Reps.	3	.98	1.18	Minor Elements	1.6*
Treats.	4	6.16	7.40**	Sodium	1.3
Error	12	.83		Potassium	1.9*
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.
3/ The significance of treatment differences in this table and all following tables was determined according to the method given below:
Duncan, D. B. A significance test for differences between ranked treatments in an analysis of variance. Va. Jour. Sci., 2:171-189. 1951.

* Significant at 5% level.
** Significant at 1% level.

Table 8. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on June 22, 1949. Location - A.

Treatment 1/ Lbs./Acre	Dry Weight in Lbs./Acre Replications 1	2	3	4	Average
Check	1,891	1,855	1,807	1,795	1,837
800 Lbs. 0-12-12	1,843	1,819	2,238	2,023	1,981
800 Lbs. 0-12-12 30 Lbs. Minor Elements 2/	2,035	2,035	2,179	2,155	2,101
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	2,131	2,131	2,035	2,047	2,086
800 Lbs. 0-12-12 120 Lbs. K_2O	2,035	2,107	2,214	2,047	2,101

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.89	1.20	Minor Elements	1.0
Treats.	4	3,64	4.90*	Sodium	.8
Error	12	.74		Potassium	1.0
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.

Table 9. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on July 25, 1949. Location - A.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre Replications 1	2	3	4	Average
Check	1,810	1,972	1,786	1,694	1,815
800 Lbs. 0-12-12	1,972	1,972	1,995	1,926	1,966
800 Lbs. 0-12-12 30 Lbs. Minor Elements[2]	1,926	1,926	1,786	1,926	1,891
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	1,810	1,694	1,972	1,926	1,850
800 Lbs. 0-12-12 120 Lbs. K_2O	2,204	1,972	2,227	1,972	2,094

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.086	.37	Minor Elements	.3
Treats.	4	.910	3.95*	Sodium	.5
Error	12	.230		Potassium	.5
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.

Table 10. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on September 9, 1949. Location - A.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre Replications				
	1	2	3	4	Average
Check	2,569	2,250	2,625	2,513	2,489
800 Lbs. 0-12-12	2,719	2,157	2,907	2,438	2,555
800 Lbs. 0-12-12 30 Lbs. Minor Elements[2]	2,738	2,325	2,719	2,625	2,601
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	3,019	2,550	2,907	2,325	2,700
800 Lbs. 0-12-12 120 Lbs. K_2O	2,775	2,682	3,188	2,438	2,770

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 11. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia in 1949. (A Summary of Four Cuttings). Location - A.

Treatment[1/] Lbs./Acre	Lbs./Acre Cuttings 1	2	3	4	Total	Tons per Acre
Check	2,877	1,837	1,815	2,489	9,018	4.51
800 Lbs. 0-12-12	3,056	1,981	1,966	2,555	9,558	4.78
800 Lbs. 0-12-12 30 Lbs. Minor Elements[2/]	3,326	2,101	1,891	2,601	9,919	4.96
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	3,288	2,086	1,850	2,700	9,924	4.96
800 Lbs. 0-12-12 120 Lbs. K_2O	3,382	2,101	2,094	2,770	10,347	5.17

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	18.98	6.56**	Minor Elements	2.5
Treats.	4	36.16	12.51**	Sodium	2.5
Error	12	2.89		Potassium	4.6*
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

Table 12. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on May 9, 1949. Location - B.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre Replications 1	2	3	4	Average
Check	2,816	3,040	2,624	2,880	2,840
800 Lbs. 0-12-12	2,880	3,120	3,088	3,200	3,072
800 Lbs. 0-12-12 30 Lbs. Minor Elements[2]	2,736	2,992	2,816	2,768	2,828
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	3,056	3,072	2,992	2,992	3,028
800 Lbs. 0-12-12 120 Lbs. K_2O	3,120	2,960	3,696	3,120	3,224

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 13. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on June 22, 1949. Location - B.

Treatment1/ Lbs./Acre	Dry Weight in Lbs./Acre				
	Replications				
	1	2	3	4	Average
Check	1,851	2,209	1,366	1,992	1,854
800 Lbs. 0-12-12	1,877	2,617	2,324	2,617	2,359
800 Lbs. 0-12-12 30 Lbs. Minor Elements2/	2,171	2,515	2,119	2,119	2,231
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	2,030	2,260	2,107	2,630	2,257
800 Lbs. 0-12-12 120 Lbs. K_2O	2,298	2,554	2,528	2,809	2,547

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	13.73	5.05*	Minor Elements	1.0
Treats.	4	15.76	5.79**	Sodium	.8
Error	12	2.72		Potassium	1.5
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

Table 14. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on July 25, 1949. Location - B.

Treatment 1/ Lbs./Acre	Dry Weight in Lbs./Acre — Replications 1	2	3	4	Average
Check	2,362	2,108	2,413	2,337	2,305
800 Lbs. 0-12-12	2,540	2,261	2,794	2,667	2,565
800 Lbs. 0-12-12 30 Lbs. Minor Elements 2/	2,540	2,540	2,540	2,489	2,527
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	2,286	2,642	2,794	2,489	2,553
800 Lbs. 0-12-12 120 Lbs. K_2O	2,921	2,921	2,794	2,667	2,826

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.45	1.12	Minor Elements	.1
Treats.	4	2.12	5.30*	Sodium	.0
Error	12	.40		Potassium	1.1*
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.

Table 15. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on September 9, 1949. Location - B.

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre				
	Replications				
	1	2	3	4	Average
Check	2,072	1,791	1,756	1,703	1,830
800 Lbs. 0-12-12	2,159	2,089	1,827	2,054	2,032
800 Lbs. 0-12-12 30 Lbs. Minor Elements[2/]	1,931	1,931	1,966	2,001	1,957
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	2,423	1,878	1,984	2,089	2,093
800 Lbs. 0-12-12 120 Lbs. K_2O	2,212	2,159	2,546	1,966	2,221

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	1.68	2.02	Minor Elements	.5
Treats.	4	2.79	3.36*	Sodium	.2
Error	12	.83		Potassium	1.0
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.

Table 16. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia in 1949. (A Summary of Four Cuttings). Location - B.

Treatment[1] Lbs./Acre	Lbs./Acre Cuttings 1	2	3	4	Total	Tons per Acre
Check	2,840	1,854	2,305	1,830	8,829	4.41
800 Lbs. 0-12-12	3,072	2,359	2,565	2,032	10,028	5.01
800 Lbs. 0-12-12 30 Lbs. Minor Elements[2]	2,828	2,231	2,527	1,957	9,543	4.77
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	3,028	2,257	2,553	2,093	9,931	4.97
800 Lbs. 0-12-12 120 Lbs. K_2O	3,224	2,547	2,826	2,221	10,818	5.41

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	6.53	.81	Minor Elements	3.2
Treats.	4	78.76	9.79**	Sodium	.8
Error	12	8.04		Potassium	4.5*
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

significant yield response to potash was obtained, while no significant increases were obtained for either minor elements or sodium. This indicates that potassium is the only limiting factor. Throughout the growing season, those plots receiving the extra potassium treatment could be easily detected due to the denser, more vigorous growth and darker green foliage.

Yields at Glade Spring for 1950 are reported in Tables 17 through 21. Significant yield responses were obtained in three cuttings (Tables 17, 19 and 20) from the first increment of potash. Yield differences resulting from the first increment of potash was much greater in 1950 than in 1949. The decreasing supply of available potassium on the plots receiving no potassium topdressing probably explains the continually lowering yields on these plots from 1949 to 1950.

Field observations in 1950 showed that on the no-potash plots, native grasses had begun to substitute rather heavily for the alfalfa. Rather severe potassium deficiency symptoms were also noted in the alfalfa on these plots.

Rainfall was abundant throughout the 1950 growing season. This may explain why the yields stood up better as the growing season progressed, than in 1949.

A small insignificant increase in yield resulted from the use of sodium. Minor elements, on the other hand, depressed the yield as in 1949. The response from the second increment of phosphorus was significant for the year as a whole, although insignificant for each cutting. The highest yields in 1950 resulted from the 2-24-24 treatment in three cuttings

Table 17. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, Sampled on May 21, 1950.

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre Replications				
	1	2	3	4	Average
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2/] 100 Lbs. Na_2CO_3	3,252	2,730	2,105	2,759	2,711
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	2,439	2,367	3,136	2,904	2,711
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	2,904	2,207	2,512	1,917	2,385
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	3,194	2,817	2,352	2,323	2,671
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,946	2,207	2,120	1,307	1,895
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	2,788	2,584	2,730	2,294	2,599

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	253,584	1.89	Phosphorus	72
Treats.	5	406,249	3.03*	Minor Elements	326
Error	15	133,892		Sodium	0
Total	23			2-12-0 vs 2-12-12	816*
				2-12-12 vs 2-12-24	40

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.

Table 18. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, Sampled on July 7, 1950.

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre Replications				
	1	2	3	4	Average
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2/] 100 Lbs. Na_2CO_3	2,860	3,252	3,223	3,281	3,154
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	3,238	2,730	2,933	4,036	3,234
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	2,933	4,356	3,630	3,688	3,652
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	3,703	3,122	2,991	3,180	3,249
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	4,719	1,771	2,497	2,076	2,766
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	4,632	3,528	3,281	3,978	3,855

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 19. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, Sampled on August 21, 1950.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre Replications 1	2	3	4	Average
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2] 100 Lbs. Na_2CO_3	1,481	1,234	1,336	1,641	1,423
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	1,408	1,074	1,118	1,147	1,187
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	1,757	1,859	1,423	1,452	1,623
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,408	1,583	1,452	1,830	1,568
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	755	813	610	770	762
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	2,018	1,437	1,728	1,917	1,775

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	54,257	1.50	Phosphorus	207
Treats.	5	562,284	17.98**	Minor Elements	200
Error	15	31,279		Sodium	236
Total	23			2-12-0 vs 2-12-12	661*
				2-12-12 vs 2-12-24	145

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$

* Significant at 5% level.
** Significant at 1% level.

Table 20. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, Sampled on October 17, 1950.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre Replications				
	1	2	3	4	Average
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2] 100 Lbs. Na_2CO_3	1,365	1,408	1,394	1,045	1,303
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	1,394	1,466	1,466	973	1,325
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	1,336	1,060	1,249	1,307	1,238
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,278	1,350	1,466	1,132	1,306
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,147	958	842	508	864
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,437	1,495	1,335	1,350	1,404

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	95,470	4.62*	Phosphorus	98
Treats.	5	147,296	7.13**	Minor Elements	65
Error	15	20,646		Sodium	22
Total	23			2-12-0 vs 2-12-12	439*
				2-12-12 vs 2-12-24	3

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

Table 21. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, in 1950. (A Summary of Four Cuttings).

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre Cuttings 1	2	3	4	Total
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2/] 100 Lbs. Na_2CO_3	2,711	3,954	1,423	1,303	8,591
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	2,711	3,234	1,187	1,325	8,457
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	2,385	3,652	1,623	1,238	8,898
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	2,671	3,249	1,568	1,306	8,794
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,895	2,766	762	864	6,287
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	2,599	3,855	1,775	1,404	9,633

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	1,686,522	7.24*	Phosphorus	838*
Treats.	5	6,222,489	26.70**	Minor Elements	306
Error	15	233,073		Sodium	134
Total	23			2-12-0 vs 2-12-12	2,330*
				2-12-12 vs 2-12-24	204

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

(Tables 18, 19 and 20), indicating that the response from phosphorus was building up as the season progressed. It seems from this data, that phosphorus, unlike potassium, becomes available in small amounts at any one time.

The 1950 yield results at Culpeper are reported in Tables 22 through 31. Tables 22 through 25 give the yields obtained at Location A. Tables 27 through 30 give the yields obtained at Location B. The yield data is summarized in Tables 26 and 31, respectively.

The sodium treated plots at Location A gave the highest yields obtained. Potassium gave slight, but insignificant increases in yield. At Location B, increments of sodium and potassium gave slight but insignificant increases in yield. Minor elements at both locations depressed yields.

The alfalfa stands at both locations declined in 1950, probably due to dry weather, the heavy yields of 1949 and severe chickweed infestation. The stand at Location B became so poor at the last cutting in August that the experiment there was discontinued. However, the experiment at Location A was continued. The wide differences in the quantity of forage and effect of sodium and potassium on yield at Locations A and B bring to the attention the striking fact that soils can affect plants differently even though they might be on the same farm, of the same soil type and receive the same fertilization measures.

Yields at Glade Spring for 1951 are reported in Tables 32 through 36. The results obtained were quite similar to those of 1949 and 1950. Table 36 shows that the only significant yield response occurred with the

Table 22. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on May 21, 1950. Location - A.

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre Replications				
	1	2	3	4	Average
Check 1000 Lbs. 0-10-20	2,400	2,550	3,100	2,400	2,612
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	3,100	2,700	2,750	3,550	3,025
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 30 Lbs. Minor Elements[2/]	2,750	2,550	3,200	3,550	3,012
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 100 Lbs. Na_2CO_3	3,200	3,000	4,100	3,650	3,487
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	2,600	2,900	4,100	2,600	3,050

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 23. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on June 22, 1950. Location - A.

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre Replications 1	2	3	4	Average
Check 1000 Lbs. 0-10-20	1,000	1,300	1,500	1,300	1,275
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	1,200	1,700	1,800	1,900	1,650
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 30 Lbs. Minor Elements[2/]	1,500	1,400	1,800	2,000	1,675
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 100 Lbs. Na_2CO_3	1,800	1,700	2,100	1,900	1,875
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	1,700	1,900	2,100	1,700	1,850

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.68	6.18**	Minor Elements	.10
Treats.	4	.92	8.36**	Sodium	.50
Error	12	.11		Potassium	.40
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

Table 24. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on July 28, 1950. Location - A.

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre Replications 1	2	3	4	Average
Check 1000 Lbs. 0-10-20	1,700	1,850	2,350	2,100	2,000
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	2,100	2,400	2,300	2,350	2,287
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 30 Lbs. Minor Elements[2/]	2,400	2,000	2,350	2,350	2,275
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 100 Lbs. Na_2CO_3	2,400	2,550	2,500	2,350	2,450
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	2,400	2,300	2,550	2,350	2,400

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.18	1.64	Minor Elements	.0
Treats.	4	.49	4.45*	Sodium	.3
Error	12	.11		Potassium	.2
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.

Table 25. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on August 31, 1950. Location - A.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre — Replications 1	2	3	4	Average
Check 1000 Lbs. 0-10-20	700	650	1,050	800	800
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	900	1,150	1,150	1,500	1,175
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 30 Lbs. Minor Elements[2]	1,050	700	1,300	1,300	1,087
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 100 Lbs. Na_2CO_3	1,800	1,400	1,700	1,550	1,612
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	1,250	1,100	1,450	1,100	1,225

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.41	3.15	Minor Elements	.2
Treats.	4	1.37	10.53**	Sodium	.8*
Error	12	.13		Potassium	.1
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

Table 26. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia in 1950. (A Summary of Four Cuttings). Location - A.

Treatment1/ Lbs./Acre	Lbs./Acre Cuttings 1	2	3	4	Total	Tons per Acre
Check 1000 Lbs. 0-10-20	2,612	1,275	2,000	800	6,687	3.34
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	3,025	1,650	2,287	1,175	8,137	4.07
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 30 Lbs. Minor Elements2/	3,012	1,675	2,275	1,087	8,049	4.02
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 100 Lbs. Na_2CO_3	3,487	1,875	2,450	1,612	9,424	4.71
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	3,050	1,850	2,400	1,225	8,525	4.26

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	10.45	5.12*	Minor Elements	.2
Treats.	4	15.66	7.67**	Sodium	2.5*
Error	12	2.04		Potassium	.7
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

Table 27. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on May 21, 1950. Location - B.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre Replications 1	2	3	4	Average
Check 1000 Lbs. 0-10-20	1,850	1,200	1,250	1,250	1,387
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	2,200	2,000	1,600	1,750	1,887
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 30 Lbs. Minor Elements[2]	1,700	1,600	2,000	1,550	1,712
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 100 Lbs. Na_2CO_3	2,300	1,800	1,600	1,950	1,912
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	2,100	1,500	1,900	1,800	1,825

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.73	4.29*	Minor Elements	.4
Treats.	4	.73	4.29*	Sodium	.0
Error	12	.17		Potassium	.1
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.

