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PREFACE

In the fall of 1951, the writer was assigned to the problem of comparing the methods of determining available potassium of soils which are used by the Agronomy Department of the Oklahoma Agricultural and Mechanical College, the Soil Conservation Service and the County Agent Soils Laboratories. Lack of agreement in results of soil analysis by the different methods led to this investigation.

The writer wishes to express his appreciation to Dr. H. F. Murphy and Dr. Fenton Gray of the Agronomy Department for their helpful advice and criticisms, to Mr. Robert O. Woodward of the Extension Service for his collecting soil samples and other help indispensable to this study, and to Mr. George E. Stroup for making available for this study his County Agent Soils Laboratory.

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INTRODUCTION

Many of the soils of Oklahoma are high in potassium and apparently do not need potassium fertilizers to produce high yields of the commonly grown crops when the other factors are not limiting. But as cropping continues some of these soils are beginning to give increased yields from potassium fertilization. Several agencies including the Agronomy Department of the Oklahoma Agricultural and Mechanical College, the Soil Conservation Service and the County Agent Soils Laboratories are evaluating the ability of our soils to supply potassium to the various crops grown, and are giving potassium fertilizer recommendations for these soils and crops.

The three agencies mentioned use different laboratory procedures in determining the available potassium. Often times when the results of these procedures are compared, considerable differences are found.

The purpose of this investigation is to compare the different laboratory procedures and plant responses to potassium fertilization of soils. It is also to aid in finding corrective measures or replacements for these procedures, where needed, which will bring about the desired close correlation between the results of the different laboratories, and at the same time, bring about dependable evaluations of the available potassium of the soils being tested with a minimum of time and expense.

REVIEW OF LITERATURE

Source of Available Potassium and Its Extraction

To evaluate the ability of a soil to supply potassium to plants, we need to know not only the present level of the exchangeable and water soluble potassium, but also the rate of release of potassium from the nonexchangeable form. Many workers have found that this rate of release varies, and often times tremendously, from one soil to another (3, 8, 11, 13, 40). Evans and Simon (12) grew alfalfa for 36 months in pot cultures using Wisconsin soils. They found that the portion of the total potassium absorbed by the alfalfa being nonexchangeable at the start of the experiment ranged within the different soils from less than one-third to more than two-thirds.

Hoagland and Martin (17) studied two California soils with about equal exchangeable potassium contents. One of these soils did not give evidence of potassium deficiency over long periods of almost continuous cropping in the greenhouse with tomatoes and barley. The other soil soon became extremely deficient in supplying power for potassium as was indicated by these plants. For the former soil, the rye plants of the Neubauer method extracted 2.5 times as much potassium as was represented by the initial exchangeable potassium content. The rye seedlings only took about the same amount of potassium from the latter soil as was represented by the initial exchangeable potassium content.

Stewart and Volk (36) grew several southern crop plants under greenhouse conditions in Alabama soils of wide variation. Twelve crops were harvested over a 4-year period. The portion of the potassium extracted by the plants being nonexchangeable at the start of the experiment ranged from 39 to 87%.

Rouse and Bertramson (34) conclude from their study of 23 Indiana soils that the potassium supplying power appears to remain rather constant within a given soil series and type from one location to another, and that the exchangeable potassium was apparently not related to the potassium supplying power of the soils studied.

Pratt (31) states that the more weathered soils give less accurate predictions of their potassium supplying power from their exchangeable potassium than do the less weathered soils. He pointed out that the soils studied by Rouse and Bertramson, and Stewart and Volk were more weathered than the Iowa soils that he studied. He considers the exchangeable potassium as being the best single measurement of the potassium availability of the Iowa soils. By using an equation which employed the nonexchangeable potassium which was released to Dowex-50 cation exchange resin, and the exchangeable potassium, a better measure of the available potassium was made. He found normal HNO_3 to be a close rival of Dowex-50 for correctly extracting the soil for the purpose of measuring available potassium.

Bray (6) found that the exchangeable potassium values did not correlate closely with increases in corn yield in bushels per acre from potash fertilizers. But when the yields from plots having a system of legumes and crop residues turned under, limed, and phosphated are expressed as percentages of the yields from similar plots but having potash fertilizers applied, a closer correlation with the exchangeable potassium values was obtained. He ventures to say that these findings are applicable to the great majority of the soils of the corn belt.

Reed (32) used the three extracting reagents, neutral normal ammonium acetate, 0.05 normal HCl and 0.2 normal barium chloride buffered with triethanolamine at pH 8.1. Good agreement was found with the potassium extracted by these methods and the field response to potassium fertilization.

Mehlich (21) reports that in general Aspergillus niger absorbed more than the exchangeable potassium from soil during 4.5 days of incubation, and considerably more potassium was absorbed by the A. niger than by rye seedlings, using the Neubauer technique. However, there were good correlation between the A. niger method, Neubauer method and the exchangeable potassium.

Long (19) used A. niger and a method which employs $NaClO_4$ in 0.1 normal $HClO_4$ to extract potassium from the soil. He found neither method satisfactory for predicting cotton and wheat responses to potassium fertilization of the several Tennessee soils studied. Winters (40) obtained similar results for Tennessee soils by using a method employing $NaClO_4$ as the extracting agent.

Release of potassium over a 30-day period by electrodialysis gave a very high correlation coefficient with potassium released to Ladino clover over a 740-day period, using several soils from various locations in the eastern humid areas of the United States (33). Normal HNO_3 gave almost as high a coefficient, followed by a modified Neubauer procedure. A method whereby the soil was extracted every 30 days for 210 days with neutral normal ammonium acetate correlated poorly with the clover uptake of potassium. Allowing the soil to undergo ten freezing and thawing cycles during each 30-day storage period reduced the effectiveness of the ammonium acetate method.

Legg and Beacher (18) grew Ladino clover and ryegrass on several Arkansas soils having a wide range of physical and chemical properties. They found a direct relationship between the potassium supplying power, as shown by growing these plants, and the potassium solubilized by normal HNO_3. However, two sandy soils with low basic exchange capacities did not show this relationship. Carbonic acid, neutral normal ammonium acetate and sodium acetate were ineffective as extracting agents in measuring the potassium supplying power of the soils studied here.

Rouse and Bertramson (34) also give a favorable report for normal HNO_3, but 0.2 normal HNO_3 did not give desirable results. They suggest sampling in the spring and drying the soil at 70 degrees C. if a measure of the potassium status of the soil is to be had from the exchangeable form. Chandler (11) suggests sampling both in the spring and in the fall to get a measure of the rate at which the exchangeable potassium is replenished in order to increase the value of the exchangeable potassium as an index to the potassium requirement of different soils.

Williams and Jenny (39) found that the potassium replaced with various 0.1 normal acid solutions with pH ranges between 3 and 7 was mostly from the exchangeable form, whereas that replaced at pH values below 3 included a large proportion of the nonexchangeable form. However, HCl leaching solutions of pH 3 and 4 removed far less potassium from the soil than did 0.1 normal solutions of the weak acids at corresponding pH values possibly as a result of the buffering capacity of the weak acids. They found the relative replacing abilities of the metallic cations to be in the order $Na^+ > Li^+ > Ca^{++} > Mg^{++} > NH_4^+$. The ammonium ion was the only one of the group which did not replace non-exchangeable potassium. For the same concentrations HCl is much more effective than the salts used of the metallic cations in replacing potassium from the soil.

