NUTRIENTS REMOVED BY A POTATO CROP[1]

by

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There are almost as many fertilizer practices as potato growers, and, within limits, most of them do pretty well. The search for a method to determine the amount and kind of fertilizer to use has been going on for a long time. Tissue analysis and soil analysis have been only partially successful.

If everything could be adequately taken into consideration, we should be able to predict yields on the basis of the analysis. Until we can predict yields, on the basis of the analysis, we are only in the "quess work" business. Soil and tissue testing are helpful tools when it comes to making potato fertilizer recommendations, but they are only tools. The practice of mixing different kinds of fertilizers and measuring the effects is still the most reliable, but the results apply primarily to the conditions of the experiment. Much time, money and effort have gone into measuring what happened with almost no attention being given to why it happened. We have measured large differences in yield and quality resulting from the same fertilizer in the same rows, but at opposite ends of the field.

There are many factors which can affect the concentration of nutrients in various plant parts besides the concentration of available nutrients in the environment of the root system. Soil temperature, soil moisture, growth rate, and translocation can all change the concentration of a given element in the tissue. It is possible to have a so-called normal mineral content of the tissue and still have a very small, unproductive plant. Because of these reasons we have given up petiole analysis and started analysing the entire plant, excluding roots.

The effect of one nutrient on another is frequently disregarded and the question can logically be asked, "was the response oberved the direct effect of the nutrient applied or an indirect effect on some other essential nutrient?". The effect of applying one nutrient on another is illustrated in Figure 1. Increasing the amount of nitrogen in the fertilizer increased the concentration of magnesium in the petiole of Russet Burbank potatoes.

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Increasing the amount of phosphorus in the fertilizer tended to decrease the magnesium in the petiole, but not nearly to the same degree as increasing the amount of potassium in the fertilizer. The effect of one essential element on another is further illustrated in Table 1. The degree of relationship can be expressed as a correlation coefficient. The higher the number the greater the degree of correlation, in other words, the greater the degree association.

A perfect correlation is 1.000. A negative correclation indicates the amount of the two nutrients in the two plant parts are inversely correlated. Many of the correlation values are small, below 5, and their effects can be considered inconsequential.

These studies were performed on two fertility levels, 1250 lbs/A of 16-16-16 fertilizer which was adequate for an early August harvest date, and 3125 lb/A, which contained 2 1/2 times as much fertilizer, and which would have been sufficient for a mid-October harvest date.

Chemical analyses of potato plants have shown the approximate composition of the plant. The results can be used to estimate the amount of any one nutrient absorbed from the soil by the plant, and these data can be used as "guestimates" as to the amount of the major nutrients to apply to grow a potato crop of a given size.

A record of the nutrients applied and the estimated amount of nutrients removed by crops is also valuable information to have to aid in determining how much fertilizer to use. The quantities of fertilizer elements removed in the crops can be approximated from tables available from several sources.

No one uses fertilizer rates as high as theoretical "guestimates" indicate are necessary for maximum production because some of the nutrients come from other sources, such as decaying organic residues, previously applied but unused fertilizers, irrigation water and weathering of the soil. Studies in this and other states have shown, however, that there is a relationship between the size of the crop and the nutrients required.

Fertility is only one factor of many responsible for achieving maximum yields. When responses in yield are no longer obtained from increased fertility, other limiting factors should be looked for. In 1960 we achieved a top yield of 627 cwt per acre and predicted that 800 cwt yields per acre should be possible in the Columbia Basin. Since then, we have achieved yields over 800 cwt several times and once achieved a yield of 1,000 cwt per acre. Several growers have achieved 700 cwt per acre on commercial fields.

Yields of 1,000 cwt per acre no longer seem unreasonable. Trips to the moon are based on this kind of thinking. No one has landed yet, but each day it seems more plausible.

It is easy to demonstrate that the concentration of nitrogen, phosphorus and potassium in the petiole of potatoes increases as the amount of complete fertilizer applied increases.

Petiole analysis is an aid in pinpointing deficiencies after levels of the constituants necessary for growth have been established. They also demonstrate the availability of the nutrients to potatoes, but are of little value in assessing either the amount of the nutrient required or the amount removed from the soil. For these purposes, the amount present in the entire plant must be determined. This was done in an experiment with four planting dates, two fertilizer rates, and four harvest dates. Some of the results are shown in Table 2. The differences amoung the four planting dates are relatively minor when compared to the differences associated with the dates of harvest. Harvest date differences reflect the increases in yield which resulted from the longer growing periods. As the yield increased, there was almost a proportional increase in the amount of nutrients in the tubers which was accompanied by a decrease in the amount in the tops. This was generally true for nitrogen, phosphorus and potassium.

The changes in the yield of tops is a measure of the rate of growth and also the extent of foliar dying.