Table 28. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on June 22, 1950. Location - B

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre				
	Replications				
	1	2	3	4	Average
Check 1000 Lbs. 0-10-20	750	550	900	950	787
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	1,050	1,400	1,150	1,300	1,225
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 30 Lbs. Minor Elements[2/]	1,400	950	1,150	950	1,112
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 100 Lbs. Na_2CO_3	1,200	950	1,200	1,750	1,275
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	1,450	1,250	1,650	1,650	1,500

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.31	1.72	Minor Elements	.3
Treats.	4	1.09	6.05**	Sodium	.1
Error	12	.18		Potassium	.5
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

Table 29. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on July 28, 1950. Location - B.

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre Replications				
	1	2	3	4	Average
Check 1000 Lbs. 0-10-20	1,700	800	1,200	1,250	1,237
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	1,900	1,950	1,100	1,900	1,712
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 30 Lbs. Minor Elements[2/]	2,150	1,300	1,300	1,500	1,562
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 100 Lbs. Na_2CO_3	1,950	1,150	1,800	2,550	1,862
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	2,250	1,600	2,000	2,000	1,962

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO4$, $MnSO_4$ and $ZnSO_4$.

Table 30. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on August 31, 1950. Location - B.

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre				
	Replications				
	1	2	3	4	Average
Check 1000 Lbs. 0-10-20	350	150	650	200	337
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	300	300	850	650	525
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 30 Lbs. Minor Elements[2/]	350	450	800	250	462
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 100 Lbs. Na_2CO_3	550	300	500	1,300	662
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	450	450	800	900	650

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 31. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled in 1950. (A Summary of Four Cuttings). Location - B.

Treatment[1/] Lbs./Acre	Lbs./Acre Cuttings 1	2	3	4	Total	Tons per Acre
Check 1000 Lbs. 0-10-20	1,387	787	1,237	337	3,748	1.87
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	1,887	1,225	1,712	525	5,349	2.67
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 30 Lbs. Minor Elements[2/]	1,712	1,112	1,562	462	4,848	2.42
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 100 Lbs. Na_2CO_3	1,912	1,275	1,862	662	5,711	2.86
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	1,825	1,500	1,962	650	5,937	2.97

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	6.51	2.82	Minor Elements	1.0
Treats.	4	12.09	5.23*	Sodium	.7
Error	12	2.31		Potassium	1.2
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.

Table 32. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, Sampled on May 22, 1951.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre				
	Replications				
	1	2	3	4	Average
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2] 100 Lbs. Na_2CO_3	3,277	2,757	2,877	2,997	2,977
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	2,198	2,118	3,037	2,477	2,458
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	3,117	2,837	2,757	3,077	2,947
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	3,676	3,277	3,516	4,356	3,706
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	2,517	1,678	2,238	959	1,848
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	2,637	3,676	2,957	3,357	3,157

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	40,484	.18	Phosphorus	549
Treats.	5	1,584,873	7.14**	Minor Elements	30
Error	15	222,016		Sodium	519
Total	23			2-12-0 vs 2-12-12	1,129*
				2-12-12 vs 2-12-24	729

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

Table 33. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, Sampled on July 11, 1951.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre Replications				
	1	2	3	4	Average
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2] 100 Lbs. Na_2CO_3	2,759	——[3]	1,844	2,483	2,362
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	1,350	2,758	——	——	2,054
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	2,991	3,020	2,163	2,076	2,562
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	3,107	2,657	2,904	2,889	2,889
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	2,643	2,294	2,280	2,047	2,316
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,888	2,889	1,568	2,744	2,272

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.
3/ Samples not taken due to faulty mowing.

Table 34. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, Sampled on August 16, 1951.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre				
	Replications				
	1	2	3	4	Average
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2] 100 Lbs. Na_2CO_3	1,481	1,489	1,346	1,441	1,439
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	1,307	1,117	1,346	1,449	1,305
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	1,703	2,138	1,869	1,410	1,780
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,362	1,964	1,307	1,719	1,588
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,354	713	942	855	966
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	2,487	1,426	1,829	1,584	1,831

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	49,798	.50	Phosphorus	243
Treats.	5	417,312	4.56**	Minor Elements	341
Error	15	91,439		Sodium	134
Total	23			2-12-0 vs 2-12-12	473
				2-12-12 vs 2-12-24	149

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

Table 35. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, Sampled on October 11, 1951.

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre Replications 1	2	3	4	Average
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2/] 100 Lbs. Na_2CO_3	863	867	942	867	885
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	792	871	942	847	863
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	1,025	962	938	788	928
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	911	1,113	1,037	820	970
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	808	1,097	713	344	740
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	851	958	590	1,073	868

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 36. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia, in 1951. (A Summary of Four Cuttings).

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre — Cuttings 1	2	3	4	Total
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2/] 100 Lbs. Na_2CO_3	2,977	2,362	1,439	885	7,663
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	2,458	2,054	1,305	863	6,680
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	2,947	2,562	1,780	928	8,217
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	3,706	2,889	1,588	970	9,153
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	1,848	2,316	966	740	5,870
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	3,157	2,272	1,831	868	8,128

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	648,063	.86	Phosphorus	1,008
Treats.	5	5,570,296	7.39**	Minor Elements	260
Error	15	753,472		Sodium	1,279
Total	23			2-12-0 vs 2-12-12	2,088*
				2-12-12 vs 2-12-24	1,178

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

first increment of potash. As in 1949 and 1950, the second increment of potash increased yields slightly, but these yield responses were not significant. It is noted from Table 36 that minor elements again depressed yields, as in 1949 and 1950. By what mechanism the minor elements are able to continually depress yields is not fully understood. It may be possible that the amount of minor elements applied in this particular experiment resulted in a toxic effect and that if minor elements had been excluded from the other treatments, the yields might still have been higher than they actually were in this experiment.

As in 1949 and 1950, the sodium treatment resulted in small, but insignificant increases in yield. Yields were depressed consistently in 1951 by an extra increment of phosphorus.

Yields at this location were not as high in 1951 as in 1950. The yields in 1951 dropped steadily as the growing season progressed, and were therefore very low at the last cutting in October. This may be due to the lack of sufficient moisture, as the season was very dry in the late summer and fall.

Yields of the only cutting at Culpeper in 1951 are presented in Table 37. Results for this cutting were very similar to those in the previous two years. The differences among treatments for this cutting were found to be statistically insignificant, although both potassium and sodium gave slight yield increases. Yields were depressed as usual by the minor element application.

Table 38 gives a summary of yields for the three years at Glade Spring. The data indicate that significant yield responses were obtained from the

Table 37. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, Sampled on May 14, 1951. Location - A.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre Replications 1	2	3	4	Average
Check	1,412	1,238	1,540	1,528	1,430
800 Lbs. 0-12-12	1,731	1,702	1,557	2,109	1,775
800 Lbs. 0-12-12 30 Lbs. Minor Elements[2]	1,598	1,511	1,569	1,789	1,617
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	2,237	1,935	1,423	1,743	1,835
800 Lbs. 0-12-12 120 Lbs. K_2O	1,673	2,138	1,993	2,353	2,039

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.22	1.39	Minor Elements	.28
Treats.	4	.63	3.99*	Sodium	.10
Error	12	.16		Potassium	.45
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.

Table 38. Effect of Six Fertilizer Treatments on Yield of Alfalfa Hay Grown at Glade Spring, Virginia in 1949, 1950 and 1951. (A Summary of Three Years).

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre — Cuttings 1	2	3	4	Total
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2/] 100 Lbs. Na_2CO_3	6,956	8,029	3,467	2,188	20,640
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	6,247	7,615	3,015	2,188	19,065
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	6,434	8,882	4,060	2,166	21,542
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	7,501	8,798	3,819	2,276	22,394
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	4,827	7,168	2,168	1,604	15,767
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	6,928	8,942	4,348	2,272	22,490

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	4,277,429	1.57	Phosphorus	224
Treats.	5	28,662,971	10.54**	Minor Elements	1,213
Error	15	2,718,556		Sodium	3,722*
Total	23			2-12-0 vs 2-12-12	10,389**
				2-12-12 vs 2-12-24	2,886*

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

sodium application and both increments of potash. In fact, the two highest yields occurred where the second increment of potash was applied. Phosphorus gave a very slight, but insignificant response, to yield, while minor elements slightly depressed the yield. The results definitely indicate that potassium was the main limiting factor at this location.

Tables 39 and 40 give a summary of yields at Culpeper for Locations A and B, respectively. Significant yield responses were obtained at Location A with both sodium and potassium applications. In fact, the highest yield occurred with sodium application. It might be mentioned that Location A was the only one of the three locations, either at Glade Spring or at Culpeper, that gave a yield increase with minor elements. This increase, however, was insignificant when compared with the plots without minor elements.

The chemical composition of the alfalfa at Glade Spring for 1949 is reported in Tables 41 through 43. Table 44 gives the analysis of variance for potassium content. As a rule, the potassium content was highest in those plants fertilized with 2-12-24, second highest with 2-24-24 and lowest where 2-12-0 had been applied. It is seen from the analysis of variance that the potassium content was significantly high with both increments of potash. No relationship was found between yields and potassium content within cuttings, but a direct relationship was found from one cutting to another; that is, in the cuttings where yields were high, potassium content in the plant was high, and in the cuttings where yields were low, potassium content was low.

Table 39. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, in 1949, 1950 and 1951. (A Summary of Three Years). Location - A.

Treatment[1] Lbs./Acre	Dry Weight in Lbs./Acre				
	Cuttings				
	1	2	3	4	Total
Check 1000 Lbs. 0-10-20	6,919	3,112	3,815	3,289	17,135
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	7,856	3,631	4,253	3,730	19,470
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 30 Lbs. Minor Elements[2]	7,955	3,776	4,166	3,688	19,585
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 100 Lbs. Na_2CO_3	8,610	3,961	4,300	4,312	21,183
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	8,471	3,951	4,494	3,995	20,911

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	43.86	7.47**	Minor Elements	2.1
Treats.	4	102.74	17.50**	Sodium	5.2*
Error	12	5.87		Potassium	5.9*
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$

* Significant at 5% level.
** Significant at 1% level.

Table 40. Effect of Five Fertilizer Treatments on Yield of Alfalfa Hay Grown at Culpeper, Virginia, in 1949 and 1950. (A Summary of Two Years). Location - B.

Treatment[1/] Lbs./Acre	Dry Weight in Lbs./Acre				
	Cuttings				
	1	2	3	4	Total
Check 1000 Lbs. 0-10-20	4,227	2,641	3,542	2,167	12,577
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	4,959	3,584	4,277	2,577	15,377
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 30 Lbs. Minor Elements[2/]	4,540	3,343	4,089	2,419	14,391
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 100 Lbs. Na_2CO_3	4,940	3,532	4,415	2,755	15,642
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	5,049	4,047	4,788	2,871	16,755

Analysis of Variance

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	4.38	.33	Minor Elements	4.3
Treats.	4	148.76	11.08**	Sodium	.2
Error	12	13.42		Potassium	5.5
Total	19				

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

* Significant at 5% level.
** Significant at 1% level.

Table 41. Effect of Six Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Glade Spring, Virginia, Sampled on July 12, 1949.

Treatment[1] Lbs./Acre	Replicate	Yield Lbs./Acre	% K	% Ca	% Mg	% N	% P
1000 Lbs. 2-12-12	1	1,200	.99	2.09	.37	2.96	.28
30 Lbs. Minor	2	1,456	1.56	2.13	.35	4.11	.30
Elements[2]	3	1,320	1.49	2.44	.49	3.65	.30
100 Lbs. Na_2CO_3	4	1,096	1.08	1.88	.42	4.04	.28
AVERAGE		1,268	1.28	2.13	.41	3.69	.29
1000 Lbs. 2-12-12	1	1,280	1.61	2.05	.35	3.06	.33
30 Lbs. Minor	2	912	1.40	2.02	.42	3.96	.31
Elements	3	1,024	1.69	1.95	.45	4.01	.31
	4	1,096	.97	1.84	.37	3.83	.32
AVERAGE		1,078	1.42	1.97	.40	3.72	.31
1000 Lbs. 2-12-12	1	1,488	1.31	2.01	.39	2.70	.30
100 Lbs. Na_2CO_3	2	1,072	1.42	2.38	.40	4.39	.29
	3	936	1.32	2.15	.58	4.09	.29
	4	912	1.27	2.43	.26	3.91	.31
AVERAGE		1,102	1.33	2.24	.41	3.77	.29
1000 Lbs. 2-12-24	1	1,136	1.77	2.20	.32	3.81	.34
30 Lbs. Minor	2	1,072	1.59	2.39	.49	3.23	.28
Elements	3	1,072	1.84	1.98	.45	4.27	.30
100 Lbs. Na_2CO_3	4	1,216	1.52	1.76	.34	3.92	.30
AVERAGE		1,124	1.68	2.08	.40	3.81	.30
1000 Lbs. 2-12-0	1	1,472	1.23	2.01	.45	2.94	.32
30 Lbs. Minor	2	1,000	1.03	2.19	.39	3.22	.31
Elements	3	1,064	1.24	1.96	.52	4.07	.30
100 Lbs. Na_2CO_3	4	800	.71	2.04	.38	4.25	.28
AVERAGE		1,084	1.05	2.05	.43	3.62	.30
1000 Lbs. 2-24-24	1	1,384	1.19	2.19	.46	3.10	.31
30 Lbs. Minor	2	1,064	1.68	1.95	.46	4.04	.30
Elements	3	1,216	1.56	2.40	.55	3.99	.29
100 Lbs. Na_2CO_3	4	1,024	1.63	1.89	.34	4.01	.30
AVERAGE		1,172	1.51	2.11	.45	3.78	.30

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 42. Effect of Six Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Glade Spring, Virginia, Sampled on August 24, 1949.

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% K	% Ca	% Mg	% N	% P
1000 Lbs. 2-12-12	1	2,603	2.02	1.59	.33	4.52	.39
30 Lbs. Minor	2	2,831	2.56	2.20	.36	3.27	.35
Elements[2/]	3	2,287	2.09	2.27	.42	3.39	.36
100 Lbs. Na_2CO_3	4	2,330	2.08	2.28	.43	3.72	.40
AVERAGE		2,513	2.19	2.08	.38	3.72	.37
1000 Lbs. 2-12-12	1	2,091	2.57	1.39	.25	3.80	.39
30 Lbs. Minor	2	2,232	2.33	2.30	.39	3.34	.44
Elements	3	2,744	2.54	2.29	.42	3.21	.38
	4	2,243	2.50	2.68	.35	4.35	.34
AVERAGE		2,327	2.48	2.16	.35	3.68	.39
1000 Lbs. 2-12-12	1	2,276	2.23	1.12	.26	3.49	.43
100 Lbs. Na_2CO_3	2	4,040	1.67	1.79	.26	4.29	.39
	3	2,178	2.00	2.35	.40	3.62	.35
	4	2,178	2.18	2.33	.39	3.77	.33
AVERAGE		2,668	2.02	1.90	.33	3.79	.37
1000 Lbs. 2-12-24	1	2,505	2.20	1.45	.20	4.45	.36
30 Lbs. Minor	2	2,309	2.29	1.43	.26	3.44	.31
Elements	3	2,712	2.52	2.41	.34	3.17	.37
100 Lbs. Na_2CO_3	4	3,114	2.66	2.20	.36	3.36	.31
AVERAGE		2,660	2.42	1.87	.29	3.60	.34
1000 Lbs. 2-12-0	1	2,222	2.38	1.12	.28	3.80	.45
30 Lbs. Minor	2	2,004	1.53	1.37	.32	3.72	.37
Elements	3	2,309	1.66	2.44	.48	3.58	.36
100 Lbs. Na_2CO_3	4	1,808	.99	2.66	.40	3.51	.33
AVERAGE		2,086	1.64	1.90	.37	3.65	.38
1000 Lbs. 2-24-24	1	2,679	2.02	1.46	.22	3.96	.36
30 Lbs. Minor	2	2,810	2.84	2.34	.31	3.23	.36
Elements	3	3,093	2.05	2.38	.28	3.13	.31
100 Lbs. Na_2CO_3	4	2,679	2.69	2.31	.36	3.41	.41
AVERAGE		2,815	2.40	2.12	.29	3.43	.36

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 43. Effect of Six Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Glade Spring, Virginia, Sampled on October 27, 1949.