Peech (30) states that the ammonium ion exerts a very pronounced blocking effect on the conversion of the nonexchangeable potassium into the exchangeable form. Because of this, ammonium acetate affords an accurate measure of the amount of exchangeable potassium in the soil at any one time.

Determining Potassium in Soil Extracts

Flame photometer

Brown and Lilleland (9) ran comparisons of ammonium acetate extracts of soil read by a model 18 Perkin-Elmer flame photometer with a gravimetric chloroplatinate method. The photometric value averaged 1.7% lower than the chemical value. The standard deviation of the photometric method from the chemical method was found to be $4.8 \pm 3.7\%$. However, the photometric method had the advantage of being much faster.

Attoe and Troug (1) found that many of the salts and acids which are often present in soil extracts affect the surface tension of the extracts, resulting in erroneous flame photometer readings. By using 2 normal ammonium acetate and 0.2 normal magnesium acetate as the extracting agent, the error was greatly reduced.

Myers (25) obtained similar results by keeping the acid contents of both the standards and the extracts constant, and by adding to the standards the amounts of calcium and magnesium that were considered to be present in average soil extracts. As a help in speeding up standardization, a 4-way stop cock was placed on the flame photometer used by Myers.

The use of a flame photometer which uses an internal standard is described by Berry (4). Here, the light intensity ratio of lithium to potassium is measured. Where known amounts of potassium were present in the solutions being determined, an average error of ± 1.01% was obtained by this method compared to ± 3% for the absolute method.

Cobaltinitrite methods

Bray (7) describes a sodium cobaltinitrite turbidimetric method for determining potassium in soil extracts where either $NaClO_4$ or $NaNO_3$ may be used as the extracting agent, and the resulting turbidity is read in a photometer. This test was proved to extract and measure the total exchangeable potassium in soils. A 50-50 mixture of methyl and isopropyl alcohol, or ethyl alcohol by itself is used to aid in the precipitation. He warns that the precipitate should be developed at temperatures anywhere between 16 and 23 degrees C. but should be fairly constant, not varying over 1 or 2 degrees C. for any run. Graham (14) describes a procedure using tap water to cool the reagents and the soil extract.

Peech and English (29) claim less erratic results from temperature changes with a method employing isopropyl alcohol as the only alcohol used than when Bray's method is used. However, they found it best to bring about the precipitation at 25 degrees ± 4 degrees C. and caution that temperatures above 29 degrees C. should be avoided. Burkhart (10), using a sodium cobaltinitrite turbidimetric method somewhat different from the above mentioned methods, found marked decreases in precipitation at temperatures above 30 degrees C. Volk (37), using another sodium cobaltinitrite turbidimetric method, found it impossible to calibrate the changes in temperature against the apparent quantity of potassium present.

Ammonia forms a similar precipitate to that of potassium with sodium cobaltinitrite. Several workers have successfully used formaldehyde to avoid this precipitation (2, 29, 37).

The sodium cobaltinitrite salt decomposes upon aging. There are various ways of overcoming or partially offsetting this action (10, 29, 37, 38). Baver and Bruner (2) mix a solution of $NaNO_2$ containing formaldehyde and a solution of cobaltous nitrate acidized with acetic acid just prior to adding the soil extract. They explain that neither single solution deteriorates with age, but that previously combined solutions not only deteriorate with age, but also give precipitates which rapidly increase in density with time.

Baver and Bruner use 0.3 normal HCl as the extracting agent and buffer the alcohol to overcome the acidity. Melsted (22) gives some suggestions whereby more accurate results might be obtained when using 0.3 normal HCl as the extracting agent. Morgan (23) uses 0.5 normal acetic acid buffered with sodium acetate for the potassium extracting agent and determines the potassium turbidimetrically.

Wilcox (38) uses normal HNO_3, rather than the ordinarily used acetic acid to maintain the nitrate-nitrite equilibrium in the sodium cobaltinitrite solution. It is claimed that the precipitate approaches the ideal formula $K_2NaCo(NO_2)_6$ when using this method. He describes both volumetric and gravimetric procedures for determining potassium where the potassium is precipitated in the presence of the HNO_3. By using Wilcox's precipitation method, Peech (28) employs nitroso-R-salt to determine the potassium colorimetrically.

No attempt will be made in this report to name all of the different means in use of extracting and measuring potassium. The report entitled "Soil Testing in the United States," prepared by the Soil Test Work Group of the National Soil and Fertilizer Research Committee, lists on pages 79 through 97 the extracting solutions, means of measuring the extracted potassium and the soil-solution ratios used by the various laboratories in the United States.

Potassium Levels

The classification of soils as having different levels of available potassium is generally based on chemical tests which measure a portion of the exchangeable potassium. Such classification of soils is of more value where crop response correlates closely with the exchangeable potassium than where this correlation is poor. Often times soils show varied abilities to replace the exchangeable potassium once it is removed from the soil. This makes it very difficult to correlate the exchangeable potassium value of soils with crop response from one soil to another. Winters (40) states that caution should be exercised in use of exchangeable potassium values as a basis of fertilizer recommendations when knowledge of soil, climatic or crop conditions is inadequate. Considering the high potassium increment as being 100% for the Tennessee soils of his study, he considers as a general rule a 90% yield as being 155 pounds of exchangeable potassium per acre for corn, 160 for alfalfa, 185 for cotton, and 220 for Irish potatoes.

Bray (5) reports for 25 different soil experiment fields in

Illinois that it did not pay to use potassium fertilizer where there were 70 p.p.m. or more of replaceable potassium in the surface soil, soils having 45 p.p.m. or less gave a profitable response to potassium fertilization, soils having 45 to 70 p.p.m. gave erratic responses to potassium fertilization.

Olson and Bledsoe (27) conclude from 40 cotton field experiments conducted from 1932 through 1942 in Georgia that 0 to 140 pounds per acre of potash should be considered low for the soils of his study, 140 to 240 as medium, and 240+ as high.

Murphy (24) found from a study of a large group of Oklahoma soils that in general soils containing less than 60 p.p.m. of replaceable potassium give positive responses to potassium fertilization where the other needs of the plants are met. He found that where the replaceable potassium was 60 to 79 p.p.m. a response is obtained in many cases, doubtful for 80 to 99, very doubtful for 100 to 124, occasional response for 125 to 199 and no response for over 200.

Harper (16) reports that some crops require a higher level of potassium than others. Here, it is reported that alfalfa can be expected to give a response to potassium fertilization when the exchangeable potassium is less than 150 p.p.m., with the cotton requirement being somewhat less, and corn needs 100 p.p.m. or more for a high yield and 50 p.p.m. is adequate where the expected yield is low. The requirement for wheat is given as the same as that for corn.

