LONG TERM FERTILITY EFFECTS

by
R. Kunkel
Washington State University, Pullman, Washington

A very comprehensive potato fertilizer experiment was started in 1965. The first objective was to determine the effect of the amount and ratio of N-P-K on blackspot. In as much as the cost of growing the crop was the major expense it was decided to obtain all the data possible which included yield, grade, specific gravity, chip color and soil, petiole and tuber analyses. In this report only changes in yield and effects on the soil will be included.

Each year the same fertilizer treatments were put on their respective plots (except as noted) to hasten depletion of nutrients in some plots and hasten excessive build-up in others by using what was thought to be excessive amounts of N-P-K. Because of the known cropping and fertilizer response records this little plot of ground has become more valuable experimentally with each additional year's results. The cropping history is in Table 1.

Four levels of N-P-K were combined in all possible combinations to make 64 fertilizer treatments. Each treatment was replicated six times. The exact amounts of nutrients applied each year are in Table 2. The nitrogen rates were increased in 1971 and 1972 because the yields of potatoes had become so low on those plots which did not receive fertilizer nitrogen. The same phosphorus and potassium rates of fertilization were maintained throughout. The total amount of each nutrient applied over the years is also shown.

The yield data for the potato and wheat crops are in Table 3. The detailed results were not included because the trends are more evident when the overall effects of N-P-K on yield and soil are considered. Potato yields were highest in 1965, the first year the land was planted to potatoes. Each year thereafter the yields decreased regardless of the fertilizer used. In the spring of 1967 the land was fumigated with the equivalent of Telone C but even this failed to restore productivity to its original level.

Table 1. Cropping History.

1965	First year in potatoes
1966	Second year in potatoes
1967	Third year in potatoes--fumigated with Telone C
1968	Wheat
1969	Wheat
1970	Potatoes--vines burned
1971	Potatoes--vines burned, fumigated, solid set sprinkler
1972	Potatoes--fumigated, solid set irrigation

Table 2. $N\text{-}P_2O_5\text{-}K_2O$ applied to their respective plots from 1965 to 1972.[1]

Years	N_1	N_2	N_3	N_4	P_1	P_2	P_3	P_4	K_1	K_2	K_3	K_4
1965	0	130	260	390	0	133	267	400	0	133	267	400
1966	0	130	260	390	0	133	267	400	0	133	267	400
1967	0	133	267	400	0	133	267	400	0	133	267	400
1968	No Fertilizer (Wheat)											
1969	No Fertilizer (Wheat)											
1970	0	130	260	390	0	133	267	400	0	133	267	400
1971	100	200	300	400	0	133	267	400	0	133	267	400
1972	430	430	430	430	0	0	0	0	0	0	0	0
Total	530	1153	1777	2400	0	665	1335	2000	0	665	1335	2000

[1] To convert P_2O_5 to P multiply by .44
To convert K_2O to K multiply by .83

Table 3. Yields in hundred weight (cwt) per acre of potatoes and bushels per acre of wheat as influenced by fertilizers applied.

Years		N_1	N_2	N_3	N_4	P_1	P_2	P_3	P_4	K_1	K_2	K_3	K_4
1965	Potatoes	480	614	662	630	540	610	610	626	574	591	606	614
1966		248	447	510	515	336	433	473	478	376	433	450	464
1967		266	424	412	379	359	372	368	381	353	376	369	383
1968	Wheat	46	71	87	91	72	72	75	75	74	74	73	74
1969		8	11	13	20	13	13	13	13	12	14	13	13
1970	Potatoes	222	399	444	438	321	380	397	407	370	378	381	376
1971		477	495	492	485	412	498	511	527	466	477	499	507
1972		508	487	499	505	460	499	514	526	454	475	532	538

The first year (1968) the land was planted to wheat there was a sizeable yield response from the residual N in the soil after the potato crops. The second year of wheat did not show the large yield response indicating the first crop of wheat depleted the soil of its residual nitrogen supply. No yield increases of wheat were obtained for either P or K. The low nitrogen status of the soil following the second crop of wheat is also indicated by the large increases in potato yields resulting from increasing amounts of fertilizer N in 1970. Increasing the amount of fertilizer P in the soil also increased the yield but fertilizer K did not.

The falls of 1970 and 1971 the potato vines were burned off and in the springs of 1971 and 1972 the land was fumigated with Telone C.