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% K	% Ca	% Mg	% N	% P
1000 Lbs. 2-12-12	1	724	1.38	2.16	.36	3.81	.23
30 Lbs. Minor	2	466	1.00	1.88	.43	3.38	.19
Elements[2/]	3	618	.91	2.04	.49	3.40	.18
100 Lbs. Na_2CO_3	4	614	.61	2.48	.61	3.38	.20
AVERAGE		605	.97	2.14	.47	3.49	.20
1000 Lbs. 2-12-12	1	494	1.05	2.01	.42	3.36	.20
30 Lbs. Minor	2	496	.56	1.84	.45	2.81	.20
Elements	3	490	.89	1.59	.46	3.16	.19
	4	652	1.08	2.14	.49	3.38	.24
AVERAGE		533	.89	1.89	.45	3.17	.21
1000 Lbs. 2-12-12	1	626	.91	2.24	.41	3.67	.22
100 Lbs. Na_2CO_3	2	788	.73	2.43	.48	3.76	.24
	3	616	.89	1.96	.60	3.07	.17
	4	600	.81	2.26	.57	3.57	.18
AVERAGE		657	.83	2.22	.51	3.52	.20
1000 Lbs. 2-12-24	1	608	1.49	1.87	.30	3.18	.17
30 Lbs. Minor	2	688	1.12	2.07	.36	3.57	.17
Elements	3	578	1.28	1.56	.43	2.94	.16
100 Lbs. Na_2CO_3	4	780	1.22	2.08	.47	3.41	.19
AVERAGE		663	1.28	1.89	.39	3.28	.17
1000 Lbs. 2-12-0	1	526	.70	2.26	.48	3.88	.24
30 Lbs. Minor	2	332	.40	2.46	.62	3.30	.20
Elements	3	462	.58	1.69	.57	3.28	.20
100 Lbs. Na_2CO_3	4	440	.56	2.34	.61	3.54	.19
AVERAGE		440	.56	2.19	.57	3.50	.21
1000 Lbs. 2-24-24	1	880	.93	2.25	.42	3.56	.22
30 Lbs. Minor	2	576	1.16	2.03	.34	3.70	.19
Elements	3	834	1.11	2.16	.34	3.31	.20
100 Lbs. Na_2CO_3	4	680	1.14	2.26	.43	3.48	.20
AVERAGE		742	1.08	2.17	.38	3.51	.20

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 44. Analysis of Variance in Alfalfa Grown at Glade Spring, Virginia in 1949. Percent Potassium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
First Cutting - July 12, 1949.					
Reps.	3	.85	3.40*	Minor Elements	.1
Treats.	5	1.18	4.72**	Phosphorus	.4
Error	15	.25		Sodium	.3
Total	23			2-12-0 vs 2-12-12	.7
				2-12-12 vs 2-12-24	.9*
Second Cutting - August 24, 1949.					
Reps.	3	.053	.09	Minor Elements	.4
Treats.	5	1.830	3.21*	Phosphorus	.0
Error	15	.570		Sodium	.6
Total	23			2-12-0 vs 2-12-12	1.2
				2-12-12 vs 2-12-24	.4
Third Cutting - October 27, 1949.					
Reps.	3	.63	2.25	Minor Elements	.38
Treats.	5	2.23	7.96**	Phosphorus	.51
Error	15	..28		Sodium	.23
Total	23			2-12-0 vs 2-12-12	.34
				2-12-12 vs 2-12-24	.87*
Summary of Three Cuttings - 1949.					
Reps.	3	1.56	.795	Minor Elements	.56
Treats.	5	14.29	7.290**	Phosphorus	.95
Error	15	1.96		Sodium	.69
Total	23			2-12-0 vs 2-12-12	3.17*
				2-12-12 vs 2-12-24	2.29

* Significant at 5% level.
** Significant at 1% level.

Neither the K-Ca nor the K-Mg ratios varied inversely within cuttings, nor did the calcium content change materially between cuttings. However, magnesium and potassium content were found to vary inversely between cuttings. Nitrogen content decreased slightly in the third cutting where potassium content was low and yields were low. Phosphorus content was, without exception, directly related to yields and to potassium content from cutting to cutting.

The low yields at the last cutting in 1949 may have been due to lack of sufficient moisture or the exhaustion of the available potassium in the soil by the first and second cuttings.

Table 45 summarizes the chemical composition of the alfalfa at Culpeper for 1949. The yields at both locations were higher where the extra increment of potash was applied. However, the potassium content of the alfalfa had an inverse relation to yields. The K-Ca ratio was inverse in the alfalfa from Location A and direct in the material from Location B. The nitrogen values were erratic and are probably unimportant. It may be added, however, that the nitrogen values were higher than are usually found in the literature. There was very little variation in the calcium, magnesium or phosphorus content of the plant material.

In Tables 46, 47, 48 and 49 are presented the chemical composition of alfalfa grown at Glade Spring in 1950. The analysis of variance for percent sodium and potassium is given in Tables 50 and 51.

The application of both increments of potash resulted in a high potassium content in the alfalfa. The potassium content of the plants varied from 1.14 percent on the 2-12-0 treated plots to 2.47 percent on

Table 45. Effect of Three Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Culpeper, Virginia in 1949. A Summary of Four Cuttings.

Location - A

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% K	% Ca	% Mg	% N	% P
Check	1	9,126	2.41	1.49	.31	4.51	.41
	2	8,762	3.31	1.47	.34	5.15	.45
	3	9,125	2.57	1.66	.31	5.76	.44
	4	9,063	2.41	1.47	.37	5.34	.45
AVERAGE		9,019	2.67	1.52	.33	5.44	.44
800 Lbs. 0-12-12	1	9,749	2.89	1.38	.33	5.22	.44
	2	9,026	2.91	1.26	.30	5.01	.43
	3	10,286	3.74	1.39	.35	5.40	.44
	4	9,174	3.69	1.31	.32	5.12	.42
AVERAGE		9,559	3.31	1.33	.32	5.19	.43
800 Lbs. 0-12-12 120 Lbs. K_2O	1	10,366	3.14	1.44	.29	5.55	.44
	2	10,044	3.19	1.36	.32	5.03	.44
	3	10,946	3.40	1.43	.26	5.76	.45
	4	10,031	3.12	1.36	.32	5.76	.44
AVERAGE		10,347	3.21	1.40	.30	5.52	.44

Location - B

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% K	% Ca	% Mg	% N	% P
Check	1	9,101	1.85	1.38	.30	5.55	.42
	2	9,148	1.48	1.47	.42	5.67	.42
	3	8,159	1.01	1.74	.42	6.12	.45
	4	8,912	.90	1.59	.43	5.14	.44
AVERAGE		8,830	1.31	1.54	.39	5.87	.43
800 Lbs. 0-12-12	1	9,456	2.26	1.44	.34	5.68	.44
	2	10,087	2.90	1.27	.32	4.82	.41
	3	10,033	1.35	1.50	.37	5.75	.45
	4	10,538	1.53	1.54	.34	6.12	.44
AVERAGE		10,029	2.01	1.44	.34	5.59	.43
800 Lbs. 0-12-12 120 Lbs. K_2O	1	10,551	1.92	1.10	.28	3.88	.38
	2	10,594	2.01	1.41	.36	5.14	.44
	3	11,564	2.07	1.32	.28	5.60	.43
	4	10,562	1.79	1.56	.31	5.42	.42
AVERAGE		10,818	1.95	1.35	.31	5.01	.42

1/ 10 Lbs. borax used on all plots.

Table 46. Effect of Six Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Glade Spring, Virginia, Sampled on May 21, 1950.

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% N	% P
1000 Lbs. 2-12-12	1	3,252	.065	2.41	1.58	.31	4.42	.32
10 Lbs. Minor	2	2,730	.045	2.49	1.28	.28	4.12	.40
Elements[2/]	3	2,105	.060	2.75	1.35	.24	4.76	.40
100 Lbs. Na_2CO_3	4	2,759	.068	2.23	1.42	.29	4.25	.39
AVERAGE		2,711	.060	2.47	1.53	.28	4.39	.38
1000 Lbs. 2-12-12	1	2,439	.030	2.97	1.37	.26	4.53	.42
30 Lbs. Minor	2	2,367	.026	2.88	1.45	.28	4.18	.42
Elements	3	3,136	.039	2.40	1.49	.21	4.57	.39
	4	2,904	.035	2.86	1.45	.26	3.67	.42
AVERAGE		2,711	.033	2.78	1.46	.25	4.24	.41
1000 Lbs. 2-12-12	1	2,904	.059	2.41	1.55	.36	4.15	.40
100 Lbs. Na_2CO_3	2	2,207	.068	2.27	2.01	.40	3.51	.40
	3	2,512	.064	2.80	1.80	.36	4.38	.39
	4	1,917	.072	2.60	1.60	.27	4.49	.29
AVERAGE		2,385	.066	2.52	1.74	.35	4.13	.40
1000 Lbs. 2-12-24	1	3,194	.039	3.32	1.24	.29	4.17	.39
30 Lbs. Minor	2	2,817	.044	2.98	1.37	.33	3.53	.37
Elements	3	2,352	.039	3.19	1.31	.24	4.63	.40
100 Lbs. Na_2CO_3	4	2,323	.041	3.05	1.14	.19	4.42	.37
AVERAGE		2,671	.041	3.13	1.34	.26	4.19	.38
1000 Lbs. 2-12-0	1	1,946	.100	1.39	2.11	.42	4.46	.46
30 Lbs. Minor	2	2,207	.109	.96	1.85	.40	4.68	.43
Elements	3	2,120	.070	1.39	1.52	.27	4.65	.43
100 Lbs. Na_2CO_3	4	1,307	.126	.95	2.08	.37	4.61	.41
AVERAGE		1,895	.101	1.17	1.89	.36	4.65	.43
1000 Lbs. 2-24-24	1	2,788	.057	3.03	1.42	.33	3.54	.42
30 Lbs. Minor	2	2,584	.039	3.16	1.22	.24	4.14	.41
Elements	3	2,730	.056	3.57	1.37	.25	4.45	.42
100 Lbs. Na_2CO_3	4	2,294	.050	3.11	1.25	.25	3.31	.41
AVERAGE		2,599	.051	3.22	1.31	.27	3.86	.42

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 47. Effect of Six Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Glade Spring, Virginia, Sampled on July 7, 1950.

Treatment[1] Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% N	% P
1000 Lbs. 2-12-12	1	2,860	.078	1.77	1.71	.23	3.05	.31
30 Lbs. Minor	2	3,252	.052	2.02	1.53	.26	3.22	.33
Elements[2]	3	3,223	.066	1.84	1.81	.23	3.12	.31
100 Lbs. Na_2CO_3	4	3,281	.064	1.62	1.81	.26	3.17	.35
AVERAGE		3,154	.065	1.81	1.71	.24	3.14	.32
1000 Lbs. 2-12-12	1	3,238	.031	2.33	1.46	.19	2.99	.34
30 Lbs. Minor	2	2,730	.044	1.72	1.48	.21	3.04	.33
Elements	3	2,933	.045	1.81	1.68	.25	3.16	.32
	4	4,036	.035	1.98	1.69	.26	3.21	.34
AVERAGE		3,234	.039	1.96	1.58	.23	3.10	.33
1000 Lbs. 2-12-12	1	2,933	.053	1.51	1.53	.20	3.16	.33
100 Lbs. Na_2CO_3	2	4,356	.087	1.64	2.01	.25	2.95	.34
	3	3,630	.069	1.78	2.01	.22	2.77	.31
	4	3,688	.079	1.48	1.91	.25	2.91	.31
AVERAGE		3,652	.072	1.60	1.86	.23	2.95	.32
1000 Lbs. 2-12-24	1	3,703	.033	2.63	1.65	.20	2.98	.31
30 Lbs. Minor	2	3,122	.052	2.31	1.82	.22	2.95	.32
Elements	3	2,991	.038	2.60	1.51	.20	2.99	.29
100 Lbs. Na_2CO_3	4	3,180	.044	2.38	1.34	.25	3.03	.31
AVERAGE		3,249	.042	2.48	1.58	.22	2.99	.31
1000 Lbs. 2-12-0	1	4,719	.079	1.47	1.69	.29	3.21	.37
30 Lbs. Minor	2	1,771	.088	.82	2.26	.33	3.53	.37
Elements	3	2,497	.080	1.09	1.90	.19	3.24	.36
100 Lbs. Na_2CO_3	4	2,076	.079	.83	2.09	.38	3.36	.35
AVERAGE		2,766	.081	1.05	1.98	.30	3.33	.36
1000 Lbs. 2-24-24	1	4,632	.058	2.21	1.79	.22	2.79	.32
30 Lbs. Minor	2	3,528	.040	2.80	1.46	.19	2.83	.31
Elements	3	3,281	.061	2.44	1.49	.19	2.66	.32
100 Lbs. Na_2CO_3	4	3,978	.045	2.44	1.48	.22	2.88	.32
AVERAGE		3,855	.051	2.47	1.55	.21	2.79	.32

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 48. Effect of Six Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Glade Spring, Virginia, Sampled on August 21, 1950.

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% N	% P
1000 Lbs. 2-12-12	1	1,481	.095	1.43	2.52	.32	3.05	.31
30 Lbs. Minor	2	1,234	.042	1.83	2.20	.25	2.80	.31
Elements[2/]	3	1,336	.073	1.47	2.20	.49	3.01	.30
100 Lbs. Na_2CO_3	4	1,641	.095	1.31	2.22	.46	3.09	.33
AVERAGE		1,423	.076	1.51	2.28	.38	2.99	.31
1000 Lbs. 2-12-12	1	1,408	.026	2.10	1.64	.18	3.06	.32
30 Lbs. Minor	2	1,074	.026	1.61	1.86	.18	2.91	.33
Elements	3	1,118	.037	1.57	1.90	.46	2.99	.32
	4	1,147	.025	1.71	2.01	.42	3.29	.36
AVERAGE		1,187	.028	1.75	1.85	.31	3.06	.33
1000 Lbs. 2-12-12	1	1,757	.069	1.78	2.11	.24	3.16	.35
100 Lbs. Na_2CO_3	2	1,859	.092	1.54	2.03	.30	2.86	.36
	3	1,423	.030	1.40	2.77	.58	3.01	.31
	4	1,452	.079	1.49	2.13	.40	3.01	.31
AVERAGE		1,623	.080	1.55	2.26	.38	3.01	.33
1000 Lbs. 2-12-24	1	1,408	.046	2.13	1.80	.22	2.99	.31
30 Lbs. Minor	2	1,583	.052	2.08	2.04	.21	2.94	.30
Elements	3	1,452	.027	2.45	1.31	.33	2.76	.27
100 Lbs. Na_2CO_3	4	1,830	.035	2.31	1.75	.34	3.26	.31
AVERAGE		1,568	.040	2.24	1.72	.27	2.99	.30
1000 Lbs. 2-12-0	1	755	.064	1.35	1.66	.27	2.29	.35
30 Lbs. Minor	2	813	.101	.96	2.61	.41	3.41	.37
Elements	3	610	.074	1.10	1.87	.59	3.05	.35
100 Lbs. Na_2CO_3	4	770	.082	.96	2.38	.49	2.92	.36
AVERAGE		762	.080	1.09	2.13	.44	2.92	.36
1000 Lbs. 2-24-24	1	2,018	.067	1.88	2.44	.28	2.98	.31
30 Lbs. Minor	2	1,437	.030	2.43	2.25	.16	2.79	.31
Elements	3	1,728	.065	2.20	2.04	.41	2.95	.31
100 Lbs. Na_2CO_3	4	1,917	.053	2.18	1.61	.33	3.07	.31
AVERAGE		1,775	.054	2.17	2.08	.29	2.95	.31

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 49. Effect of Six Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Glade Spring, Virginia, Sampled on October 17, 1950.