Data presented by Magistad (20) indicated for a group of Hawaiian soils that pineapples give no increase in yield when the replaceable potash exceeds 500 pounds per acre foot of soil.

Troug[1] reports that under Wisconsin conditions it is desirable to have about 200 pounds per acre of exchangeable potassium in the plow layer for the growing of general farm crops including alfalfa. But satisfactory yields of many crops can be obtained with about 125 pounds. To insure alfalfa from succumbing to unfavorable conditions he considers it poor economy to grow alfalfa with much less than the 200 pounds.

Lathwell[2] reports that Morgan's solution (23) is used by Cornell University to extract for available potassium, and that below 100 pounds per acre is considered low, 100 to 150 pounds as medium, and above 150 pounds as high. However, he admits that there is need for getting at the suppling power of the soil and that this is being attempted with dilute solution extracts, below 0.01 normal in strength. As yet not enough evidence has been obtained by the workers in his laboratory to ascertain whether or not this will give the information desired.

The Agricultural Extension Service of Ohio considers 0 to 100 pounds per acre of exchangeable potassium as critical, 150 for poor, 175 for fair, and 250 for good.[3] The University of Missouri soil scientists find low to be 50 p.p.m. or less, medium to be 50 to 100 and high to be above 100 for their medium exchange capacity soils.[4]

If a method for determining potassium is used which measures more than just the exchangeable potassium, there will be a tendency to raise

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[1] By correspondence from Professor E. Truog, Chairman, Department of Soils, University of Wisconsin. June 26, 1952.

[2] By correspondence from Dr. Douglas J. Lathwell, Assistant Professor of Soil Science, Department of Agronomy, Cornell University. June 24, 1952.

[3] By correspondence from Dr. F. J. Salter, Extension Agronomist, Ohio Agricultural Extension Service. June 20, 1952.

[4] By correspondence from Dr. E. R. Graham, Professor of Soils, Department of Soils, University of Missouri. July 7, 1952.

the level of the recommended extractable potassium. Under greenhouse conditions the soils studied by Legg and Beacher (18) having less than 250 p.p.m. of potassium solubilizable by normal HNO_3 and a basic exchange capacity of greater than five milliequivalents per 100 grams gave a positive response to potassium fertilization. In the Soils Testing Laboratory of Purdue University, 0.7 normal HCl is employed to extract soil for available potassium.[/1] Here, less than 120 pounds per acre of available potash is classified as very low, 120 to 180 as low, 180 to 250 as medium, 250 to 350 as high and above 350 as very high. Recommendations coming from this laboratory include two fertilization rates for each soil test. The lower rate is suggested for the farmer who wants immediate returns for a smaller fertilizer investment. The higher rate is suggested for the farmer who wants maximum yields and returns and also wants to build up the phosphate-potash reserve in his soil.

[/1] By correspondence from Mr. J. M. Spain, Analyst, Purdue University.

MATERIALS AND METHODS

Laboratory

Soil samples were collected from various counties throughout the state of Oklahoma. The samples were air dried and run through a 20-mesh sieve. Four different procedures were used to estimate the available potassium. Soil analysis by the County Agent method for the results given in Table 9 (see Appendix) were made December 26, 1951 through January 2, 1952. There were no two readings for a given soil made on the same day. Only one reading was obtained for a given soil by each of the ammonium acetate methods. Rather than obtain duplicate readings for each soil by each method, soil 208 was analyzed as a check by each of the ammonium acetate methods in each group of soils analyzed. Sixteen soils were analyzed by the three ammonium acetate methods in one setting, making a total of 48 samples for each group. The figures for the ammonium acetate methods were obtained April 16 through June 16, 1952. On March 15 and again on July 3, 1952 additional soil analysis were made by the County Agent method. These results are shown in Tables 5 and 6, respectively.

County Agent method (procedure 1)

This procedure is very similar to the Bray method (7). It differs from the Bray method mainly in that no attempt is made to control the temperature of precipitation, and isopropyl alcohol is used instead of a mixture of isopropyl and methyl alcohols. In this procedure approximately 6.2 grams (spoon measure) of soil are placed in a test tube containing 10 ml. of a molal solution of sodium nitrate. The test tube is vigorously shaked 30, 25 and 20 times with a lapse of 5 minutes between them, then filtered. Two ml. of isopropyl alcohol are forcibly injected into 6 drops of sodium cobaltinitrite solution contained in a flat bottom vial. Two ml. of the soil extract are immediately injected into the center of this mixture with a medical syringe. This material is allowed to stand 10 minutes before the turbidity is read in a Klett-Summerson colorimeter.

Ammonium acetate-flame photometric methods

(procedures 2, 3 and 4)

Warm method (procedure 2, used by the Agronomy Department): Approximately 10 grams (spoon measure) of soil are placed in a test tube and 20 ml. of neutral normal ammonium acetate are added to the soil. The tube is vigorously shaked and placed in a water bath having a temperature of 70 degrees C. The test tube is left in the bath for one hour, during which time it is shaked every 15 minutes, then filtered. The soil extract is read in a model 52-C Perkin-Elmer flame photometer.

Cold methods (procedures 3 and 4): Procedure 3 is the same as procedure 2 except that the soil extraction takes place at room temperature. Procedure 4, which is used by the Soil Conservation Service, is the same as procedure 2 except that 10 grams of soil are accurately weighed out, and the soil extraction takes place at room temperature in an Erlenmeyer flask.

Greenhouse

Soil samples

All soils used in this study were taken from the plow layer. The four soils used are designated as 5A, 6A, 7A, and 185. The available potassium was determined by procedures 2, 3, and 4. Satisfactory readings by procedure 1 were unobtainable. This is discussed later under the secondary heading, Discussion of the County Agent Method. The easily soluble phosphorus was determined by an acetic acid method (15), the organic matter by a modified Schollenberger procedure (35) and the pH with a Beckman glass electrode pH meter.

Soil 5A - This sample of soil was obtained from a Parsons silt loam in Hughes County, where it has been in continuous cultivation about 45 years and has never been limed or fertilized. Peanuts, cotton and corn have been the predominating crops grown on this soil. The yields have fallen off considerably during recent years. Available potassium as determined by procedures 2, 3 and 4 was 120, 104 and 104 pounds per acre, respectively. The values for easily soluble phosphorus, organic matter and pH were low, 1.04% and 5.7, respectively.

Soil 6A - This sample of soil was obtained from a Bates very fine sandy loam in Hughes County, where it has been in continuous cultivation about 45 years. Peanuts, cotton and corn have been the predominating crops grown on this soil. In recent years yields have fallen off, and because of this lime and mixed fertilizers have been applied. The crops grown have responded well to these treatments. Available potassium as determined by procedures 2, 3 and 4 was 88, 88 and 84 pounds per acre, respectively. The values for easily soluble phosphorus, organic matter and pH were very low, 1.13% and 6.2, respectively.