Each value in the table is the mean of 8 replications. The highest yield was 659 cwt per acre, and was attained by planting on April 15 and harvesting on October 15. The 659 cwt of potatoes removed from the soil 204 pounds of nitrogen, 51 pounds of phosphorus (117 pounds of P_2O_5) and 306 pounds of potassium (367 pounds of K_2O). Other comparisons show a somewhat different amount of nutrients within the tubers. No reliable plant top samples were obtainable for the October 15 harvest.

By adding together the amounts of nutrients in the tops to those in the tubers, it is possible to estimate the amount in the total plant, excluding the roots.

A similar experiment was conducted in 1968 to verify the 1967 findings, but the chemical analyses are not complete.

In another experiment we kept account of the nutrients added, the potatoes removed from the plot, and the changes in phosphorus and potassium levels in the soil by soil analysis.

	1965	1966	1967	Total
Nitrogen added	400	400	400	1200
P_2O_5 added	133	133	133	399
K_2O added	400	400	400	1200
Cwt of potatoes	802	686	393	1881

With these amounts of nutrients, nitrogen and phosphorus accumulated in the soil. The level of potassium remained the same.

The carry-over effect of three years' residual fertilizer on wheat was:

Nitrogen	Bu. Wheat	P_2O_5	(P)	Bu. Wheat	K_2O	(K)	Bu. Wheat
0	46	0	0	72	0	0	74
133	71	133	53	72	133	107	74
267	87	167	106	75	167	114	73
400	91	400	156	75	400	221	74

The Nugaines wheat responded only to residual nitrogen.

The fact that the soil test showed phosphorus was accumulating in the soil, with even such a low application of phosphorus, does not mean that sufficient phosphorus was being added for maximum yield. In each of the 3 years the experiment was in potatoes, the linear effect for levels of phosphorus was statistically significant.

The fact that no increase in soil test potassium was found after the application of 1200 pounds of K_2O (960 lbs. of K) per acre is explainable on the basis of the amount of potassium removed from the soil in the tubers.

During the 3 years, 1881 cwt of potatoes were removed. On the basis of the tuber analysis, about 1/2 pound of potassium is removed per cwt. On this basis, 1200 pounds of K_2O were applied and 1128 pounds of K_2O were removed in the potatoes. This is remarkably good agreement, considering all of the "ifs" and "ands" which can affect the results.

When our results were compared to those published by the American Potash Institute, we found somewhat less nitrogen, but slightly more phosphorus and potassium were removed from the soil by our potatoes.

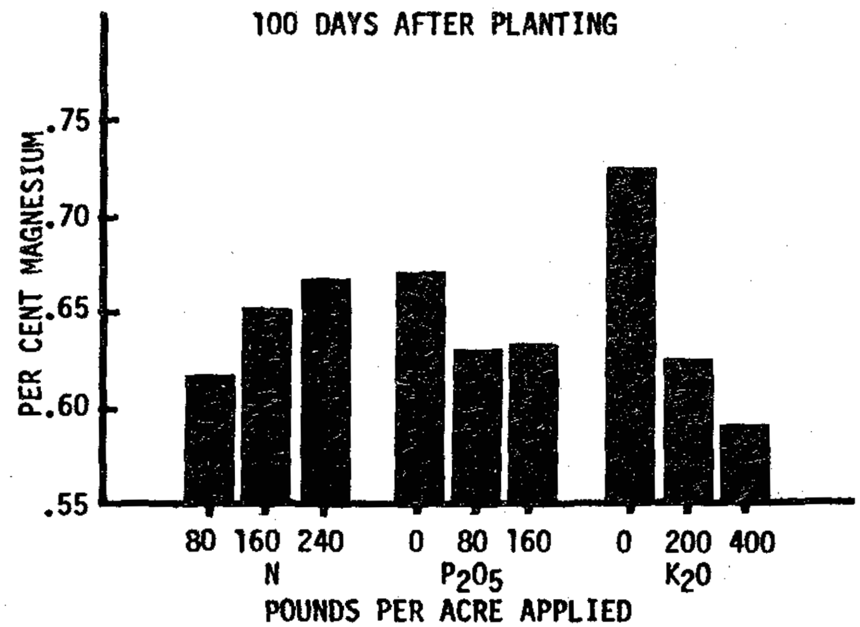

Figure 1. Effects of nitrogen, phosphorus and potassium on the concentration of magnesium in the petiole.

Table 1. Linear correlation coefficients showing the effect of one nutrient on another in the potato plant and in the tuber.