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% N	% P
1000 Lbs. 0-12-12	1	1,365	.199	1.13	2.93	.37	3.08	.31
30 Lbs. Minor	2	1,408	.137	1.30	2.25	.29	3.21	.33
Elements[2/]	3	1,394	.173	.95	2.59	.39	3.17	.34
100 Lbs. Na_2CO_3	4	1,045	.225	.66	2.86	.38	3.39	.34
AVERAGE		1,303	.183	1.01	2.66	.36	3.21	.33
1000 Lbs. 2-12-12	1	1,394	.067	1.43	2.19	.26	3.07	.30
30 Lbs. Minor	2	1,466	.098	1.17	2.46	.34	3.21	.34
Elements	3	1,466	.103	1.19	2.44	.75	3.16	.30
	4	973	.066	1.31	2.26	.34	3.12	.35
AVERAGE		1,325	.083	1.27	2.34	.42	3.14	.32
1000 Lbs. 2-12-12	1	1,336	.162	1.18	2.37	.33	2.88	.34
100 Lbs. Na_2CO_3	2	1,060	.191	.87	3.03	.36	2.94	.34
	3	1,249	.166	.93	3.19	.40	2.81	.34
	4	1,307	.169	1.25	2.64	.28	2.90	.31
AVERAGE		1,238	.172	1.06	2.81	.34	2.88	.33
1000 Lbs. 2-12-24	1	1,278	.063	2.25	2.07	.22	2.90	.28
30 Lbs. Minor	2	1,350	.123	1.81	2.41	.25	3.05	.28
Elements	3	1,466	.065	2.33	2.03	.50	2.93	.28
100 Lbs. Na_2CO_3	4	1,132	.086	1.77	2.08	.41	3.31	.30
AVERAGE		1,306	.084	2.04	2.15	.34	3.05	.28
1000 Lbs. 2-12-0	1	1,147	.123	1.19	2.14	.34	3.04	.36
30 Lbs. Minor	2	958	.225	2.60	3.16	.50	3.09	.36
Elements	3	842	.194	.74	2.12	1.05	2.98	.35
100 Lbs. Na_2CO_3	4	508	.217	.48	2.63	.52	2.93	.37
AVERAGE		864	.190	1.25	2.51	.60	3.01	.36
1000 Lbs. 2-24-24	1	1,437	.123	1.76	2.45	.24	3.04	.31
30 Lbs. Minor	2	1,495	.067	2.37	2.17	.21	2.82	.27
Elements	3	1,335	.130	1.87	2.61	.22	3.09	.31
100 Lbs. Na_2CO_3	4	1,350	.107	1.74	2.18	.29	3.26	.30
AVERAGE		1,404	.107	1.93	2.35	.24	3.05	.30

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 50. Analysis of Variance for Percent Potassium and Sodium in Alfalfa Grown at Glade Spring, Virginia in 1950.

First Cutting - May 21, 1950 - Percent Potassium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.290	1.57	Minor Elements	.09
Treats.	5	9.130	49.60**	Phosphorus	.13
Error	15	.184		Sodium	.56
Total	23			2-12-0 vs 2-12-12	2.84*
				2-12-12 vs 2-12-24	1.17*

First Cutting - May 21, 1950. Percent Sodium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.017	1.13	Minor Elements	.08
Treats.	5	.304	20.27**	Phosphorus	.12
Error	15	.015		Sodium	.36*
Total	23			2-12-0 vs 2-12-12	.43*
				2-12-12 vs 2-12-24	.23*

Second Cutting - July 7, 1950. Percent Potassium

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.280	3.40*	Minor Elements	.46*
Treats.	5	5.620	67.70**	Phosphorus	.01
Error	15	.083		Sodium	.30
Total	23			2-12-0 vs 2-12-12	1.82*
				2-12-12 vs 2-12-24	1.32*

Second Cutting - July 7, 1950. Percent Sodium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.0067	.447	Minor Elements	.08
Treats.	5	.1700	11.300**	Phosphorus	.13
Error	15	.0150		Sodium	.33*
Total	23			2-12-0 vs 2-12-12	.18
				2-12-12 vs 2-12-24	.29*

* Significant at 5% level.
** Significant at 1% level.

Table 51. Analysis of Variance for Percent Potassium and Sodium in Alfalfa Grown at Glade Spring, Virginia in 1950. (Continued).

Third Cutting - August 21, 1950. Percent Sodium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.003	.079	Minor Elements	.06
Treats.	5	.310	8.150**	Phosphorus	.18
Error	15	.038		Sodium	.60*
Total	23			2-12-0 vs 2-12-12	.06
				2-12-12 vs 2-12-24	.43*

Fourth Cutting - October 17, 1950. Percent Potassium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	1.62	1.49	Minor Elements	.16
Treats.	5	4.69	4.30*	Phosphorus	.21
Error	15	1.09		Sodium	.76
Total	23			2-12-0 vs 2-12-12	.39
				2-12-12 vs 2-12-24	2.47*

Fourth Cutting - October 17, 1950. Percent Sodium

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.03	.5	Minor Elements	.07
Treats.	5	.64	9.8**	Phosphorus	.21
Error	15	.06		Sodium	.80*
Total	23			2-12-0 vs 2-12-12	.04
				2-12-12 vs 2-12-24	.79*

Summary of Four Cuttings - 1950. Percent Potassium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	4.15	1.44	Minor Elements	.10
Treats.	5	80.03	27.79**	Phosphorus	.24
Error	15	2.88		Sodium	2.15
Total	23			2-12-0 vs 2-12-12	5.34*
				2-12-12 vs 2-12-24	6.52*

Summary of Four Cuttings - 1950. Percent Sodium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.07	.2	Minor Elements	.14
Treats.	5	5.10	13.3**	Phosphorus	.64
Error	15	.38		Sodium	2.10*
Total	23			2-12-0 vs 2-12-12	.70
				2-12-12 vs 2-12-24	1.75*

* Significant at 5% level.
** Significant at 1% level.

the 2-12-24 treated plots. An observation of the data shows that percent potassium in the alfalfa bore a direct relation with the amount of fertilizer potassium applied, regardless of yields. It is known that many other factors influence yields of forage besides potassium applications, among these being rainfall and various soil factors.

The potassium content of the alfalfa was highest at the first cutting and dropped steadily with each successive cutting, regardless of yield. The potassium content of the fourth cutting was about 40 percent of that obtained in the first cutting. The excessive rainfall in the spring and summer of 1950 may have been a deciding factor in the dropping of the potassium content later in the season.

From the analysis of variance it is seen that both sodium and potassium greatly influence the sodium content of the alfalfa. The sodium content varied from .046 percent on the 2-12-12 plot with no sodium application to .113 percent on the 2-12-0 treated plot with sodium. It is striking that the sodium content of the forage remained about the same through the first three cuttings, then exhibited a sharp rise in the last cutting. This excess sodium may have been taken up to replace part of the available potassium, which had been used up in the previous three cuttings.

The calcium content of the forage was lowest at the first cutting and increased steadily with each successive cutting. Magnesium showed a somewhat similar trend, though it was more erratic than was calcium. It was found, by means of a correlation test, that percent potassium in the alfalfa was inversely related to the calcium, sodium and magnesium content.

Throughout the growing season, it was apparent that nitrogen and phosphorus followed much the same trend. These two elements were distinctly higher in the first cutting where potassium was high; however, both were depressed by potassium within cuttings.

The chemical composition of alfalfa grown at Culpeper in 1950 is reported in Tables 52, 53, 54 and 55. It has been mentioned before that yield increases due to potash in 1950 at neither location A nor B were not significant. Percentage potassium in the alfalfa, however, was directly related to the amount of potash applied. It may be of importance to add that at both Glade Spring and Culpeper so far, the potassium in the plants was related directly to amount of potash applied, regardless of yields. Also, field observations indicated that the lack of potassium deficiency symptoms correlated very closely with the high potassium content of the forage. This would lead to the assumption that plant analysis is a very good test in deciding plant needs for potassium.

The sodium values for the forage were erratic, but in general, it is safe to say that the trend was decreased sodium with high potassium. The calcium uptake seemed to be unaffected by potassium except in the last cutting (Table 55), in which calcium was depressed by potassium. All the calcium values in this experiment were surprisingly low. Magnesium uptake was not affected by potassium in the first and second cuttings, but was depressed by potassium in the third and fourth cuttings.

The chemical composition of the alfalfa grown at Glade Spring in 1951 is reported in Tables 56, 57, 58 and 59. The analysis of variance for percent sodium and potassium is given in Tables 60 and 61.

Table 52. Effect of Three Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Culpeper, Virginia, Sampled on May 21, 1950.

Location - A

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% N	% P
Check	1	2,400	.063	3.02	.35	.40	3.95	.51
1000 Lbs. 0-10-20	2	2,550	.068	3.13	.34	.42	3.70	.45
	3	3,100	.061	2.99	.38	.30	4.36	.48
	4	2,400	.081	3.02	.47	.35	4.79	.48
AVERAGE		2,612	.068	3.04	.38	.37	4.20	.48
800 Lbs. 0-12-12	1	3,100	.074	2.87	.64	.25	4.36	.51
1000 Lbs. 0-10-20	2	2,700	.060	2.93	.51	.25	3.98	.50
	3	2,750	.156	3.37	.48	.36	3.95	.48
	4	3,550	.066	3.48	.58	.27	4.49	.50
AVERAGE		3,025	.089	3.16	.55	.28	4.19	.50
800 Lbs. 0-12-12	1	2,600	.088	3.24	.52	.34	2.75	.50
1000 Lbs. 0-10-20	2	2,900	.069	2.94	.49	.24	4.49	.50
120 Lbs. K_2O	3	4,100	.078	3.90	.51	.25	4.36	.50
	4	2,600	.088	3.41	.60	.32	4.14	.48
AVERAGE		3,050	.081	3.37	.53	.29	3.93	.49

Location - B

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% N	% P
Check	1	1,850	.121	2.94	.58	.25	2.78	.45
1000 Lbs. 0-10-20	2	1,200	.151	3.32	.52	.33	3.32	.46
	3	1,250	.147	2.73	.63	.27	3.84	.48
	4	1,250	.114	3.54	.42	.34	3.46	.44
AVERAGE		1,387	.133	3.13	.54	.30	3.35	.46
800 Lbs. 0-12-12	1	2,200	.073	2.86	.49	.27	3.21	.49
1000 Lbs. 0-10-20	2	2,000	.096	3.14	.62	.36	3.46	.48
	3	1,600	.068	2.92	.65	.30	4.79	.51
	4	1,750	.061	2.68	.64	.35	4.52	.50
AVERAGE		1,887	.074	2.90	.60	.32	3.99	.49
800 Lbs. 0-12-12	1	2,100	.127	3.94	.57	.30	3.84	.53
1000 Lbs. 0-10-20	2	1,500	.126	3.59	.53	.33	3.60	.48
120 Lbs. K_2O	3	1,900	.138	3.25	.56	.30	2.89	.51
	4	1,800	.059	2.72	.71	.32	4.63	.51
AVERAGE		1,825	.112	3.37	.59	.31	3.74	.51

1/ 10 Lbs. borax used on all plots.

Table 53. Effect of Three Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Culpeper, Virginia, Sampled on June 22, 1950.

Location - A

Treatment[1/] Lbs./Acre	Rep-lic-ate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% N	% P
	1	1,000	.054	2.66	1.19	.33	3.26	.37
Check	2	1,300	.062	2.32	1.11	.35	3.51	.36
1000 Lbs. 0-10-20	3	1,500	.134	2.72	.88	.43	3.59	.39
	4	1,300	.060	2.66	1.32	.42	3.53	.37
AVERAGE		1,275	.077	2.59	1.12	.38	3.47	.37
	1	1,200	.052	2.94	1.19	.32	3.53	.43
800 Lbs. 0-12-12	2	1,700	.041	2.99	.98	.27	3.10	.37
1000 Lbs. 0-10-20	3	1,800	.055	3.15	1.19	.29	3.83	.42
	4	1,900	.054	3.43	.83	.24	3.26	.38
AVERAGE		1,650	.051	3.13	1.05	.28	3.43	.40
800 Lbs. 0-12-12	1	1,700	.047	3.15	1.22	.33	3.51	.41
1000 Lbs. 0-10-20	2	1,900	.054	3.40	.96	.29	3.45	.37
120 Lbs. K_2O	3	2,100	.047	3.68	.76	.27	3.75	.38
	4	1,700	.051	3.24	.88	.29	3.45	.38
AVERAGE		1,850	.050	3.37	.95	.29	3.54	.38

Location - B

Treatment[1/] Lbs./Acre	Rep-lic-ate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% N	% P
	1	750	.084	2.66	.89	.38	3.04	.35
Check	2	550	.065	2.88	.92	.32	3.40	.39
1000 Lbs. 0-10-20	3	900	.052	2.86	1.26	.29	3.70	.42
	4	950	.075	2.39	.98	.29	3.51	.39
AVERAGE		787	.069	2.70	1.01	.32	3.41	.39
	1	1,050	.127	3.24	.80	.29	3.53	.40
800 Lbs. 0-12-12	2	1,400	.066	3.26	.84	.33	2.64	.40
1000 Lbs. 0-10-20	3	1,150	.078	2.77	.92	.29	2.94	.42
	4	1,300	.080	2.91	.73	.25	2.80	.40
AVERAGE		1,225	.088	3.04	.82	.29	2.98	.41
800 Lbs. 0-12-12	1	1,450	.070	4.13	.79	.26	3.51	.39
1000 Lbs. 0-10-20	2	1,250	.079	3.86	.88	.26	3.59	.42
120 Lbs. K_2O	3	1,650	.061	3.89	.84	.24	3.40	.42
	4	1,650	.090	3.37	.71	.29	3.40	.40
AVERAGE		1,500	.075	3.81	.81	.26	3.47	.41

1/ 10 Lbs. borax used on all plots.

Table 54. Effect of Three Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Culpeper, Virginia, Sampled on July 28, 1950.

Location – A

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% N	% P
Check	1	1,700	.036	2.31	.80	.41	3.20	.37
1000 Lbs. 0-10-20	2	1,850	.044	2.30	.87	.30	3.53	.36
	3	2,350	.039	2.41	.80	.31	3.26	.39
	4	2,100	.048	2.51	.72	.44	3.39	.36
AVERAGE		2,000	.042	2.38	.80	.36	3.34	.37
800 Lbs. 0-12-12	1	2,100	.043	2.58	.60	.42	2.96	.43
1000 Lbs. 0-10-20	2	2,400	.036	2.77	.93	.33	3.34	.36
	3	2,300	.027	2.59	.60	.38	4.01	.38
	4	2,350	.056	2.69	.51	.35	3.39	.34
AVERAGE		2,287	.041	2.66	.66	.37	3.42	.38
800 Lbs. 0-12-12	1	2,400	.042	2.90	.71	.41	3.39	.41
1000 Lbs. 0-10-20	2	2,300	.036	2.85	.59	.36	3.42	.35
120 Lbs. K_2O	3	2,550	.043	3.32	.53	.33	3.20	.35
	4	2,350	.039	3.02	.87	.29	3.28	.36
AVERAGE		2,400	.040	3.02	.67	.35	3.32	.37

Location – B

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% N	% P
Check	1	1,700	.025	2.63	.65	.44	2.77	.40
1000 Lbs. 0-10-20	2	1,800	.023	2.45	.78	.42	3.31	.40
	3	1,200	.030	2.25	.66	.46	3.28	.41
	4	1,250	.042	2.23	.55	.42	3.63	.40
AVERAGE		1,237	.030	2.39	.66	.43	3.25	.40
800 Lbs. 0-12-12	1	1,900	.020	3.03	.43	.25	3.15	.44
1000 Lbs. 0-10-20	2	1,950	.039	2.49	.65	.30	3.36	.39
	3	1,100	.022	2.92	.65	.38	3.31	.48
	4	1,900	.029	2.74	.55	.41	2.96	.44
AVERAGE		1,712	.027	2.79	.57	.33	3.19	.44
800 Lbs. 0-12-12	1	2,250	.021	3.36	.63	.26	3.39	.40
1000 Lbs. 0-10-20	2	1,600	.020	3.12	.53	.38	2.79	.43
120 Lbs. K_2O	3	2,000	.021	2.95	.59	.26	3.45	.40
	4	2,000	.021	3.31	.49	.23	3.45	.44
AVERAGE		1,962	.021	3.18	.56	.28	3.77	.42

1/ 10 Lbs. borax used on all plots.

Table 55. Effect of Three Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Culpeper, Virginia, Sampled on August 31, 1950.