Soil 7A - This sample of soil was obtained from a Waynesboro very fine sandy loam of the Heavener Experiment Station, located in LeFlore County, where it has been in cultivation for an undetermined number of years. During the last 20 years it has been used for crop variety testing, principally cotton. During this 20 years this soil has received an annual application of 150 pounds per acre of 4-12-4 fertilizer, and it has been limed. Available potassium as determined by procedures 2, 3, and 4 was 244, 236 and 224 per acre, respectively. The values for easily soluble phosphorus, organic matter and pH were low, 1.09% and 6.8, respectively.

Soil 185 - This sample of soil was obtained from an eroded Zaneis fine sandy loam in Grady County. Small grains and sorghums have been the predominating crops grown on this soil. Available potassium as determined by procedures 2, 3 and 4 was 264, 260 and 236 pounds per acre, respectively. The values for easily soluble phosphorus, organic matter and pH were very low, 0.95% and 5.8, respectively.

Experimental procedure

Each soil was thoroughly mixed and 9.15 pounds (oven dry basis) were placed in one-gallon, glazed earthenware pots. The treatments for the 5A and 6A soils were the check, N, P, K, NK, PK, NP and NPK. The treatments for the 7A and 185 soils were the check, NP and NPK. All treatments were done in triplicate. The first treatment of nitrogen was supplied by 0.21 grams of NH_4NO_3, which was calculated to be at the rate of 100 pounds per 2,000,000 pounds of soil. The phosphorus was supplied by 0.42 grams of 20% super phosphate. The potassium was supplied by 0.21 grams of 60% muriate of potash. The phosphorus and potassium fertilizers were placed in a layer about two inches below the surface of the soil before the time of planting. The nitrogen fertilizer was added to the surface of the soil 16 days after the time of planting.

Snap beans were chosen as the experimental crop because of their vigorous growth and early maturity. Six uninoculated seeds of the Contender variety were planted in each pot on March 18, 1952. The plants were watered and grown under greenhouse conditions throughout the experiment. Poor stands were obtained in 13 of the pots of the 5A soil and in three of the pots of the 6A soil. Beans were replanted in these pots one week after the first planting. All stands were thinned to three plants per pot 21 days after planting. Forty-one days after the first planting, all pots having been previously treated with only nitrogen were given an additional 0.21 grams of NH_4NO_3, and the pots having been previously treated with nitrogen plus some other nutrient were given an additional 0.42 grams of NH_4NO_3.

The 5A and 6A series were harvested 57 days after the first planting, except for the plants having the NP and NPK treatments. These were left along with the 7A and 185 series for further study. All plants of all four soils having the NP and NPK treatments were given an additional treatment of 0.42 grams of NH_4NO_3 at this time.

The 7A and 185 series were harvested all at the same time, at which time most beans were mature or nearing maturity. The remaining plants of the 5A and 6A soils tended to die upon maturity of seed. These plants were harvested individually after each had matured its seed. With this method of determining the time of harvest each plant was allowed to show its maximum deficiency symptoms and produce its maximum weight of seed under the existing conditions.

LABORATORY RESULTS AND DISCUSSION

Comparison of the Different Ammonium Acetate-flame Photometric Methods

Procedures 3 and 4 gave an average of 92.32% and 92.90% as great an evaluation, respectively, as procedure 2 gave for the 92 samples analyzed by all three procedures (see Table 9 in the Appendix). This would mean that the warm method extracts an appreciably greater amount of potassium from soil than the cold methods. There was very little difference in the extracting abilities of the two cold methods.

It is shown in Table 1 that the resulting calculated pounds per acre of available potassium is much in direct proportion to the amount of soil used for analysis. The soil samples ranged in weight when spoon measured from 8.15 to 12.28 grams. This would allow for approximately a 50% greater reading for the larger sample than for the smaller sample when normally both should read about the same, whereas by accurately weighing the samples this error would be avoided.

The flame photometric method for determining the potassium in the ammonium acetate extractions seems to be very satisfactory when conditions are favorable. Tobacco smoke or dust can cause erratic readings. It is also important to keep the air pressure constant for atomizing the soil extract. Restandardizing the machine at short intervals is highly important in obtaining accurate readings. The check sample, 208, used with each group of 16 samples gave a variation of

Table 1. A comparison of results obtained for the samples falling into three weight groups as measured by procedure 3 with the results obtained from the 10 gram weighed samples of procedure 4.

Less than 9 grams (8.15-8.95)			10.00 ± 0.35 grams (9.71-10.35)			Over 11 grams (11.05-12.28)		
Sample number	Proc. 3	Proc. 4	Sample number	Proc. 3	Proc. 4	Sample number	Proc. 3	Proc. 4
	Calculated pounds/A of available potassium			Calculated pounds/A of available potassium			Calculated pounds/A of available potassium	
10	184	176						
13	270	274	5A	104	104			
20	125	130	6A	88	84			
22	232	253	5	176	172	4	60	52
23	412	484	6	176	172	18	31	22
24	330	360	14	84	80	32	284	260
27	108	130	16	36	31	33	288	250
28	292	320	17	74	74	34	138	125
36	316	385	31	236	220	39	130	96
41	348	388	35	320	320	47	48	44
42	320	364	43	146	149	62	84	74
46	210	228	50	138	134	69	176	152
48	416	450	57	104	104	70	108	100
52	116	146	58	125	120	71	138	112
56	244	284	59	120	116	72	180	138
82	281	316	60	176	168	73	156	125
84	382	436	61	184	184	74	146	112
85	278	326	68	96	120	77	316	278
86	504	568	81	309	296	78	260	206
Averages	282.5	316.7		149.6	147.1		159.0	134.2
Percentage ratio of proc. 3 to proc. 4	89.2%			101.6%			118.5%	

267 to 300 pounds per acre of available potassium by procedure 2, as shown in Table 9 (see Appendix). The higher reading very likely came about as a result of allowing appreciable evaporation of the soil extract before determining its potassium content.

Comparison of the Ammonium Acetate Methods with the County Agent Method

The lowest average reading for pounds per acre of available potassium by the County Agent method was 66.5, see Table 2, while the ammonium acetate methods gave much lower results for several of the soils tested. The highest average reading by the County Agent method was 319, also shown in Table 2, while the ammonium acetate methods gave much higher results for several of the soils tested. These differencs may be due to one or more of several causes. Among them are imperfect conditions for the potassium precipitation by the County Agent method, differences in the abilities of the extracting agents to replace potassium and inaccurate interpretation of pounds per acre of potassium as shown by the dial on the colorimeter used in the County Agent method. The procedure used by the County Agent method to interpret pounds per acre from the colorimeter is to read the pounds directly from the dial without the use of any conversion factor.

Comparisons of the results of the four different procedures of this study for the samples of Table 9 (see Appendix) which gave average readings by the County Agent method of 100 to 150 and 150 to 200 pounds per acre of available potassium are presented in Tables 3 and 4, respectively. The results for these samples follow much in the same order by the different ammonium acetate methods, but this trend is lacking

Table 2. A comparison of the County Agent method with the ammonium acetate methods using the procedure 2 as a basis of comparison.