In 1972 the entire area was fertilized with 430 lb/acre of N from ammonium nitrate but no P or K was applied. The potatoes were irrigated by solid-set sprinklers. Thus it was expected that neither water nor disease would limit yield.

The yield data for 1972, Table 4, indicate that 430 lb/acre was ample N to grow the crop of potatoes but that the residual P and K levels in the soil from previous applications was insufficient for maximum production. The potato yields, nevertheless, were not equal to those obtained the first year the land was planted to potatoes.

A summary of the nutrients added in the fertilizer, the amount of nutrients removed in the crops, the theoretical balance of N-P-K left in the soil, the soil test values and the yields in 1972 are also shown in Table 4. The data for the effects on the land of adding such large quantities of fertilizer are in Table 5. The effects on the land in those plots which received the N treatments are shown in part A, those for P are in part B and those for K are in part C.

To date, insignificant changes have occurred in soil pH and salt content. The soil test level for P increased even on those plots which were not fertilized with P. Soil test P levels increased with increasing amounts of P added in the fertilizer. Soil test K levels increased at the two higher rates of fertilizer K application. It should be remembered, however, that the P and K accumulation would not have occurred if the potato yield levels had been as high as it was the first year the land was planted to potatoes.

Table 4. Main effects of actual N-P_2O_5-K_2O on the total yield and the percentage grade of tubers over 2 inches in diameter.

	N_1	N_2	N_3	N_4	P_1	P_2	P_3	P_4	K_1	K_2	K_3	K_4
lbs added in 8 years	530	1153	1777	2400	0	290	583	873	0	552	1108	1660
lbs removed by potatoes	660	860	906	886	170	195	201	206	1141	1201	1248	1268
lbs removed by wheat	58	89	126	153	77	71	79	74	21	21	22	20
Residual	-188	204	745	1361	-247	24	303	593	-1162	-669	-162	372
1972 soil test	---	---	---	---	12	22	28	36	127	139	171	190
1972 yield	508	487	499	505	460	499	514	526	454	475	532	538
Differences in yield	-21	-9	-3		39	54	66		21	78	84	
% No. 1's	70	69	69	69	70	70	68	69	68	69	70	70

Table 5. Effects of adding N-P_2O_5-K_2O over a 7 year period on the levels in the soil of each nutrient, effect on pH and on salts.

A. Addition of N

	Start				After 7 years				
	Total lb/acre	pH	P	K	Total lb/acre	pH	P	K	Salts
N_1	0	8.0	3.2	134	100	7.9	26	167	.28
N_2	0	8.0	2.8	125	723	7.8	25	153	.29
N_3	0	8.0	3.3	139	1347	7.7	24	157	.29
N_4	0	8.0	3.0	128	1970	7.7	23	152	.31
	Mean	8.0	3.1	131	Mean	7.8	24	157	.29

B. Addition of P_2O_5

P_1	0	7.9	3.3	137	0	7.8	12	169	.28
P_2	0	8.0	3.0	130	665	7.8	22	155	.30
P_3	0	8.0	2.9	128	1335	7.8	28	150	.29
P_4	0	8.0	3.1	131	2000	7.7	36	154	.30
	Mean	8.0	3.1	131	Mean	7.8	24	157	.29

C. Addition of K_2O

K_1	0	7.9	3.2	139	0	7.7	24	127	.28
K_2	0	8.0	3.1	131	665	7.8	24	139	.29
K_3	0	8.0	3.2	131	1335	7.8	25	171	.30
K_4	0	8.0	2.8	125	2000	7.8	25	190	.30
	Mean	8.0	3.1	131	Mean	7.8	24	157	.29

The loss in yield is not explainable on the basis of either disease, water or nutrition. A compacted soil layer about eight inches deep, through which roots were not penetrating, was observed in the experimental area. Such a layer not only restricts the nutrient and water reservoir but could limit the root oxygen supply which would reduce the roots ability to absorb both water and nutrients. Such layers are apparently not uncommon even on sandy soils.

The following conclusions seem justified:

1. It is evident from the data that fertilization alone did not maintain yields of potatoes equal to those obtained the first year the land was planted to potatoes.

2. Vine burning and soil fumigation to eliminate soil borne diseases did not restore the land to its original productivity though improved yields were obtained.

3. The critical soil test level for phosphorus should be increased above 10 ppm.

4. Cursory observations suggest that soil compaction might be responsible for the loss of yield since the plants were adequately irrigated, major and minor elements were adequately supplied and soil pathogens were reduced. This aspect of the problem is now being investigated.