		Linear Correlation	
		1250 lbs/A 16-16-16	3125 lbs/A 16-16-16
Tops	Tops		
N	P	.790	.765
N	K	.419	.594
N	Ca	.493	.104
N	Mg	.122	.343
Tops	Tubers		
N	N	.306	.481
N	P	.533	.418
N	K	.427	.643
N	Ca	.400	.559
N	Mg	.254	.366
Tubers	Tops		
N	P	.242	.415
N	K	.390	.426
N	Ca	.107	.179
N	Mg	.260	.092
Tubers	Tubers		
N	P	.223	.247
N	K	.558	.605
N	Ca	.039	.270
N	Mg	.298	.007
Tops	Tops		
P	K	.458	.628
P	Ca	.374	.029
P	Mg	.089	.307
Tops	Tubers		
P	P	.518	.269
P	K	.436	.577
P	Ca	.416	.433
P	Mg	.178	.355
Tubers	Tops		
P	P	.518	.269
P	K	.450	.361
P	Ca	.294	.122
P	Mg	.128	.037

		Linear Correlation 1250 lbs/A 16-16-16	Linear Correlation 3125 lbs/A 16-16-16
Tubers	Tubers		
P	K	.405	.444
P	Ca	.267	.324
P	Mg	.054	.041
Tops	Tops		
K	Mg	.448	.134
Tops	Tubers		
K	K	.624	.707
K	Ca	.329	.435
K	Mg	.224	.085
Tubers	Tops		
K	K	.624	.707
K	Ca	.347	.264
K	Mg	.462	.179
Tubers	Tubers		
K	Ca	.259	.506
K	Mg	.164	.062
Tops	Tops		
Ca	Mg	.444	.624
Tops	Tubers		
Ca	Ca	.134	.011
Ca	Mg	.127	.078
Tubers	Tops		
Ca	Ca	.134	.011
Ca	Mg	.066	.087
Tubers	Tubers		
Ca	Mg	.017	.041
Tubers	Tops		
Mg	Mg	.343	.412

Table 2. Nutrients in different size potato crops. All values on a Per Acre bases.

Planted March 30, 1967

Harvest Date	Pounds 16-16-16	cwt tops	cwt tubers	Pounds N tops	Pounds N tubers	Pounds P tops	Pounds P tubers	Pounds K tops	Pounds K tubers
July 15	1250	275	224	82	49	7	14	148	100
Aug. 15	1250	258	408	57	99	4	26	158	175
Sep. 15	1250	98	591	27	146	2	41	118	270
Oct. 15	1250	--	595	--	170	-	41	---	272
July 15	3125	384	105	156	28	20	7	212	44
Aug. 15	3125	522	286	137	79	11	21	299	128
Sep. 15	3125	458	521	127	155	11	38	296	222
Oct. 15	3125	---	570	---	174	--	41	---	266

Planted April 15, 1967

Harvest Date	Pounds 16-16-16	cwt tops	cwt tubers	Pounds N tops	Pounds N tubers	Pounds P tops	Pounds P tubers	Pounds K tops	Pounds K tubers
July 15	1250	277	203	81	46	11	14	164	89
Aug. 15	1250	313	375	60	91	5	24	173	172
Sep. 15	1250	96	576	28	152	2	37	118	262
Oct. 15	1250	--	598	--	153	-	41	---	262
July 15	3125	422	111	151	29	22	7	250	48
Aug. 15	3125	460	292	133	79	12	20	265	120
Sep. 15	3125	452	558	100	151	8	41	305	238
Oct. 15	3125	---	659	---	204	-	51	---	306

Planted May 1, 1967

Harvest Date	Pounds 16-16-16	cwt tops	cwt tubers	Pounds N tops	Pounds N tubers	Pounds P tops	Pounds P tubers	Pounds K tops	Pounds K tubers
July 15	1250	269	185	81	43	10	13	158	86
Aug. 15	1250	290	329	53	76	4	21	129	137
Sep. 15	1250	117	536	31	142	2	35	110	248
Oct. 15	1250	---	564	--	162	-	39	---	272
July 15	3125	392	86	150	23	16	6	198	36
Aug. 15	3125	454	283	128	78	11	20	267	118
Sep. 15	3125	347	509	75	137	7	41	219	221
Oct. 15	3125	---	604	--	205	--	48	---	284

Planted May 15, 1967

Harvest Date	Pounds 16-16-16	cwt tops	cwt tubers	Pounds N tops	Pounds N tubers	Pounds P tops	Pounds P tubers	Pounds K tops	Pounds K tubers
July 15	1250	277	102	101	25	13	7	155	43
Aug. 15	1250	266	320	60	82	4	20	149	147
Sep. 15	1250	241	542	42	164	3	31	156	255
Oct. 15	1250	---	534	--	156	-	33	---	247
July 15	3125	305	36	127	10	13	2	162	15
Aug. 15	3125	511	219	171	63	14	14	315	95
Sep. 15	3125	501	472	139	135	12	32	292	213
Oct. 15	3125	---	613	---	211	--	41	---	281