Location - A

Treatment[1/] Lbs./Acre	Rep-lic-ate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% P
	1	700	.043	2.09	.66	.25	.31
Check	2	650	.041	1.89	.71	.32	.30
1000 Lbs. 0-10-20	3	1,050	.035	2.01	.77	.25	.50
	4	800	.042	1.78	.72	.35	.28
AVERAGE		800	.040	1.94	.71	.29	.30
	1	900	.048	2.21	.76	.20	.32
800 Lbs. 0-12-12	2	1,150	.027	2.34	.73	.33	.30
1000 Lbs. 0-10-20	3	1,150	.033	2.26	.74	.24	.32
	4	1,500	.045	2.30	.72	.25	.30
AVERAGE		1,175	.038	2.28	.74	.25	.31
800 Lbs. 0-12-12	1	1,250	.039	2.42	.59	.20	.30
1000 Lbs. 0-10-20	2	1,100	.036	2.28	.70	.24	.31
120 Lbs. K_2O	3	1,450	.060	2.04	.73	.24	.30
	4	1,100	.052	2.39	.72	.21	.27
AVERAGE		1,225	.047	2.28	.68	.22	.29

Location - B

Treatment Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% P
	1	350	.025	1.67	.76	.35	.27
Check	2	150	.036	1.50	.69	.32	.29
1000 Lbs. 0-10-20	3	650	.017	1.57	.64	.30	.35
	4	200	.047	1.50	.57	.23	.29
AVERAGE		337	.031	1.56	.66	.30	.30
	1	300	.020	1.67	.60	.24	.29
800 Lbs. 0-12-12	2	300	.036	1.78	.61	.25	.32
1000 Lbs. 0-10-20	3	850	.026	1.77	.74	.40	.34
	4	650	.020	1.67	.59	.41	.31
AVERAGE		525	.025	1.72	.63	.32	.31
800 Lbs. 0-12-12	1	450	.016	1.87	.57	.31	.28
1000 Lbs. 0-10-20	2	450	.015	1.88	.55	.30	.32
120 Lbs. K_2O	3	800	.018	1.68	.40	.25	.31
	4	900	.021	1.77	.38	.27	.31
AVERAGE		650	.017	1.80	.47	.28	.31

1/ 10 Lbs. borax used on all plots.

Table 56. Effect of Six Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Glade Spring, Virginia, Sampled on May 22, 1951.

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% P
1000 Lbs. 2-12-12	1	3,277	.085	2.03	1.22	.25	.36
30 Lbs. Minor	2	2,757	.084	2.00	1.09	.20	.35
Elements[2/]	3	2,877	.068	1.41	1.58	.32	.36
100 Lbs. Na_2CO_3	4	2,997	.118	1.87	1.06	.38	.36
AVERAGE		2,977	.089	1.83	1.24	.29	.36
1000 Lbs. 2-12-12	1	2,198	.042	2.04	1.18	.23	.39
30 Lbs. Minor	2	2,118	.047	2.03	1.22	.23	.37
Elements	3	3,037	.055	2.53	1.21	.30	.35
	4	2,477	.048	2.56	1.18	.50	.38
AVERAGE		2,458	.048	2.29	1.20	.31	.37
	1	3,117	.074	1.89	1.16	.21	.37
1000 Lbs. 2-12-12	2	2,837	.073	2.02	1.28	.30	.40
100 Lbs. Na_2CO_3	3	2,757	.085	1.89	1.75	.34	.37
	4	3,077	.108	1.89	1.29	.47	.35
AVERAGE		2,947	.085	1.92	1.37	.33	.37
1000 Lbs. 2-12-24	1	3,676	.062	2.50	1.06	.23	.34
30 Lbs. Minor	2	3,277	.061	2.89	1.03	.20	.33
Elements	3	3,516	.050	2.67	.92	.26	.34
100 Lbs. Na_2CO_3	4	4,356	.052	2.95	.98	.33	.36
AVERAGE		3,706	.056	2.75	1.00	.26	.34
1000 Lbs. 2-12-0	1	2,517	.058	1.33	1.33	.38	.36
30 Lbs. Minor	2	1,678	.148	.85	1.37	.30	.40
Elements	3	2,238	.107	1.13	1.22	.43	.39
200 Lbs. Na_2CO_3	4	959	.172	.80	1.34	.62	.36
AVERAGE		1,848	.121	1.03	1.31	.43	.38
1000 Lbs. 2-24-24	1	2,637	.061	2.30	1.11	.25	.37
30 Lbs. Minor	2	3,676	.070	2.78	.99	.17	.39
Elements	3	2,957	.058	2.80	1.61	.32	.39
100 Lbs. Na_2CO_3	4	3,357	.060	3.14	.93	.30	.41
AVERAGE		3,157	.062	2.75	1.16	.26	.39

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 57. Effect of Six Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Glade Spring, Virginia, Sampled on July 11, 1951.

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% P
1000 Lbs. 2-12-12	1	2,759	.086	1.67	1.11	.27	.32
30 Lbs. Minor	2	——[3/]	——	——	——	——	——
Elements[2/]	3	1,844	.070	1.66	.79	.30	.35
100 Lbs. Na_2CO_3	4	2,483	.072	1.44	.88	.39	.32
AVERAGE		2,362	.076	1.59	.92	.32	.33
1000 Lbs. 2-12-12	1	1,350	.050	1.58	1.09	.26	.34
30 Lbs. Minor	2	2,758	.062	1.63	.89	.22	.34
Elements	3	——	——	——	——	——	——
	4	——	——	——	——	——	——
AVERAGE		2,054	.056	1.60	.99	.24	.34
1000 Lbs. 2-12-12	1	2,991	.066	1.91	1.02	.22	.33
100 Lbs. Na_2CO_3	2	3,020	.077	1.84	1.07	.49	.34
	3	2,163	.070	1.62	.90	.39	.33
	4	2,076	.060	1.55	1.73	.36	.34
AVERAGE		2,562	.068	1.73	1.18	.36	.33
1000 Lbs. 2-12-24	1	3,107	.047	2.42	.90	.16	.32
30 Lbs. Minor	2	2,657	.059	2.32	.92	.21	.30
Elements	3	2,904	.041	2.59	.74	.26	.30
100 Lbs. Na_2CO_3	4	2,889	.039	2.44	.60	.32	.33
AVERAGE		2,889	.046	2.44	.79	.24	.31
1000 Lbs. 2-12-0	1	2,643	.084	1.49	.97	.14	.36
30 Lbs. Minor	2	2,294	.145	1.03	1.18	.33	.39
Elements	3	2,280	.068	1.32	.92	.30	.40
100 Lbs. Na_2CO_3	4	2,047	.053	1.17	.77	.43	.40
AVERAGE		2,316	.087	1.25	.96	.30	.39
1000 Lbs. 2-24-24	1	1,888	.053	2.06	.86	.26	.33
30 Lbs. Minor	2	2,889	.049	2.37	.92	.16	.32
Elements	3	1,568	.056	2.25	.83	.27	.34
100 Lbs. Na_2CO_3	4	2,744	.051	2.14	.72	.37	.34
AVERAGE		2,272	.052	2.20	.83	.26	.33

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.
3/ Samples not taken due to faulty mowing.

Table 58. Effect of Six Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Glade Spring, Virginia, Sampled on August 16, 1951.

Treatment[1/] Lbs./Acre	Rep-lic-ate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% P
1000 Lbs. 2-12-12	1	1,481	.073	3.03	1.37	.63	.31
30 Lbs. Minor	2	1,489	.043	3.64	1.23	.32	.30
Elements[2/]	3	1,346	.062	3.05	1.10	.11	.30
100 Lbs. Na_2CO_3	4	1,441	.065	2.59	1.37	.38	.32
AVERAGE		1,439	.061	3.08	1.27	.36	.31
1000 Lbs. 2-12-12	1	1,307	.032	3.67	1.10	.21	.32
30 Lbs. Minor	2	1,117	.036	2.64	1.14	.18	.31
Elements	3	1,346	.034	2.84	.90	.21	.30
	4	1,449	.026	3.09	1.19	.35	.32
AVERAGE		1,305	.032	3.06	1.08	.24	.31
1000 Lbs. 2-12-12	1	1,703	.062	3.92	1.10	.51	.32
100 Lbs. Na_2CO_3	2	2,138	.059	3.32	1.06	.57	.35
	3	1,869	.062	2.75	1.32	.27	.31
	4	1,410	.072	3.03	1.19	.47	.33
AVERAGE		1,780	.064	3.25	1.17	.46	.33
1000 Lbs. 2-12-24	1	1,362	.044	4.72	1.23	.51	.28
30 Lbs. Minor	2	1,964	.055	4.18	1.17	.25	.29
Elements	3	1,307	.045	4.05	1.04	.33	.29
100 Lbs. Na_2CO_3	4	1,719	.041	4.38	.88	.35	.30
AVERAGE		1,588	.046	4.33	1.08	.36	.29
1000 Lbs. 2-12-0	1	1,354	.039	3.47	.82	.57	.34
30 Lbs. Minor	2	713	.079	1.73	1.24	.52	.34
Elements	3	942	.045	1.90	.98	.51	.33
100 Lbs. Na_2CO_3	4	855	.054	1.77	1.01	.35	.39
AVERAGE		966	.054	2.22	1.01	.49	.35
1000 Lbs. 2-24-24	1	2,487	.062	4.30	1.04	.26	.32
30 Lbs. Minor	2	1,426	.045	4.41	.94	.29	.30
Elements	3	1,829	.070	4.27	1.01	.32	.31
100 Lbs. Na_2CO_3	4	1,584	.056	3.66	1.10	.21	.31
AVERAGE		1,831	.058	4.16	1.02	.27	.31

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 59. Effect of Six Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Glade Spring, Virginia, Sampled on October 11, 1951.

Treatment[1] Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% P
1000 Lbs. 2-12-12	1	863	.174	1.28	2.90	.83	.30
30 Lbs. Minor	2	867	.103	1.62	1.91	.46	.27
Elements[2]	3	942	.119	1.44	2.79	.74	.27
100 Lbs. Na_2CO_3	4	867	.185	1.10	2.75	.67	.29
AVERAGE		885	.145	1.36	2.58	.67	.28
1000 Lbs. 2-12-12	1	792	.052	1.60	2.61	.53	.32
30 Lbs. Minor	2	871	.089	1.24	2.16	.64	.32
Elements	3	942	.075	1.33	2.08	.55	.28
	4	847	.056	1.19	2.56	.67	.33
AVERAGE		863	.068	1.34	2.35	.60	.31
1000 Lbs. 2-12-12	1	1,025	.119	1.64	2.45	.60	.32
100 Lbs. Na_2CO_3	2	962	.135	1.30	2.92	.39	.33
	3	938	.149	1.19	2.38	.74	.29
	4	788	.145	1.30	2.36	.44	.30
AVERAGE		928	.137	1.36	2.53	.54	.31
1000 Lbs. 2-12-24	1	911	.079	2.09	2.22	.60	.28
30 Lbs. Minor	2	1,113	.089	1.69	2.30	.39	.30
Elements	3	1,037	.069	1.93	1.66	.40	.29
100 Lbs. Na_2CO_3	4	820	.079	1.80	1.91	.64	.29
AVERAGE		970	.079	1.88	2.02	.51	.29
1000 Lbs. 2-12-0	1	808	.091	1.44	1.91	.39	.29
30 Lbs. Minor	2	1,097	.164	.67	2.79	.67	.34
Elements	3	713	.135	.88	2.36	.44	.33
100 Lbs. Na_2CO_3	4	344	.227	.65	2.81	.44	.33
AVERAGE		740	.154	.91	2.46	.48	.32
1000 Lbs. 2-24-24	1	851	.109	1.80	2.61	.60	.33
30 Lbs. Minor	2	958	.070	2.29	2.02	.39	.32
Elements	3	590	.109	1.87	2.16	.44	.30
100 Lbs. Na_2CO_3	4	1,073	.098	1.96	1.91	.67	.32
AVERAGE		868	.097	1.98	2.17	.52	.32

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 60. Analysis of Variance for Percent Potassium and Sodium in Alfalfa Grown at Glade Spring, Virginia in 1951.

First Cutting - May 22, 1951. Percent Potassium

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.07	.008	Minor Elements	.22
Treats.	5	8.00	24.100**	Phosphorus	.01
Error	15	.33		Sodium	.94
Total	23			2-12-0 vs 2-12-12	1.97*
				2-12-12 vs 2-12-24	1.80*

First Cutting - May 22, 1951. Percent Sodium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.08	2.01	Minor Elements	.04
Treats.	5	.27	7.21**	Phosphorus	.08
Error	15	.04		Sodium	.45*
Total	23			2-12-0 vs 2-12-12	.25
				2-12-12 vs 2-12-24	.35*

Second Cutting - July 11, 1951. Percent Potassium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.15	1.72	Minor Elements	.33
Treats.	5	3.57	40.11**	Phosphorus	.46*
Error	15	.09		Sodium	.03
Total	23			2-12-0 vs 2-12-12	.81*
				2-12-12 vs 2-12-24	1.77*

Second Cutting - July 11, 1951. Percent Sodium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.10	5.17*	Minor Elements	.14
Treats.	5	.14	7.59**	Phosphorus	.13
Error	15	.02		Sodium	.35*
Total	23			2-12-0 vs 2-12-12	.03
				2-12-12 vs 2-12-24	.40*

Third Cutting - August 16, 1951. Percent Potassium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	1.99	4.14*	Minor Elements	.28
Treats.	5	6.72	14.00**	Phosphorus	.25
Error	15	.48		Sodium	.04
Total	23			2-12-0 vs 2-12-12	1.63*
				2-12-12 vs 2-12-24	1.92*

* Significant at 5% level.
** Significant at 1% level.

Table 61. Analysis of Variance for Percent Potassium and Sodium in Alfalfa Grown at Glade Spring, Virginia in 1951. (Continued).

Third Cutting - August 16, 1951. Percent Sodium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.00	.00	Minor Elements	.04
Treats.	5	.10	4.57**	Phosphorus	.15
Error	15	.02		Sodium	.38*
Total	23			2-12-0 vs 2-12-12	.09
				2-12-12 vs 2-12-24	.18

Fourth Cutting - October 11, 1951. Percent Potassium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.66	2.16	Minor Elements	.02
Treats.	5	3.80	12.42**	Phosphorus	.21
Error	15	.31		Sodium	.04
Total	23			2-12-0 vs 2-12-12	1.27*
				2-12-12 vs 2-12-24	1.20*

Fourth Cutting - October 11, 1951. Percent Sodium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.05	.77	Minor Elements	.05
Treats.	5	.40	6.55**	Phosphorus	.16
Error	15	.06		Sodium	.69*
Total	23			2-12-0 vs 2-12-12	2.27*
				2-12-12 vs 2-12-24	.56*

Summary of Four Cuttings - 1951. Percent Potassium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	5.23	1.68	Minor Elements	.85
Treats.	5	82.65	26.49**	Phosphorus	.50
Error	15	3.12		Sodium	.89
Total	23			2-12-0 vs 2-12-12	5.67*
				2-12-12 vs 2-12-24	6.68*

Summary of Four Cuttings - 1951. Percent Sodium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.21	.63	Minor Elements	.18
Treats.	5	3.00	9.18**	Phosphorus	.46
Error	15	.33		Sodium	.86*
Total	23			2-12-0 vs 2-12-12	.25
				2-12-12 vs 2-12-24	1.49*

* Significant at 5% level.
** Significant at 1% level.

From the latter two tables it is seen that both increments of potash caused a highly significant increase in potassium uptake. The average potassium content was 1.35 percent for the 2-12-0 treatment, 1.97 percent for the 2-12-12 treatment and 2.85 percent for the 2-12-24 treatment. As in the previous experiments percent potassium was found to be correlated with the fertilizer potassium applied, irrespective of yields. Yields were highest at the first cutting and dropped steadily with each successive cutting. The potassium content, however, was excessively high in the third cutting, and lowest in the last cutting.

In general, sodium content of the alfalfa was influenced by sodium application and the second increment of potash. An increase in sodium uptake resulted from sodium application and a decrease resulted from the second increment of potash. The average sodium content of the forage varied from .051 percent for the 2-12-12 treatment without sodium to .104 percent for the 2-12-0 treatment with sodium. Sodium content dropped steadily with the first, second and third cuttings, then exhibited a sharp rise in the last cutting. Perhaps the same explanation would suffice in 1951 as in 1950; that is, the sodium may have been used as a partial replacement for available potassium, which had become deficient at this time in the soil.