Sample number	Procedure 1. County Agent method			Procedures 2, 3 and 4. Ammonium acetate-flame photometric methods		
	Trial 1	Trial 2	Average	Proc. 2	Proc. 3	Proc. 4
	Calculated pounds per acre of available potassium					
	Ten low[1]					
16	69	64	66	40	36	31
11	77	86	81	44	36	26
18	83	72	77	44	31	22
15	113	93	103	56	48	48
1	104	106	105	60	56	--
47	93	79	86	64	48	44
53	87	78	82	68	64	64
4	122	113	117	80	60	52
25	90	72	81	80	68	74
54	107	108	107	80	64	60
		Averages	90	62	51	--[2]
	Ten high[3]					
83	248	246	247	360	326	337
41	184	170	177	376	348	388
35	298	294	296	382	320	320
48	152	140	146	399	416	450
84	315	320	317	412	382	436
64	328	310	319	419	388	416
80	300	321	310	422	408	422
23	321	300	310	439	412	484
79	184	194	189	476	426	450
86	266	264	265	550	504	568
		Averages	258	423	393	427

[1] The ten samples of Table 9 (see Appendix) giving the lowest number of pounds per acre of available potassium by procedure 2.

[2] Average not given because of missing datum above in this column.

[3] The ten samples of Table 9 (see Appendix) giving the highest number of pounds per acre of available potassium by procedure 2.

Table 3. A comparison of the results of the County Agent method with the results of the ammonium acetate methods for the samples which gave average readings of 100 to 150 pounds per acre of available potassium by the County Agent method.

Sample number	Procedure 1. County Agent method			Procedures 2, 3 and 4. Ammonium acetate-flame photometric methods		
	Trial 1	Trial 2	Average	Proc. 2	Proc. 3	Proc. 4
	Calculated pounds per acre of available potassium					
8	108	98	103	96	84	96
1	104	106	105	60	56	—
15	113	93	105	56	48	48
26	109	106	107	125	116	125
54	107	108	107	80	64	60
14	115	107	111	88	84	80
4	122	113	117	80	60	52
57	123	112	117	112	104	104
17	123	114	118	84	74	74
9	129	124	126	116	112	104
29	133	123	128	160	142	149
21	133	124	128	152	—	142
27	134	124	129	134	108	130
46	136	122	129	224	210	228
51	138	126	132	152	142	142
63	126	141	133	138	120	134
20	140	134	137	130	125	130
58	146	129	137	146	125	120
52	146	130	138	138	116	146
50	141	143	142	156	138	134
62	148	137	142	96	84	74
70	148	139	143	120	108	100
48	152	140	146	399	416	450
Percentages of the samples which fall into the 100 to 150 pounds group as shown by procedures 2, 3 and 4.				39.1%	54.6%	59.1%
Percentages of the samples which fall below the 100 to 150 pounds group as shown by procedures 2, 3 and 4.				34.8%	36.4%	31.8%
Percentages of the samples which fall above the 100 to 150 pounds group as shown by procedures 2, 3 and 4.				26.1%	9.1%	9.1%

Table 4. A comparison of the results of the County Agent method with the results of the ammonium acetate methods for the samples which gave average readings of 150 to 200 pounds per acre of available potassium by the County Agent method.

Sample number	Procedure 1. County Agent method			Procedures 2, 3 and 4. Ammonium acetate-flame photometric methods		
	Trial 1	Trial 2	Average [1]	Proc. 2	Proc. 3	Proc. 4
	Calculated pounds per acre of available potassium					
49	154	150	152	164	138	146
34	165	144	154	156	138	125
68	157	153	155	130	96	120
3	165	146	155	142	130	138
7	159	153	156	156	125	142
65	159	153	156	164	138	130
59	171	155	163	138	120	116
19	174	158	166	125	108	104
2	168	167	167	168	160	168
74	165	173	169	156	146	112
30	170	169	169	——	156	142
60	172	173	172	184	176	168
56	176	172	174	232	244	284
41	184	170	177	376	348	388
5	188	169	178	190	176	172
6	181	180	180	184	176	172
85	184	180	182	306	278	326
71	188	177	182	138	138	112
28	191	185	188	326	292	320
43	196	181	188	176	146	149
79	184	194	189	476	426	450
66	195	189	192	198	180	184
36	205	186	195	320	316	385
72	198	194	196	202	180	138
Percentages of the samples which fall into the 150 to 200 pounds group as shown by procedures 2, 3 and 4.				47.8%	29.2%	20.8%
Percentages of the samples which fall below the 150 to 200 pounds group as shown by procedures 2, 3 and 4.				21.7%	45.8%	54.2%
Percentages of the samples which fall above the 150 to 200 pounds group as shown by procedures 2, 3 and 4.				30.4%	25.0%	25.0%

[1] Where there were three trials made, as shown in Table 9 (see Appendix), the two figures having the closest agreement are used in this table.

between the results of the County Agent method and the results of the ammonium acetate methods. Many of the samples gave results by the ammonium acetate methods which would place them in a group which would call for an entirely different potassium fertilizer recommendation from that as indicated to be needed by the County Agent method.

Discussion of the County Agent Method

Readings obtained in December and January by the different trials by the County Agent method agree closely in most instances, as shown in Table 9 (see Appendix). For some undetermined cause these readings are generally higher than those obtained by the County Agents (see Table 11 in the Appendix). However, results of both tables classified the soils much in the same order. Poor agreement was obtained by readings of different extractions for a given soil on March 15, see Table 5. Two trials were made for each extraction to see if the irregularity of the readings was caused by variations in the technique used after the soil was extracted. These trials resulted in close agreement, indicating that the technique employed after the soil was extracted was consistent. This may indicate that the sodium cobaltinitrite solution used to precipitate the potassium was not the cause of the erratic readings. However, an attempt to get close agreement by two trials from each soil extract was unsuccessful on July 3. Variations in weight of the samples do not seem to be the cause of the erratic readings, as indicated by data presented in Table 5.

In Table 6 the results are shown of two trials of separate extractions for each soil tested. The blanks consisted only of the reagents. High readings of available potassium were obtained for each of the blanks,

Table 5. Soil samples analyzed a multiple of times on March 15 by the County Agent method showing its erratic results.

Sample number	1st extraction Trial 1	1st extraction Trial 2	Weight of sample used for 2nd extraction [1]	2nd extraction Trial 1	2nd extraction Trial 2
	Calculated pounds/A of available potassium		Grams	Calculated pounds/A of available potassium	
5A	173	175	6.53	151	124
5A	128	132	6.47	118	117
7A	199	210	6.76	199	-- [2]
7A	255	271	6.85	232	--
181	93	98	6.22	104	86
181	169	186	6.15	124	107
183	140	156	6.04	135	127
183	168	157	6.00	166	146
185	176	163	5.96	157	165
185	157	152	5.76	168	161
187	113	109	6.30	113	108
187	116	116	6.57	161	159
201	153	152	6.75	153	138
201	198	201	6.51	180	175

[1] The samples for the second extraction were spoon measured the same as was done for the first extraction. The spoon measured samples were then weighed for the second extraction to see if variations in sample weights were causing the erratic readings.

[2] Insufficient extraction for two injections.

Table 6. Results by the County Agent method obtained July 3 including the blanks, the greenhouse soils, and the other soils. The soil results are compared with the results of the ammonium acetate methods.