As in the two previous years, correlation tests showed that potassium definitely depressed calcium, magnesium and sodium uptake.

The analysis of variance for percent sodium and percent potassium of alfalfa at Glade Spring over the three year period is presented in Table 62.

Table 62. Analysis of Variance in Alfalfa Grown at Glade Spring, Virginia in 1949, 1950 and 1951. (A Summary of Three Years).

1949-1951 - Percent Potassium

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	27.2	1.43	Minor Elements	.19
Treats.	5	468.0	24.7**	Phosphorus	1.69
Error	15	19.0		Sodium	3.72
Total	23			2-12-0 vs 2-12-12	14.19*
				2-12-12 vs 2-12-24	15.49*

1950-1951 - Percent Sodium

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	.41	.32	Minor Elements	.05
Treats.	5	15.90	12.50**	Phosphorus	1.09
Error	15	1.30		Sodium	3.97*
Total	23			2-12-0 vs 2-12-12	.94
				2-12-12 vs 2-12-24	3.24*

* Significant at 5% level.
** Significant at 1% level.

A highly significant increase in potassium uptake by the forage was effected by both increments of potash. In this particular field experiment, therefore, a direct relation existed between applications of potash fertilizer and amount of potassium in the forage. The application of minor elements, phosphorus and sodium had no effect on potassium content in the alfalfa.

An increase in sodium content resulted from the application of sodium and a decrease resulted from the second increment of potash.

Phosphorus and minor elements had no effect on the sodium content.

Tables 63 and 64 give the chemical composition of alfalfa grown at Culpeper in 1951. It has been mentioned previously that only one cutting for 1951 was obtained due to the serious decline of the alfalfa stands. However, in August of that year, enough of a stand was left to take samples for chemical analysis and this is reported in Table 64.

A study of Table 63 shows that there was a positive correlation between percent potassium in the forage and the rate of potash fertilization. At the higher rate of potash, sodium and magnesium uptake were depressed while potassium, calcium and phosphorus uptake were increased. It is seen from Table 64 that the decline in the stand of alfalfa was accompanied by a marked decrease in calcium and magnesium content. Sodium decreased slightly while potassium and phosphorus remained about the same as in the first cutting.

The phosphorus and potassium in pounds per acre applied in the fertilizer and removed from the soil in 1949 at Glade Spring are given in Tables 65 and 66. Both potassium and phosphorus showed a smaller removal than

Table 63. Effect of Three Fertilizer Treatments on Yield and Chemical Composition of Alfalfa Grown at Culpeper, Virginia, Sampled on May 14, 1951. Location - A.

Treatment[1/] Lbs./Acre	Replicate	Yield Lbs./Acre	% Na	% K	% Ca	% Mg	% P
Check	1	1,412	.044	2.61	.79	.34	.31
	2	1,238	.048	2.66	.87	.43	.33
	3	1,540	.042	2.61	.91	.39	.32
	4	1,528	.055	2.14	1.16	.30	.34
AVERAGE		1,430	.047	2.50	.93	.37	.32
800 Lbs. 0-12-12	1	1,731	.090	3.19	.89	.31	.35
	2	1,702	.048	3.02	1.07	.31	.36
	3	1,557	.054	2.53	1.09	.31	.36
	4	2,109	.055	3.02	1.07	.43	.38
AVERAGE		1,775	.062	2.94	1.03	.34	.36
800 Lbs. 0-12-12 120 Lbs. K_2O	1	1,673	.037	3.09	.95	.24	.38
	2	2,138	.043	2.79	1.33	.28	.37
	3	1,993	.050	3.39	1.16	.24	.38
	4	2,353	.062	3.32	1.12	.26	.39
AVERAGE		2,039	.048	3.15	1.14	.25	.38

1/ 10 Lbs. borax used on all plots.

Table 64. Effect of Three Fertilizer Treatments on Chemical Composition of Alfalfa Grown at Culpeper, Virginia, Sampled in August, 1951. Location - A.

Treatment[1/] Lbs./Acre	Replicate	% Na	% K	% Ca	% Mg	% P
Check	1	.043	2.71	.58	.17	.32
	2	.045	2.18	.91	.22	.26
	3	.039	2.78	.58	.19	.33
	4	.035	2.54	.62	.19	.36
AVERAGE		.041	2.55	.67	.19	.34
800 Lbs. 0-12-12	1	.034	2.54	.95	.18	.37
	2	.027	2.71	.75	.35	.38
	3	.030	2.71	.73	.22	.36
	4	.044	2.71	.77	.21	.38
AVERAGE		.034	2.67	.80	.24	.37
800 Lbs. 0-12-12 120 Lbs. K_2O	1	.031	3.10	.63	.19	.36
	2	.037	3.01	.83	.22	.38
	3	.034	3.25	.95	.19	.41
	4	.039	2.84	1.09	.27	.36
AVERAGE		.035	3.05	.87	.22	.38

1/ 10 Lbs. borax used on all plots.

Table 65. Phosphorus and Potassium Removed per Acre by Three Cuttings of Alfalfa Grown at Glade Spring, Virginia in 1949.

Treatment[1] Lbs./Acre	Date Cut	Yield[3] (OvenDry) Lbs./A.	Percentage Composition (Oven Dry) P	Percentage Composition (Oven Dry) K	Lbs./Acre Removed P	Lbs./Acre Removed K
1000 Lbs. 2-12-12	7/12/49	1,141	.29	1.28	3.31	14.60
30 Lbs. Minor Elements[2]	8/24/49	2,262	.37	2.19	8.37	49.54
100 Lbs. Na_2CO_3	10/27/49	544	.20	.97	1.09	5.28
SEASON TOTAL		3,947	—	—	12.80	69.40
	7/12/49	970	.31	1.42	3.01	13.77
1000 Lbs. 2-12-12	8/24/49	2,094	.39	2.48	8.17	51.93
30 Lbs. Minor Elements	10/27/49	471	.21	.89	.99	4.19
SEASON TOTAL		3,535	—	—	12.20	69.90
1000 Lbs. 2-12-12	7/12/49	992	.29	1.33	2.88	13.19
100 Lbs. Na_2CO_3	8/24/49	2,401	.37	2.02	8.88	48.50
	10/27/49	591	.20	.83	1.18	4.91
SEASON TOTAL		3,984	—	—	12.90	66.60
1000 Lbs. 2-12-24	7/12/49	1,012	.30	1.68	3.04	17.00
30 Lbs. Minor Elements	8/24/49	2,394	.34	2.42	8.14	57.93
100 Lbs. Na_2CO_3	10/27/49	597	.17	1.28	1.01	7.64
SEASON TOTAL		4,003	—	—	12.20	82.60
1000 Lbs. 2-12-0	7/12/49	976	.30	1.05	2.93	10.25
30 Lbs. Minor Elements	8/24/49	1,877	.38	1.64	7.13	30.79
100 Lbs. Na_2CO_3	10/27/49	396	.21	.56	.83	2.22
SEASON TOTAL		3,249	—	—	10.90	43.30
1000 Lbs. 2-24-24	7/12/49	1,055	.30	1.51	3.16	15.93
30 Lbs. Minor Elements	8/24/49	2,533	.36	2.40	9.12	60.79
100 Lbs. Na_2CO_3	10/27/49	668	.20	1.08	1.34	7.21
SEASON TOTAL		4,256	—	—	13.60	83.90

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.
3/ Average of 4 replications.

Table 66. Phosphorus and Potassium Removed per Acre by Three Cuttings of Alfalfa Grown at Glade Spring, Virginia in 1949 Compared with the Phosphorus and Potassium Applied.

Treatment[1] Lbs./Acre	Phosphorus (Lbs./Acre)			Potassium (Lbs./Acre)		
	Applied	Removed	Applied over Removed	Applied	Removed	Applied over Removed
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2] 100 Lbs. Na_2CO_3	52.4	12.8	39.6	99.6	69.4	30.2
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	52.4	12.2	40.2	99.6	69.9	29.7
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	52.4	12.9	39.5	99.6	66.6	33.0
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	52.4	12.2	40.2	199.2	82.6	116.6
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	52.4	10.9	41.5	00.0	43.3	-43.3
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	104.8	13.6	91.2	199.2	83.9	115.3

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

application, except where no potash was applied, in which case there was a deficit of 43 pounds per acre of potassium. Under the 120 pounds per acre application, the carry-over of potassium was 30 pounds, and under the 240 pounds per acre application, the carry-over was 117 pounds. Where 240 pounds per acre of P_2O_5 had been used in conjunction with 240 pounds per acre of potash, the carry-over was 115 pounds of potassium. In contrast to the potassium, the amount of phosphorus removed from the soil was about constant regardless of the rate of phosphate and potash applications. The phosphorus removed was about one-fourth that applied where 120 pounds per acre of P_2O_5 was used and about one-eighth of the amount applied where 240 pounds per acre of P_2O_5 was used. The gain to the soil of 91 pounds of phosphorus under the larger P_2O_5 application as compared to 40 pounds of phosphorus under the smaller P_2O_5 application is evidence that alfalfa plants remove a constant amount of phosphorus, regardless of the quantity applied.

Table 65 shows the close correlation between potassium removal and yields. Where yields were high, potassium removal was high and where yields were low, potassium removal was low. At the higher rates of potash application, the carry-over of potassium in the soil was very large and a correspondingly greater benefit from potassium was derived from the fertilizer.

In contrast to 1949, more potassium was removed than was applied in the fertilizer in 1950, as indicated in Table 68. The deficit was 62 pounds of potassium where no potash was applied, 49 pounds of potassium where 120 pounds per acre of potash was used and only 9 pounds under the

Table 67. Phosphorus and Potassium Removed per Acre by Four Cuttings of Alfalfa Grown at Glade Spring, Virginia in 1950.

Treatment[1/] Lbs./Acre	Date Cut	Yield[3/] (OvenDry) Lbs./A	Percentage Composition (Oven Dry) P	Percentage Composition (Oven Dry) K	Lbs./Acre Removed P	Lbs./Acre Removed K
1000 Lbs. 2-12-12	5/21/50	2,494	.38	2.47	9.48	61.60
30 Lbs. Minor Elements[2/]	7/7/50	2,902	.32	1.90	9.29	55.14
100 Lbs. Na_2CO_3	8/21/50	1,309	.31	1.51	4.06	19.77
	10/17/50	1,199	.33	1.01	3.96	12.11
SEASON TOTAL		7,904	—	—	26.80	148.60
	5/21/50	2,494	.41	2.77	10.23	64.08
1000 Lbs. 2-12-12	7/7/50	2,975	.33	1.96	9.82	58.31
30 Lbs. Minor Elements	8/21/50	1,092	.33	1.75	3.60	19.11
	10/17/50	1,219	.32	1.25	3.90	15.24
SEASON TOTAL		7,780	—	—	27.50	161.70
	5/21/50	2,194	.39	2.52	8.56	55.29
1000 Lbs. 2-12-12	7/7/50	3,360	.32	1.60	10.75	53.76
100 Lbs. Na_2CO_3	8/21/50	1,493	.33	1.55	4.93	23.14
	10/17/50	1,139	.33	1.06	3.76	12.07
SEASON TOTAL		8,186	—	—	28.00	144.30
1000 Lbs. 2-12-24	5/21/50	2,457	.38	3.13	9.34	76.90
30 Lbs. Minor Elements	7/7/50	2,989	.31	2.48	9.27	74.13
100 Lbs. Na_2CO_3	8/21/50	1,442	.30	2.24	4.33	32.30
	10/17/50	1,201	.29	2.04	3.48	24.50
SEASON TOTAL		8,089	—	—	26.40	207.80
	5/21/50	1,743	.43	1.22	7.49	21.66
1000 Lbs. 2-12-0	7/7/50	2,545	.36	1.05	9.16	26.72
30 Lbs. Minor Elements	8/21/50	701	.36	1.05	2.52	7.36
100 Lbs. Na_2CO_3	10/17/50	795	.36	.80	2.86	6.36
SEASON TOTAL		5,784	—	—	22.00	61.70
1000 Lbs. 2-24-24	5/21/50	2,391	.41	3.22	9.80	76.99
30 Lbs. Minor Elements	7/7/50	3,547	.32	2.47	11.35	87.61
100 Lbs. Na_2CO_3	8/21/50	1,633	.31	2.17	5.06	35.44
	10/17/50	1,292	.30	1.93	3.88	24.94
SEASON TOTAL		8,863	—	—	30.10	225.00

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.
3/ Average of 4 replications.

Table 68. Phosphorus and Potassium Removed per Acre by Four Cuttings of Alfalfa Grown at Glade Spring, Virginia in 1950 Compared with the Phosphorus and Potassium Applied.

Treatment[1] Lbs./Acre	Phosphorus (Lbs./Acre)			Potassium (Lbs./Acre)		
	Applied	Removed	Applied over Removed	Applied	Removed	Applied over Removed
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2] 100 Lbs. Na_2CO_3	52.4	26.8	25.6	99.6	148.6	-49.0
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	52.4	27.5	24.9	99.6	161.7	-62.1
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	52.4	28.0	24.4	99.6	144.3	-44.7
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	52.4	26.4	26.0	199.2	207.8	-8.6
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	52.4	22.0	30.4	00.0	61.7	-61.7
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	104.8	30.1	74.7	199.2	225.0	-25.8

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

240 pounds per acre treatment. The deficit was 26 pounds of potassium where 240 pounds of P_2O_5 was used with 240 pounds of potash. The yields were highest for 1950 under the extra P_2O_5 treatment and, therefore, resulted in a greater removal of potassium than where the 2-12-24 treatment was used. As in 1949, the phosphorus removal for 1950 was about constant regardless of either the rate of application or yields. The phosphorus removed in 1950 was about 50 percent that applied under 120 pounds per acre P_2O_5 application and about 30 to 35 percent of the amount applied where 240 pounds per acre of P_2O_5 was used. Despite the fact that about twice as much phosphorus was removed by the alfalfa in 1950 as in 1949, the carry-over of phosphorus in the soil still remained quite large. Unlike phosphorus, the removal of twice as much potassium in 1950 as in 1949 resulted in large deficits in the soil. However, the deficits are not as large as they appear to be if the applied potash for 1950 is added to the carry-over of the previous year.

On an overall comparison, the amount of potassium removed in 1951 equaled that in 1950 and, therefore, large deficits again resulted (Table 70). The potassium deficit increased from 8 pounds under the 240 pounds per acre of P_2O_5 application to 69 pounds where no potash was applied.

Again phosphorus removal for 1951 was about the same regardless of rates of application. In 1951, the phosphorus removed was about 50 percent of that applied under 120 pounds per acre of P_2O_5 application and about 25 percent of the applied where 240 pounds per acre of P_2O_5 was used.

At Culpeper, both phosphorus and potassium showed a smaller removal than application. The amount of potassium removed by the forage was

Table 69. Phosphorus and Potassium Removed per Acre by Four Cuttings of Alfalfa Grown at Glade Spring, Virginia in 1951.

Treatment[1] Lbs./Acre	Date Cut	Yield (Oven Dry) Lbs. A[3]	Percentage Composition (Oven Dry) P	K	Lbs./Acre Removed P	K
1000 Lbs. 2-12-12	5/22/51	2,673	.36	1.83	9.62	48.92
30 Lbs. Minor Elements[2]	7/11/51	2,157	.33	1.59	7.12	34.30
100 Lbs. Na_2CO_3	8/16/51	1,298	.31	3.08	4.02	39.98
	10/11/51	788	.28	1.36	2.21	10.72
SEASON TOTAL		6,916	—	—	23.00	133.90
	5/22/51	2,207	.37	2.29	8.17	50.54
1000 Lbs. 2-12-12	7/11/51	1,875	.34	1.60	6.38	30.00
30 Lbs. Minor Elements	8/16/51	1,178	.31	3.06	3.65	36.05
	10/11/51	768	.31	1.34	2.38	10.29
SEASON TOTAL		6,028	—	—	20.60	126.90
	5/22/51	2,646	.37	1.92	9.79	50.80
1000 Lbs. 2-12-12	7/11/51	2,339	.33	1.73	7.72	40.46
100 Lbs. Na_2CO_3	8/16/51	1,606	.33	3.25	5.30	52.80
	10/11/51	826	.31	1.36	2.56	11.23
SEASON TOTAL		7,417	—	—	25.40	154.70
1000 Lbs. 2-12-24	5/22/51	3,327	.34	2.75	11.31	91.49
30 Lbs. Minor Elements	7/11/51	2,638	.31	2.44	8.18	64.37
100 Lbs. Na_2CO_3	8/16/51	1,433	.29	4.33	4.16	62.05
	10/11/51	863	.29	1.88	2.50	16.22
SEASON TOTAL		8,261	—	—	26.20	234.10
	5/22/51	1,659	.38	1.03	6.30	17.09
100 Lbs. 2-12-0	7/11/51	2,115	.39	1.25	8.25	26.44
30 Lbs. Minor Elements	8/16/51	872	.35	2.22	3.05	19.36
100 Lbs. Na_2CO_3	10/11/51	659	.32	.91	2.11	6.00
SEASON TOTAL		5,305	—	—	19.70	68.90
1000 Lbs. 2-24-24	5/22/51	2,834	.39	2.75	11.05	77.94
30 Lbs. Minor Elements	7/11/51	2,074	.33	2.20	6.84	45.63
100 Lbs. Na_2CO_3	8/16/51	1,652	.31	4.16	5.12	68.72
	10/11/51	773	.32	1.98	2.47	15.31
SEASON TOTAL		7,333	—	—	25.50	207.60

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.
3/ Average of 4 replications.

Table 70. Phosphorus and Potassium Removed per Acre by Four Cuttings of Alfalfa Grown at Glade Spring, Virginia in 1951 Compared with the Phosphorus and Potassium Applied.

Treatment[1] Lbs./Acre	Phosphorus (Lbs./Acre)			Potassium (Lbs./Acre)		
	Applied	Removed	Applied over Removed	Applied	Removed	Applied over Removed
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2] 100 Lbs. Na_2CO_3	52.4	23.0	29.4	99.6	133.9	-34.3
1000 Lbs. 2-12-12 30 Lbs. Minor Elements.	52.4	20.6	31.8	99.6	126.9	-27.3
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	52.4	25.4	27.0	99.6	154.7	-55.1
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	52.4	26.2	26.2	199.2	234.1	-34.9
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	52.4	19.7	32.7	00.0	68.9	-68.9
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	104.8	25.5	79.3	199.2	207.6	-8.4

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

approximately the same as that removed at Glade Spring. However, the rates of potash applied were much larger at Culpeper, which allowed a carry-over in the soil. Without exception, a larger quantity of potassium was removed from the soil where 416 pounds per acre of potash was applied than where 296 pounds per acre of potash was used. This data is presented in Tables 71, 72, 73 and 74. The yields in 1950 at Location A were higher than those at Location B (Table 71), hence a greater removal of potassium in the forage at Location A. It is seen, therefore, (Table 72) that the gain in potassium to the soil was greater at Location B. The carry-over amounted to a low of 30 pounds in Location A where 296 pounds per acre of K_2O was applied and a high of 168 pounds in location B under the 416 pounds per acre treatment.

The phosphorus and potassium removed per ton of hay at Glade Spring for 1949, 1950 and 1951 are given in Table 75, while that at Culpeper for 1950 and 1951 are presented in Table 76. Regardless of the rate of phosphorus and potassium applied, the phosphorus removed per ton of hay at Glade Spring was nearly constant, the average being about 7 pounds of phosphorus. In contrast to the phosphorus, the potassium removed per ton of forage was very closely correlated with the rate of potash fertilization. The potassium removed per ton of hay varied from a low of 21 pounds in 1950 where no potash was applied to a high of 57 pounds in 1951 under both of the 240 pounds per acre potash treatments. Per ton of hay, the potassium removed was lowest the first year (1949) and increased steadily with each successive year, regardless of yield.

Table 71. Phosphorus and Potassium Removed per Acre by Four Cuttings of Alfalfa Grown at Culpeper, Virginia in 1950.

Location - A

Treatment[1/] Lbs./Acre	Date Cut	Yield[2/] (OvenDry) Lbs./A.	Percentage Composition (Oven Dry) P	K	Lbs./Acre Removed P	K
	5/21/50	2,397	.48	3.04	11.51	72.87
Check	6/22/50	1,172	.37	2.59	4.34	30.35
1000 Lbs. 0-10-20	7/28/50	1,843	.37	2.38	6.82	43.86
	8/31/50	736	.30	1.94	2.21	14.28
SEASON TOTAL		6,148	—	—	24.90	161.40
	5/21/50	2,776	.50	3.16	13.88	87.72
800 Lbs. 0-12-12	6/22/50	1,517	.40	3.13	6.07	47.48
1000 Lbs. 0-10-20	7/28/50	2,108	.38	2.66	8.01	56.07
	8/31/50	1,081	.31	2.28	3.35	24.65
SEASON TOTAL		7,482	—	—	31.30	215.90
800 Lbs. 0-12-12	5/21/50	2,799	.49	3.37	13.72	94.33
1000 Lbs. 0-10-20	6/22/50	1,701	.38	3.37	6.46	57.32
120 Lbs. K_2O	7/28/50	2,212	.37	3.02	8.18	66.80
	8/31/50	1,127	.29	2.28	3.27	25.70
SEASON TOTAL		7,839	—	—	31.60	244.20

Location - B

Treatment	Date Cut	Yield	P	K	P	K
	5/21/50	1,273	.46	3.13	5.86	39.84
Check	6/22/50	724	.39	2.70	2.82	19.55
1000 Lbs. 0-10-20	7/28/50	1,140	.40	2.39	4.56	27.25
	8/31/50	310	.30	1.56	.93	4.84
SEASON TOTAL		3,447	—	—	14.20	91.50
	5/21/50	1,732	.49	2.90	8.49	50.23
800 Lbs. 0-12-12	6/22/50	1,127	.41	3.04	4.62	34.26
1000 Lbs. 0-10-20	7/28/50	1,578	.44	2.79	6.94	44.03
	8/31/50	483	.31	1.72	1.50	8.31
SEASON TOTAL		4,920	—	—	21.60	136.80
800 Lbs. 0-12-12	5/21/50	1,675	.51	3.37	8.54	56.45
1000 Lbs. 0-10-20	6/22/50	1,379	.41	3.81	5.65	52.54
120 Lbs. K_2O	7/28/50	1,808	.42	3.18	7.59	57.49
	8/31/50	598	.31	1.80	1.85	10.76
SEASON TOTAL		5,460	—	—	23.60	177.20

1/ 10 Lbs. borax used on all plots.
2/ Average of 4 replications.

Table 72. Phosphorus and Potassium Removed per Acre by Four Cuttings of Alfalfa Grown at Culpeper, Virginia in 1950 Compared with the Phosphorus and Potassium Applied.

Location - A

Treatment[1/] Lbs./Acre	Phosphorus (Lbs./Acre)			Potassium (Lbs./Acre)		
	Applied	Removed	Applied over Removed	Applied	Removed	Applied over Removed
Check 1000 Lbs. 0-10-20	43.7	24.9	18.9	165.9	161.4	4.5
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	85.6	31.3	54.3	245.6	215.9	29.7
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	85.6	31.6	54.0	345.2	244.2	101.0

Location - B

Treatment[1/] Lbs./Acre	Phosphorus Applied	Phosphorus Removed	Phosphorus Applied over Removed	Potassium Applied	Potassium Removed	Potassium Applied over Removed
Check 1000 Lbs. 0-10-20	43.7	14.2	29.5	165.9	91.5	74.4
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	85.6	21.6	64.0	245.6	136.8	108.8
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	85.6	23.6	62.0	345.2	177.2	168.0

1/ 10 Lbs. borax used on all plots.

Table 73. Phosphorus and Potassium Removed per Acre by One Cutting of Alfalfa Grown at Culpeper, Virginia in 1951. Location - A.

Treatment[1] Lbs./Acre	Date Cut	Yield Oven Dry Lbs./A[2]	Percentage Composition (Oven Dry)		Lbs./Acre Removed	
			P	K	P	K
Check	5/14/51	1,335	.32	2.50	4.27	33.38
800 Lbs. 0-12-12	5/14/51	1,657	.36	2.94	5.97	48.72
800 Lbs. 0-12-12 120 Lbs. K_2O	5/14/51	1,903	.38	3.15	7.23	59.94

Table 74. Phosphorus and Potassium Removed per Acre by One Cutting of Alfalfa Grown at Culpeper, Virginia in 1951 Compared with the Phosphorus and Potassium Applied. Location - A.

Treatment[1] Lbs./Acre	Phosphorus (Lbs./Acre)			Potassium (Lbs./Acre)		
	Applied	Removed	Applied over Removed	Applied	Removed	Applied over Removed
Check	00.00	4.27	-4.3	0.00	33.38	-33.4
800 Lbs. 0-12-12	41.91	5.97	35.9	79.65	48.72	30.9
800 Lbs. 0-12-12 120 Lbs. K_2O	41.91	7.23	34.7	179.22	59.94	119.3

1/ 10 Lbs. borax used on all plots.
2/ Average of 4 replications.

Table 75. Phosphorus and Potassium Removed per Ton of Hay in 1949, 1950 and 1951 Under Six Fertilizer Treatments at Glade Spring, Virginia.

Treatment[1] Lbs./Acre	1949			1950		
	Yield Hay Lbs./Acre	Lbs. Removed: per Ton Hay P	K	Yield Hay Lbs./Acre	Lbs. Removed per Ton Hay P	K
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2] 100 Lbs. Na_2CO_3	3,947	6.49	35.2	7,904	6.78	37.6
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	3,535	6.90	39.5	7,780	7.07	41.6
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	3,984	6.48	33.4	8,186	6.84	35.3
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	4,003	6.10	41.3	8,089	6.53	51.4
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	3,249	6.71	26.7	5,784	7.61	21.3
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	4,256	6.39	39.4	8,863	6.79	50.8

1951			
1000 Lbs. 2-12-12 30 Lbs. Minor Elements[2] 100 Lbs. Na_2CO_3	6,916	6.65	38.7
1000 Lbs. 2-12-12 30 Lbs. Minor Elements	6,028	6.83	42.1
1000 Lbs. 2-12-12 100 Lbs. Na_2CO_3	7,417	6.85	41.7
1000 Lbs. 2-12-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	8,261	6.34	56.7
1000 Lbs. 2-12-0 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	5,305	7.43	26.0
1000 Lbs. 2-24-24 30 Lbs. Minor Elements 100 Lbs. Na_2CO_3	7,333	6.95	56.6

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 76. Phosphorus and Potassium Removed per Ton of Hay in 1950 and 1951 Under Three Fertilizer Treatments at Culpeper, Virginia.

Treatment[1] Lbs./Acre	1950 - Location - A			1950 - Location - B		
	Yield Hay Lbs./Acre	Lbs. Removed per Ton Hay		Yield Hay Lbs./Acre	Lbs. Removed per Ton Hay	
		P	K		P	K
Check 1000 Lbs. 0-10-20	6,148	8.10	52.5	3,447	8.24	53.1
800 Lbs. 0-12-12 1000 Lbs. 0-10-20	7,482	8.37	57.7	4,920	8.78	55.6
800 Lbs. 0-12-12 1000 Lbs. 0-10-20 120 Lbs. K_2O	7,839	8.06	62.3	5,460	8.64	64.9

1951 - Location - A			
Check	1,335	6.40	50.0
800 Lbs. 0-12-12	1,657	7.21	58.8
800 Lbs. 0-12-12 120 Lbs. K_2O	1,903	7.60	63.0

1/ 10 Lbs. borax used on all plots.

At Culpeper, the phosphorus removed per ton of forage was nearly constant, while the amount of potassium removed varied with the rate of potash fertilization. The differences in potassium removal, however, were not as outstanding as at Glade Spring, the average removed being about 60 pounds of potassium.

Tables 77, 78, 79 and 80 give the results of soil analyses at Glade Spring and Tables 81, 82, 83 and 84 give the same results at Culpeper. At both Glade Spring and Culpeper, the highest amount of exchangeable potassium was found where the highest rate of potash was applied. The available potassium in the topsoil at Glade Spring varied from 106 pounds per acre where no potash was applied to 219 pounds per acre on both the 2-12-24 and 2-24-24 treated plots. There was little variation in the subsoil potassium, the average being about 128 pounds per acre. At Culpeper, the highest exchangeable potassium was 293 pounds per acre in the topsoil and 330 pounds per acre in the subsoil (Tables 81 and 82). The exchangeable potassium was consistently higher in the subsoil than topsoil.

At both Culpeper and Glade Spring, the exchangeable sodium varied considerably from treatment to treatment. At Glade Spring, there was very little variation between the topsoil and subsoil, while at Culpeper, the exchangeable sodium was higher in the topsoil than subsoil.

The exchangeable calcium at Glade Spring (Tables 77 and 78) was quite high, more than 5,000 pounds per acre being found in the topsoil and more than 3,000 pounds per acre found in the subsoil. A surprising fact regarding the soil at Culpeper was the large amounts of available phosphorus that existed in the subsoil (Table 84). In contrast to this, the available phosphorus in the subsoil at Glade Spring was very low. The pH was about neutral at both Locations.

Table 77. Exchangeable Cations of Topsoil from Alfalfa Experiment at Glade Spring, Virginia.

Treatment[1/] Lbs./Acre	Replicate	Lbs./Acre				
		H	K	Na	Ca	Mg
1000 Lbs. 2-12-12	1	67	127	83	7,120	336
30 Lbs. Minor Elements[2/]	2	89	144	87	5,640	230
100 Lbs. Na_2CO_3	3	84	140	92	4,080	192
	4	84	115	78	4,400	346
AVERAGE		81	132	85	5,310	276
	1	63	179	87	5,840	206
1000 Lbs. 2-12-12	2	80	115	55	6,440	288
30 Lbs. Minor Elements	3	82	134	69	5,200	278
	4	82	175	55	5,200	442
AVERAGE		77	151	67	5,670	304
	1	78	168	120	5,600	178
1000 Lbs. 2-12-12	2	65	146	97	6,720	202
100 Lbs. Na_2CO_3	3	75	134	87	4,240	163
	4	78	131	87	4,240	442
AVERAGE		74	145	98	5,200	246
1000 Lbs. 2-12-24	1	80	214	101	5,560	182
30 Lbs. Minor Elements	2	58	188	69	5,920	235
100 Lbs. Na_2CO_3	3	84	190	87	5,040	173
	4	82	283	92	4,080	374
AVERAGE		76	219	87	5,150	241
1000 Lbs. 2-12-0	1	76	105	78	4,680	240
30 Lbs. Minor Elements	2	87	100	69	3,400	211
100 Lbs. Na_2CO_3	3	84	120	78	4,560	346
	4	89	100	64	5,520	346
AVERAGE		84	106	72	4,540	286
1000 Lbs. 2-24-24	1	69	183	97	6,720	240
30 Lbs. Minor Elements	2	89	184	78	5,600	240
100 Lbs. Na_2CO_3	3	98	286	87	5,200	134
	4	78	223	83	5,600	365
AVERAGE		83	219	86	5,780	245

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 78. Exchangeable Cations of Subsoil from Alfalfa Experiment at Glade Spring, Virginia.