Sample number	Procedure 1. County Agent method		Procedures 2, 3 and 4. Ammonium acetate-flame photometric methods		
	Trial 1[1]	Trial 2[1]	Proc. 2	Proc. 3	Proc. 4
	Calculated pounds per acre of available potassium				
6A	127	170	88	88	84
5A	184	218	120	104	104
7A	258	260	244	236	224
185	233	232	264	260	236
Blank[2]	133	101			
Blank	96	136			
Blank	77	85			
Blank	131	142			
18	183 (83)[3]	161 (72)	36	31	24
204	239 (141)	219 (136)	----	----	----
49	216 (154)	223 (150)	164	138	146
34	210 (165)	250 (144)	156	138	125
40	290 (215)	283 (190)	264	264	274
205	243 (224)	284 (214)	----	----	----

[1] Of separate extractions.
[2] Only the reagents run.
[3] Figures in parenthesis are results obtained in December and January by the County Agent method.

and four of the blanks gave higher readings than was obtained from the first trial for the 6A soil. The results of this table indicate that the County Agent method is misleading under the conditions that existed at the time these readings were made. But it is of interest to this investigation to note in Table 6 that the available potassium values for the greenhouse soils (6A, 5A, 7A and 185) are given much in the same order by procedures 1, 2, 3 and 4. Results for the group of soils picked at random listed below the blanks indicate that the County Agent method gave much higher readings July 3 than it did in December and January. It also shows that the July 3 results by the County Agent method are higher than those obtained by the ammonium acetate methods, especially for the soils which gave the lower results by the ammonium acetate methods.

The writer has no proof of the cause for the erratic readings by the County Agent method. However, there are certain precautions discussed in the literature which have been shown to prevent erroneous readings when using the sodium cobaltinitrite turbidimetric method of evaluating potassium. In respect to the sodium cobaltinitrite turbidimetric method being used by the County Agents it might be well to use more precaution to avoid deterioration of the sodium cobaltinitrite (2, 10, 29, 37, 38). Formaldehyde is used by some workers to prevent the precipitation of ammonia with the sodium cobaltinitrite (2, 29, 37). There are no efforts made to the regulation of the temperature at which the potassium is precipitated. According to the literature (7, 10, 14, 29, 37) it is of primary importance and should be given consideration in this method of determining available potassium.

A small error was observed in December and January as a result of using one colorimetric adsorption tube common to all samples. The procedure used is to transfer the solution containing the precipitated potassium for each sample from the flat bottom vials to the adsorption tube to be placed in the colorimeter. Not all of the solution of a given sample can be removed and a small amount is left to affect the reading of the next sample. If water is used to rinse the tube, a dilution of the sample is effected by the small amount of remaining water. Graham (14) avoids this error by using a separate adsorption tube for each sample.

GREENHOUSE RESULTS AND DISCUSSION

A few days before the bloom stage was reached, the plants of all series, except 7A, not having been treated with nitrogen began to show chlorosis. About the time of blooming, many of the trifoliate leaves of the plants of all series, except 7A, not having been treated with phosphorus began to show yellow and green mottlings. These plants not having been treated with nitrogen and/or phosphorus lost many of their leaves as their leaf condition advanced. The potassium treatment seemed to make little difference in any of the series until just after the bloom stage was reached, then only the 7A series showed a positive response to potassium treatment.

Soon after the plants of all soils had set fruit, the second application of nitrogen was made. This treatment came too late for many of the plants of the first planting to avoid losing some leaves as a result of extreme chlorosis. (It was only after this that the leaves were collected as they were lost from the plants). The effect of this nitrogen treatment was very noticeable in the 7A series. The upper leaves of the plants having the NPK treatment were observed to have a dark green color about 48 hours after the application of nitrogen, but the upper leaves of the NP treated plants had not ragained their dark green color until about 5 days later. This might well indicate that potassium is essential for nitrogen metabolism and that the 7A soil would give a positive response to potassium fertilization under field conditions. Nightingale (26) observed that plants given a potassium treatment, after having been made deficient in potassium, had considerable quantities of nitrates in the phloem and cortical tissue of the stems and veins within 48 hours after treatment, whereas in lots of plants not given a potassium treatment only traces of nitrates could be found.

As the NP treated plants grown in the 6A soil neared maturity, in all replications their trifoliate leaves developed a chlorotic condition along the edges and at the apexes. The chlorotic condition extended to the midrib very rapidly, with the edges and apexes becoming necrotic. Most of these plants died within a week. The NPK treated plants grown in this soil did not show this leaf pattern, but many of the phosphorus and PK treated plants did. The PK treated plants showing this leaf pattern again suggests a nitrogen-potassium metabolic relationship. None of the plants of the other series developed the above described leaf pattern.

The dry weight of the forage and fruit of the bean plants grown in the different pots are shown in Table 10 (see Appendix). Leaves lost from the NP and NPK treated plants grown in the 5A soil were carefully collected, but some of the leaves lost from most of the other plants were not collected. Because of this the fruit yield, which consists of the seeds and pods, should be given a greater consideration than the forage yield. The average responses in fruit yield of the NP treatments over the checks and the NPK treatments over the NP treatments are shown in Table 7.

The plants grown in the 7A soil yielded an appreciable increase in fruit where potassium was added to the NP treatment. There was an appreciable decrease in fruit yield where potassium was added to the NP treatment in the 5A soil, even though this soil was shown to have only about half as much available potassium per acre as the 7A soil by the

Table 7. Response of the greenhouse soils to NP and NPK treatments compared with their available potassium as shown by procedure 4.

Soil number	Treatment	Average wt. of fruit in grams	% increase or decrease of NP over check; NPK over NP	Calculated pounds/A of available potassium by procedure 4
	Check	1.52		
6A	NP	9.54	+527.7	84
	NPK	8.77	-8.1	
	Check	0.81		
5A	NP	10.56	+1203.0	104
	NPK	8.90	-15.7	
	Check	3.24		
7A	NP	8.00	+146.9	224
	NPK	11.99	+49.9	
	Check	2.11		
185	NP	8.54	+304.7	236
	NPK	7.87	-7.8	

ammonium acetate methods. This may suggest that the added potassium depressed the availability of some other cation or cations. Plants grown in the 6A and 185 soils gave slight decreases in fruit yield where potassium was added to the NP treatment. However, the 6A soil, which was shown to have the least available potassium by the ammonium acetate methods of the four greenhouse soils, did give some indication of potassium deficiency as was shown by the leaf pattern of the bean plants. It is very possible that if plants were grown for a long period in this soil an appreciable positive response to potassium treatment could be had when both the nitrogen and phosphorus needs of the plants are met.

CONCLUSIONS AND SUGGESTIONS

The order of response to potassium fertilization of the four greenhouse soils, as shown by the bean plants, was contradictive to the order in which the ammonium acetate and the County Agent methods placed the available potassium values of these soils. However, four soils are entirely too few to give conclusive evidence that these laboratory methods do not correctly evaluate the available potassium of Oklahoma soils in general.