Treatment[1] Lbs./Acre	Replicate	Lbs./Acre H	K	Na	Ca	Mg
1000 Lbs. 2-12-12	1	95	120	87	3,440	125
30 Lbs. Minor Elements[2]	2	104	125	69	2,960	125
100 Lbs. Na_2CO_3	3	106	128	78	4,032	346
	4	102	140	83	3,648	211
AVERAGE		102	128	79	3,520	202
	1	114	108	55	3,040	134
1000 Lbs. 2-12-12	2	97	109	41	2,400	182
30 Lbs. Minor Elements	3	105	137	55	4,224	403
	4	97	137	60	3,904	211
AVERAGE		103	123	53	3,392	233
	1	134	122	69	3,200	115
1000 Lbs. 2-12-12	2	95	120	60	3,760	163
100 Lbs. Na_2CO_3	3	129	136	78	4,096	346
	4	106	122	147	3,648	173
AVERAGE		116	125	89	3,676	199
1000 Lbs. 2-12-24	1	104	134	83	3,440	144
30 Lbs. Minor Elements	2	108	128	97	3,120	173
100 Lbs. Na_2CO_3	3	111	136	110	4,288	346
	4	79	125	110	3,072	134
AVERAGE		100	131	100	3,480	199
1000 Lbs. 2-12-0	1	106	125	55	3,120	163
30 Lbs. Minor Elements	2	92	119	74	3,120	182
100 Lbs. Na_2CO_3	3	101	147	55	3,904	403
	4	101	125	78	4,160	173
AVERAGE		100	129	66	3,576	230
1000 Lbs. 2-24-24	1	88	128	83	3,760	173
30 Lbs. Minor Elements	2	109	115	74	2,560	163
100 Lbs. Na_2CO_3	3	96	128	120	3,648	355
	4	81	125	120	3,968	211
AVERAGE		94	124	99	3,484	226

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 79. Analysis of Variance for Soil at Glade Spring, Virginia.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Topsoil - Exchangeable Potassium					
Reps.	3	1,207	.7	Minor Elements	16
Treats.	5	14,352	8.6**	Phosphorus	1
Error	15	1,671		Sodium	24
Total	23			2-12-0 vs 2-12-12	33
				2-12-12 vs 2-12-24	111*
Topsoil - Exchangeable Sodium					
Reps.	3	20.7	6.3**	Minor Elements	2.7
Treats.	5	23.8	7.2**	Phosphorus	.3
Error	15	3.3		Sodium	4.0*
Total	23			2-12-0 vs 2-12-12	2.8*
				2-12-12 vs 2-12-24	.5
Subsoil - Exchangeable Sodium					
Reps.	3	54.33	3.9*	Minor Elements	2.0
Treats.	5	67.00	4.8**	Phosphorus	.2
Error	15	13.87		Sodium	5.7
Total	23			2-12-0 vs 2-12-12	3.0
				2-12-12 vs 2-12-24	4.5

* Significant at 5% level.
** Significant at 1% level.

Table 80. Truog Phosphorus and pH of Soil from Alfalfa Experiment at Glade Spring, Virginia.

Treatment[1] Lbs./Acre	Replicate	Topsoil Truog Phosphorus Lbs./Acre	Topsoil pH	Subsoil Truog Phosphorus Lbs./Acre	Subsoil pH
1000 Lbs. 2-12-12	1	84	7.2	16	7.1
30 Lbs. Minor Elements[2]	2	40	7.1	8	6.9
100 Lbs. Na_2CO_3	3	64	7.2	18	6.9
	4	58	7.2	18	6.3
AVERAGE		61	7.2	15	6.8
	1	114	7.1	20	7.0
1000 Lbs. 2-12-12	2	50	7.1	8	6.0
30 Lbs. Minor Elements	3	72	7.2	14	7.1
	4	82	7.1	18	7.0
AVERAGE		79	7.1	15	6.8
	1	114	7.0	22	6.5
1000 Lbs. 2-12-12	2	320	7.1	8	7.3
100 Lbs. Na_2CO_3	3	48	7.2	8	6.6
	4	58	7.1	12	7.0
AVERAGE		135	7.1	12	6.8
1000 Lbs. 2-12-24	1	86	7.1	16	6.9
30 Lbs. Minor Elements	2	36	7.1	8	6.9
100 Lbs. Na_2CO_3	3	48	7.1	12	6.9
	4	56	6.9	8	6.7
AVERAGE		56	7.1	11	6.9
1000 Lbs. 2-12-0	1	82	7.0	32	6.9
30 Lbs. Minor Elements	2	60	7.0	4	7.0
100 Lbs. Na_2CO_3	3	42	7.1	14	6.7
	4	78	7.1	14	6.9
AVERAGE		65	7.1	16	6.9
1000 Lbs. 2-24-24	1	156	7.3	36	7.2
30 Lbs. Minor Elements	2	88	6.9	12	6.8
100 Lbs. Na_2CO_3	3	134	7.0	20	7.0
	4	164	7.0	16	7.1
AVERAGE		135	7.0	21	7.0

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 81. Exchangeable Cations of Topsoil from Alfalfa Experiment at Culpeper, Virginia. Location - A.

Treatment[1/] Lbs./Acre	Replicate	Lbs./Acre H	K	Na	Ca	Mg
Check	1	148	109	81	4,160	403
	2	136	156	86	3,392	931
	3	154	147	74	3,840	1,075
	4	153	119	82	3,968	1,488
AVERAGE		148	133	81	3,840	974
800 Lbs. 0-12-12	1	139	234	122	3,968	739
	2	146	78	76	2,816	931
	3	179	215	87	3,840	653
	4	134	153	85	3,392	1,190
AVERAGE		150	170	93	3,504	878
800 Lbs. 0-12-12 30 Lbs. Minor Elements[2/]	1	146	128	97	3,904	355
	2	129	212	92	3,840	720
	3	109	150	67	4,160	653
	4	104	187	81	3,584	1,056
AVERAGE		122	169	84	3,872	696
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	1	169	181	120	4,736	470
	2	138	150	105	3,840	1,075
	3	161	215	110	4,032	710
	4	140	187	98	3,456	1,075
AVERAGE		152	183	108	4,016	833
800 Lbs. 0-12-12 120 Lbs. K_2O	1	144	368	113	4,032	499
	2	74	181	108	3,584	682
	3	139	253	113	4,096	1,114
	4	169	368	88	2,880	1,190
AVERAGE		132	293	106	3,648	871

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 82. Exchangeable Cations of Subsoil from Alfalfa Experiment at Culpeper, Virginia. Location - A.

Treatment[1/] Lbs./Acre	Replicate	Lbs./Acre H	K	Na	Ca	Mg
Check	1	166	175	59	3,456	605
	2	146	109	48	2,496	307
	3	152	215	52	4,032	317
	4	166	178	42	3,072	605
AVERAGE		158	169	50	3,264	458
800 Lbs. 0-12-12	1	153	181	75	3,136	461
	2	146	144	46	3,008	384
	3	135	275	59	2,816	317
	4	135	275	59	2,816	317
AVERAGE		142	186	56	3,104	415
800 Lbs. 0-12-12 30 Lbs. Minor Elements[2/]	1	143	237	64	3,584	528
	2	140	140	59	3,328	518
	3	177	200	49	2,480	317
	4	160	115	55	2,480	710
AVERAGE		155	173	57	2,968	518
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	1	146	268	94	3,968	605
	2	145	234	66	3,392	624
	3	169	346	67	3,648	384
	4	124	156	72	2,688	480
AVERAGE		146	251	75	3,424	523
800 Lbs. 0-12-12 120 Lbs. K_2O	1	148	215	55	2,560	384
	2	147	346	68	3,456	710
	3	178	321	55	3,200	442
	4	149	437	66	3,264	605
AVERAGE		156	330	61	3,120	535

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

Table 83. Analysis of Variance for Soil at Culpeper, Virginia.

Topsoil - Exchangeable Potassium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	4,368	.79	Minor Elements	1
Treats.	4	24,118	4.36*	Sodium	17
Error	12	5,522		Potassium	157*
Total	19				

Subsoil - Exchangeable Potassium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	9,518	1.32	Minor Elements	17
Treats.	4	31,131	4.32*	Sodium	83
Error	12	7,189		Potassium	184*
Total	19				

Topsoil - Exchangeable Sodium

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	1,748	3.21	Minor Elements	19
Treats.	4	2,927	5.39*	Sodium	34
Error	12	543		Potassium	28
Total	19				

Subsoil - Exchangeable Sodium.

Source	DF	MS	F	Treatment	Diff. in Ave. Yield/Treat.
Reps.	3	987	2.77	Minor Elements	1
Treats.	4	1,584	4.45*	Sodium	40*
Error	12	356		Potassium	10
Total	19				

* Significant at 5% level.

Table 84. Truog Phosphorus and pH of Soil from Alfalfa Experiment at Culpeper, Virginia.

Treatment[1] Lbs./Acre	Replicate	Topsoil: Truog Phosphorus Lbs./Acre	Topsoil: pH	Subsoil: Truog Phosphorus Lbs./Acre	Subsoil: pH
Check	1	72	7.0	54	6.9
	2	54	7.1	26	6.9
	3	78	7.2	44	7.0
	4	54	6.9	58	6.7
AVERAGE		64	7.0	45	6.9
800 Lbs. 0-12-12	1	138	7.0	132	6.9
	2	64	6.8	80	6.9
	3	78	6.8	64	6.7
	4	98	6.9	72	7.0
AVERAGE		94	6.9	87	6.9
800 Lbs. 0-12-12 30 Lbs. Minor Elements[2]	1	82	7.1	92	6.9
	2	118	7.0	54	6.9
	3	72	7.0	64	6.7
	4	194	6.9	84	6.8
AVERAGE		116	7.0	73	6.8
800 Lbs. 0-12-12 100 Lbs. Na_2CO_3	1	100	7.1	62	6.9
	2	76	7.1	84	7.0
	3	114	6.9	180	6.9
	4	110	6.8	98	6.7
AVERAGE		100	7.0	106	6.9
800 Lbs. 0-12-12 120 Lbs. K_2O	1	68	7.0	56	7.0
	2	382	7.0	152	6.9
	3	74	7.0	70	6.7
	4	164	6.9	68	6.8
AVERAGE		172	7.0	86	6.8

1/ 10 Lbs. borax used on all plots.
2/ 10 Lbs. each of $CuSO_4$, $MnSO_4$ and $ZnSO_4$.

DISCUSSION OF RESULTS

The data have conclusively shown, through soil analysis and yield response of alfalfa to fertilizer, that under the conditions existing at the locations of these two experiments, the lack of potassium was the main factor limiting growth. The rates of potash applied, 120 pounds or 240 pounds per acre in 1950 and 1951 at Glade Spring were not enough to meet the fertilizer needs of the alfalfa, as shown by the deficits of potassium that arose as the difference between application and removal by the crop. As a result the plants withdrew from the potassium reserves of the soil in an attempt to meet these needs. In time, the potassium in the soil would have become exhausted and would have supported alfalfa growth no longer. These experiments indicate that most farmers in the state are not applying enough potassium to their alfalfa fields to maintain high yields and may also be the reason for alfalfa stands dying out after two or three years.

As shown by the balance sheets on application and removal, (Tables 68 and 70) deficits of potassium existed in the soil. However, the actual deficits for 1950 were not as large as they appeared to be in the tables, if the carry-over (gain) for 1949 were added to the potassium applied in 1950. The rates of potash applied at Culpeper were 296 pounds of potash per acre. Apparently these rates were enough to supply the alfalfa needs as there were no deficits left in the soil.

The results indicated a response to sodium at Glade Spring and Location A at Culpeper over the three-year period. Cooper and Garman (22), using $NaNO_3$ as a source of sodium, showed that at all levels of potash fertilization, the plots receiving sodium produced considerably more seed cotton over a 10-year period. Sodium, likewise, benefitted alfalfa yields at Glade Spring and Culpeper over a three-year period. When 120 pounds per acre of potash was supplemented with 100 pounds of Na_2CO_3 at Glade Spring, the extra sodium produced significant yield increases. On the other hand, no benefit was derived from sodium when 100 pounds of Na_2CO_3 was used without potash. Sodium used alone appeared in no way beneficial toward producing higher yields. When used as a supplement with potash, it did, however, produce higher yields. It seems that sodium performs a function that requires the presence of potassium. The sodium content of the forage at Glade Spring in 1950 was .113 percent and .104 percent in 1951 under the 2-12-0 treatment with sodium. This was the highest sodium content obtained. On this basis, therefore, alfalfa may be called a sodium accumulating plant where both sodium and potassium are present in the soil medium. Even though the herbage from the 2-12-0 treatment contained the highest percentage sodium, the yields from this treatment were lowest and potassium deficiency symptoms were marked. Here, as described by Carolus (19), is not a case of proper absorption of the element, but one of proper utilization, once the element gets into the plant. In any event, the presence of sodium in the alfalfa did it little good.

At Glade Spring, the yields usually decreased as the season progressed. The yields were invariably the lowest at the last cutting each year. Either one of two factors, or a combination of two factors may have been responsible for this decrease in yield: scarce rainfall during the latter part of the growing season causing a lack of moisture, or depletion of the fertilizer potassium during the later stages of the season. The latter may well have been the cause in 1950 and 1951 since all the fertilizer potassium had been used up by the first few cuttings. The potash deficit would not explain the low yield obtained at the last cutting in 1949, however, since there was fertilizer potassium left over in the soil after the last cutting was taken. The moisture factor, therefore, could be a larger factor than supposed.

The results showed that minor elements caused a decreased yield in the forage at both Glade Spring and Culpeper. By what means the minor elements were able to decrease yields is not known. It may be that the rates used were sufficient to bring about a toxic effect. If this be the case, the exclusion of minor elements from the other treatments would most likely have resulted in higher yields.

Phosphorus was not particularly a factor limiting yields in this experiment. At Glade Spring and at Culpeper, the phosphorus removed in the hay was much less than that applied. That phosphorus removal was always nearly constant regardless of phosphorus application is indicative of the selectively controlled absorption of phosphorus by the plants and the relative un-availability of phosphorus in the soil. There was a greater variation in the phosphorus content of the herbage from cutting to cutting than within cuttings. This was most likely a climatic effect with rainfall especially affecting phosphorus content. It was noticed that when rainfall was high, phosphorus was high and when rainfall was low, phosphorus was low. Similar results with phosphorus content and rainfall were found by Daniel and Harper (24), working with alfalfa and native grasses.

Alfalfa is usually regarded as having more potassium than calcium. Bear and Wallace (9) reported that a soil containing 7 times as much exchangeable calcium as exchangeable potassium, should yield alfalfa with 2 percent potassium and 1.4 percent calcium. The soil at Glade Spring had approximately 30 times as much exchangeable calcium as potassium. This probably accounts for the fact that the calcium was found to be higher than potassium in the alfalfa, particularly in 1949 and the last cutting in 1950 and 1951. This high ratio of exchangeable calcium to potassium in the soil does not explain the composition of the alfalfa at Culpeper, however. Here, the alfalfa was always higher in potassium than calcium. In fact, the calcium content of the forage at Culpeper was usually below 1 percent, which is lower than is usually reported in the literature.

From the chemical composition of the forage at both Glade Spring and at Culpeper, it can be concluded that potassium decreased sodium uptake but sodium had no effect on potassium uptake. In general, potassium fertilization depressed uptake of calcium, magnesium and sodium. At Glade Spring, potassium slightly depressed phosphorus absorption, but had no noticeable effect on phosphorus uptake at Culpeper. Potassium had no effect on nitrogen content.

SUMMARY AND CONCLUSIONS

The conclusions of the alfalfa fertility investigations at Glade Spring and at Culpeper may be summarized as follows:

1. Potassium was the main limiting factor in the growth, duration of stand, vigor and color of alfalfa.
2. In general, yields were related directly to rate of potash fertilization.
3. Yield variations due to phosphorus fertilization were insignificant.
4. Sodium gave increased yields at Glade Spring and Location A at Culpeper, but had little or no effect on yields at Culpeper at Location B.
5. In general, yields were decreased by the application of minor elements.
6. In 1950 and 1951 at Glade Spring, more potassium was removed from the soil than was applied, the deficits ranging from only 8.4 pounds per acre of potassium where a 2-24-24 fertilizer was used, to 68.9 pounds per acre of potassium where a 2-12-0 fertilizer was used.
7. The potassium removed per ton of hay was closely correlated with the rate of potassium fertilization.
8. The phosphorus removed in the hay varied from 1/2 to 1/8 of the phosphorus applied in the fertilizer.

9. The phosphorus removed was nearly constant regardless of the rates of phosphorus fertilization.

10. Potassium decreased sodium uptake in the alfalfa; on the other hand, sodium had no effect on potassium uptake.

11. Alfalfa appears to be a sodium accumulating plant when sodium is used as a supplement with potassium.

12. Potassium depressed the absorption of calcium, magnesium and sodium.

13. At Glade Spring, potassium slightly depressed phosphorus absorption but had no noticeable effect on phosphorus uptake at Culpeper. Potassium appeared to have no appreciable effect on nitrogen content.

14. The soil at Glade Spring had approximately 30 times as much exchangeable calcium as potassium. As a result, the calcium content of the alfalfa was often higher than the potassium content.

15. Available phosphorus in the topsoil at Glade Spring was about five times higher than in the subsoil; on the other hand, available phosphorus at Culpeper was about equal in topsoil and subsoil.

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