The literature reviewed leans heavily in favor of the school of thought that the exchangeable potassium values do not correlate well with the available potassium values of many soils, especially the more weathered soils. It is generally understood that many of the soils of the eastern portion of Oklahoma are highly weathered. Many of these Eastern Oklahoma soils are low in available potassium (16, 24). These soils need a very critical analysis to determine their abilities to supply potassium to plants.

It has been found that the ammonium ion does not replace nonexchangeable potassium (30, 39). The sodium ion has been found to be much less effective in replacing the nonexchangeable potassium than the hydrogen ion. Sodium nitrate has been used quite commonly to extract soils to find only the exchangeable potassium values (7, 14).

With the evidence just reviewed, it seems advisable to conduct crop and laboratory correlation studies, growing the crops under field conditions, when possible, on the more widely occurring soil types of

Oklahoma, and using the presently used extracting reagents plus others which remove a portion of the nonexchangeable potassium in addition to the exchangeable potassium.

In the final selection of an extracting reagent one should be selected which gives results that closely correlate with the power of soils to supply potassium to plants and should be adaptable to use in all three soils laboratories concerned in this study. It is unlikely that close agreement will be obtained by the different soils laboratories unless all use the same extracting method and reagent. To get close agreement, as is shown in Table 1, it will also be necessary for all laboratories to use the same amount of soil for a given soil or a known proportion of the amount used by the other laboratories. Weighing the samples would lead to more correct readings than volume measuring.

Methods used for determining the amount of potassium in the soil extract need not be the same as long as the methods are accurate or nearly so. The flame photometer was found by this study to be desirable for determining potassium when conditions are favorable. Possibly a better flame photometer for reading the potassium content of soil extracts than the one used in this study is one using an internal standard (4). The sodium cobaltinitrite turbidimetric method for determining potassium gave consistent readings for the readings taken in December and January. According to literature reviewed, it is very accurate, but to maintain accuracy, much care must be taken to get the correct precipitation.

In reviewing literature it was found that normal HNO_3 is one of the better reagents for extracting potassium for the purpose of measuring the power of soils to supply potassium to plants. Rouse and Bertramson (34) describe a procedure for extracting the soil for available potassium with normal HNO_3. The extracted potassium was determined by use of the Perkin-Elmer flame photometer model 52-A. Pratt (31) describes a procedure for extracting the soil for available potassium with normal HNO_3 and determining the extracted potassium in a model 18 Perkin-Elmer flame photometer. There may be some question about precipitating potassium in the soil extract resulting from a normal HNO_3 extraction of the soil to be determined turbidimetrically. Wilcox (38) uses normal HNO_3 in determining potassium by sodium cobaltinitrite gravimetric and volumetric methods. The volume of the normal HNO_3 used for each 10 c.c. aliquot of extract can vary from 0.5 to 5 c.c. without measurable effect. Peech (28) uses the Wilcox method of precipitating potassium and determines the potassium colorimetrically. It may be worth while to study the possibility of determining potassium precipitated by the Wilcox method turbidimetrically.

It may also be possible to determine the potassium extracted by normal HNO_3 by using a method of overcoming the acid as employed by Baver (2) or as suggested by Melsted (22), and precipitate and determine the potassium by the Bray procedure (7).

There are considerable differences in the levels of the classifications of available potassium between the County Agent Soils Laboratories and the agencies using the ammonium acetate methods for determining the availability of potassium. However, this may be somewhat offset by the results of the different procedures. The classifications of the different levels of available potassium are given in Table 8 for the various agencies concerned in this study.

This study has not disclosed any information which would justify changing these classifications. Until more desirable means of evaluating available potassium are employed it is not advised to change these classification levels. But in making fertilizer recommendations, a consideration of the soil type concerned should be made. More study along this line is greatly needed.

Table 8. Classifications given by the various soils testing agencies for different levels of available potassium by their procedures of analysis.

Pounds/A of available potassium	0-50	50-100	100-150	150-200	200-250	250-300	300+
Agronomy Department	Very low	Low	Medium	Medium plus	High		Very high
Soil Conservation Service	Very deficient	Deficient	Doubtful	Not deficient			
County Agents (Extension Service)	Very low		Low		Medium		High

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A P P E N D I X

Table 9. The available potassium content of different soils as shown by four different laboratory procedures.

Sample number	Procedure 1. County Agent method			Procedures 2, 3 and 4. Ammonium acetate-flame photometric methods			
	Trial 1	Trial 2	Trial 3[1]	Sample weight for Proc. 2 and 3	Spoon measured Proc. 2	Spoon measured Proc. 3	10 grams weighed Proc. 4
	Calculated pounds per acre of available potassium			Grams	Calculated pounds per acre of available potassium		
5A[2]	---	---	---	10.23[3]	120	104	104
6A[2]	---	---	---	10.34	88	88	84
7A[2]	---	---	---	10.55	244	236	224
185[2]	---	---	---	10.46[4]	264	260	236[4]
1	104	106	---	------	60	56	---
2	168	167	---	9.08	168	160	168
3	165	146	---	9.47	142	130	138
4	122	113	---	11.35	80	60	52
208[5]	---	---	---	9.95	278	264	264
5	188	169	---	9.72	190	176	172
6	181	180	---	9.86	184	176	172
7	159	153	---	9.14	156	125	142
8	108	98	---	9.04	96	84	96
9	129	124	---	9.24	116	112	104
10	214	210	---	8.95	217	184	176
11	77	86	---	10.70	44	36	26
12	268	257	---	9.61	278	253	253
13	242	198	232	8.64	274	270	274
14	115	107	---	9.91	88	84	80
15	113	93	---	10.74	56	48	48
16	69	64	---	10.31	40	36	31
17	123	114	---	9.96	84	74	74
18	83	72	---	12.25	44	31	22
19	174	158	---	10.72	125	108	104
208	---	---	---	9.95	267	247	247
20	140	134	---	8.84	130	125	130
21	133	124	---	9.13	152	---	142
22	230	215	---	8.52	256	232	253
23	321	300	---	8.18	439	412	484
24	245	215	249	8.64	348	330	360
25	90	72	---	9.58	80	68	74
26	109	106	---	9.18	125	116	125
27	134	124	---	8.87	134	108	130
28	191	185	---	8.31	326	292	320
29	133	123	---	9.49	160	142	149
30	170	169	---	10.80	---	156	142

Table 9 (continued)

31	230	209	----	9.77	250	236	220
32	335	297	285	11.05	320	284	260
33	325	270	305	11.50	312	288	250
34	165	144	----	11.19	156	138	125
208	----	----	----	9.95	281	264	270
35	298	294	----	9.91	382	320	320
36	205	186	----	8.65	320	316	385
37	241	222	----	10.87	194	194	172
38	320	301	----	10.69	312	312	278
39	200	165	208	11.57	142	130	96
40	215	190	----	9.01	264	264	274
41	184	170	----	8.34	376	348	388
42	209	213	----	8.49	354	320	364
43	196	181	----	9.83	176	146	149
44	----	----	----	10.91	112	100	84
45	----	----	----	9.51	224	210	217
46	136	122	----	8.51	224	210	228
47	93	79	----	11.77	64	48	44
48	152	140	----	8.20	399	416	450
49	154	150	----	9.33	164	138	146
50	141	143	----	10.12	156	138	134
51	138	126	----	9.47	152	142	142
52	146	130	----	8.15	138	116	146
53	87	78	----	9.10	68	64	64
208	----	----	----	9.95	300	281	274
54	107	108	----	10.87	80	64	60
55	220	212	----	9.49	184	172	184
56	206	176	172	8.54	232	244	284
57	123	112	----	10.35	112	104	104
58	146	129	----	9.71	146	125	120
59	171	155	----	10.02	138	120	116
60	172	173	----	9.92	184	176	168
61	214	195	----	9.94	206	184	184
62	148	137	----	11.12	96	84	74
63	126	141	----	9.11	138	120	134
64	328	310	----	9.46	419	388	416
65	159	153	----	10.73	164	138	130
66	195	189	----	9.56	198	180	184
208	----	----	----	9.95	278	278	264
67	207	207	----	9.43	250	228	240
68	157	153	----	10.00	130	96	120
69	251	233	----	12.17	----	176	152
70	148	139	----	11.49	120	108	100
71	188	177	----	11.34	138	138	112
72	198	194	----	12.28	202	180	138
73	223	213	----	11.95	176	156	125
74	165	173	----	12.08	156	146	112
75	300	276	----	10.52	334	312	300
76	272	285	----	10.77	300	270	256
77	281	292	----	11.10	326	316	278

Table 9 (continued)

78	248	249	----	11.68	264	260	206
79	184	194	----	9.20	476	426	450
80	300	321	----	9.43	422	408	422
208	----	----	----	9.95	278	267	256
81	258	227	216	10.12	320	309	296
82	225	217	----	8.93	309	281	316
83	248	246	----	9.58	360	326	337
84	315	320	----	8.95	412	382	436
85	184	180	----	8.65	306	278	326
86	266	298	264	8.88	550	504	568
Averages excluding results from County Agent method				9.926[6]	216.2[7]	199.2[7]	202.3[7]
Averages of results from procedures 2 and 3 on 10 grams basis					217.8	201.0	
Percentages for average results by procedures 3 and 4 when results by procedure 2 is 100%, all on 10 grams basis						92.32%	92.90%

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[1] A third trial was made when the first two readings were not in close agreement.

[2] The first four samples in the table were taken from the soils used in the greenhouse study. Satisfactory readings were unobtainable for these soils by the County Agent method. This was discussed earlier in this report under the secondary heading of <u>Discussion of the County Agent Method</u>.

[3] The weights given in this column are not necessarily the weights used for procedures 2 and 3, but they do approximate the weights of a spoonful of the soil concerned.

[4] Several spaces in this table were left blank because of insufficient soil, or part or all of the extracting solution was lost.

[5] Soil 208 was analyzed in each set of 16 samples run as a check for the ammonium acetate methods. This soil gave readings by the County Agent method of 220 and 210 pounds per acre of potassium by the two trials run.

[6] This average included the six 208 samples run as checks. By not including these checks an average of 9.923 grams is obtained.

[7] These averages include only the samples run by all three ammonium acetate methods, 92 samples in all including the six 208 check samples.

Table 10. Dry weight in grams of forage and fruit of the bean plants grown in the greenhouse on four soils with various treatments.

	1st rep.		2nd rep.		3rd rep.		Average	
Treat-ment	Forage	Fruit	Forage	Fruit	Forage	Fruit	Forage	Fruit
				Soil 5A				
Check	2.50	0.63	3.38	1.25	2.84	0.54	2.91	0.81
N	5.05	3.18	4.49	2.08	4.31	2.16	4.62	2.47
P	3.69	1.91	3.36	1.36	4.24	0.38	3.76	1.22
K	2.54	1.29	3.72	1.36	3.02	0.78	3.09	1.14
NK	2.81	1.98	3.26	1.97	2.83	2.15	2.97	2.03
PK	4.04	0.71	3.43	0.35	3.55	1.21	3.67	0.76
NP	6.51	11.01	7.21	10.71	7.37	9.95	7.03	10.56
NPK	6.73	9.63	5.81	8.26	7.18	8.80	6.57	8.90
				Soil 6A				
Check	3.26	2.12	1.92	0.83	2.74	1.62	2.64	1.52
N	3.94	2.32	3.53	2.32	5.32	2.22	4.26	2.29
P	6.99[1]	8.34[1]	3.93	3.54	3.45	4.10	4.79	5.33
K	2.88	0.82	2.51	1.28	3.76	1.08	3.05	1.06
NK	3.29	2.64	3.02	1.68	3.06	2.00	3.12	2.11
PK	4.05	4.80	4.37	2.94	4.64	6.62	4.35	4.79
NP	5.02	10.21	5.14	10.05	5.14	8.37	5.10	9.54
NPK	5.39	8.13	4.79	9.15	6.28	9.04	5.49	8.77
				Soil 7A				
Check	5.88	2.40	4.74	5.65	5.69	1.65	5.44	3.24
NP	5.56	9.32	7.12	7.18	6.66	7.50	6.45	8.00
NPK	6.20	12.95	6.80	12.81	5.96	10.21	6.32	11.99
				Soil 185				
Check	1.97	1.32	2.53	2.78	2.60	2.23	2.37	2.11
NP	3.93	8.35	5.27	9.23	4.04	8.05	4.41	8.54
NPK	4.62	7.54	4.62	8.46	3.99	7.61	4.41	7.87

[1] Some of the pots had cracked glaze and apparently released stored nutrients to the plants from treatments of previous experiments. The pot containing the plants of the first phosphorus treated replication of soil 6A was especially noticeable in this.

Table 11. County results on soils furnished by County Agents for project on comparison of tests for available potassium.

Sample number	Calculated pounds per acre of available potassium	Sample number	Calculated pounds per acre of available potassium	Sample number	Calculated pounds per acre of available potassium	Sample number	Calculated pounds per acre of available potassium
Okfuskee		25	107	Pittsburg		72	184
1	79	26	115	49	138	73	181
2	150	27	129	50	130	74	152
3	120	28	129	51	113	75	295
4	100	29	128	52	102	76	250
5	170			53	55	77	292
6	166	Kingfisher		54	76	78	345
7	160	30	160	55	201	Grant	
8	93	31	225	56	166	79	155
9	100	32	270	57	85	80	310
10	137	33	232	58	115	81	232
		34	228			82	195
Atoka		35	218	Creek		83	246
11	77	36	275	59	163	84	305
12	296	37	272	60	120	85	113
13	203	38	311	61	134	86	270
14	106	39	93	62	116		
15	92			63	110		
16	64	Marshall		64	286		
17	128	40	188	65	136		
18	108	41	149	66	142		
19	179	42	174	67	166		
		43	184	68	125		
Nowata		44	138				
20	166	45	142	Beckham			
21	173	46	165	69	260		
22	229	47	94	70	164		
23	300	48	155	71	180		
24	214						

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