Potato Nitrogen Management - Lessons from 1993[1]

K.A. Kelling and D. Hero[2]

Without question 1993 was an unusual growing season. Review of historical records show that it was the fourth wettest year since records have been kept, and interestingly, all three of the years which were wetter occurred in the early 1880's. As shown in Figure 1, much of the excess rainfall fell during the early part of the growing season. For example, central Wisconsin received an average of 3.9 inches of excess rainfall during April and another 5.0 inches above normal by the end of June.

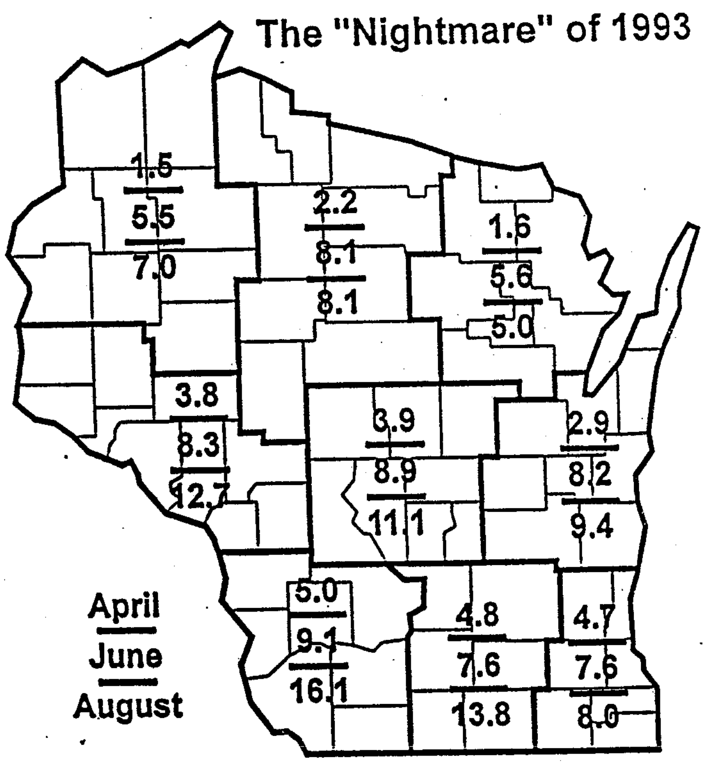

Figure 1. Cumulative deviations from normal rainfall since 1 April to the end of the indicated month, 1993. (Normal April-August rainfall ranges from 16.8-18.8 inches.)

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[2]Professor and Extension Soil Scientist and Research Associate, respectively, Department of Soil Science, University of Wisconsin-Madison.

Influence on Soil Nutrients

This extraordinary amount of precipitation likely influenced the soil nutrient supplying capacity, reserves and biochemical reactions and transformations in several identifiable ways

Influence on Nitrogen

The soil nitrogen situation in 1993 was affected in at least three ways: 1) it caused higher than usual amounts of denitrification of nitrate N on medium or heavier-textured soils; 2) it resulted in more rapid leaching losses of nitrate-N on all soils; and 3) it apparently slowed the release of N from organic sources such as manure and legumes on some soils.

Denitrification is the biological conversion of nitrate-N into the gases nitrous oxide or atmospheric nitrogen. It is accomplished by a large group of microorganisms when the soils become saturated or nearly saturated. The process has been shown to start within a few hours of when the soil becomes saturated and often has exhausted the NO_3-N supply within 5-10 days when the soil temperatures are favorable. Estimates of denitrification N losses range from 10-25% of applied N if the soil is saturated for 5-10 days with soil temperatures at 55-60°F to 60-75% loss of applied N when saturated for 3-5 days, but with temperatures at 75-80°F. Saturated warm soils may lose 95% of their nitrate N in 10 days (Shapiro, Univ. of Nebraska). On sandy soils, common in potato growing areas, this mechanism was probably not responsible for large N losses since these soils rarely become saturated for even short periods.

On these sandy soils leaching of nitrate-N likely did occur. Several studies with fertilizer or organic N sources have shown the on well-drained medium-textured Wisconsin soils typical rates of N leaching are less than 2 ft during the growing season and 2-3 ft during a calendar year (Malone, 1986; Kelling et al. 1977; Olsen et al. 1970; Comfort et al. 1987). However, on sandy soils the rate is much more rapid, with relatively little N remaining in the top 5 feet by September or October (Olsen et al., 1970; Mlynarek, 1988). In 1993, leaching measurements showed at least double the normal rate of nitrate movement.

Where manure or legumes were used to supply part or all of the nitrogen, several cases of apparent N deficiency were noted in 1993. This may have been due, at least in part, to the slower than normal release of organic-N from these sources.

Influences on P and K

There are several possible ways that the very wet weather of 1993 may influence the availability of P and K in 1994. These include: 1) an initial increase in P availability due to a change in the phosphate form under anaerobic conditions, with subsequent reversion to even less available forms upon drying; 2) a decrease in apparent P availability due to expression of the "fallow soil syndrome"; 3) an increase in P and K availability due to lower than normal removals of these nutrients because of poor 1993 crop yields; 4) a decrease in K availability due to K leaching on mineral soils; and 5) an apparent decrease in K availability due to a higher than normal amount of compaction and resulting poor aeration. Only the latter two of these were very likely on sandy soils and may have had some effect on potato production this past season.

Influence on Micronutrients

Excessive water can influence micronutrient availability in several ways: 1) increased solubility of Fe and Mn and possibly Mo when oxygen is excluded; 2) decrease in Cu, Zn, Fe and Mn availability due to pH increase from flooding; and 3) increased solubility of relative compounds of B, Mo and possibly Cu and Zn due to the extra water present. As with phosphorus, however, these changes are likely to be relatively short-lived once the soil begins to dry out, and would be relatively unimportant mechanisms on sandy potato soils.

1993 Nitrogen Experiment Results

In 1993 we conducted three sets of experiments related to nitrogen management. These include: 1) evaluation of several N timing sequences to establish the most efficient use of N; 2) evaluations of nitrogen need for the Norlands with various times of harvest; and 3) evaluation of the potato N needs in several rotations sequences including following snapbeans, sorghum-sudan and red clover.

Effect of Time of N Application

This experiment has been conducted at the Hancock Agricultural Research Station in 1991-1993. Nitrogen was applied at one marginally low supplemental N rate (120 lb N/a) such that if improvements in efficiency were present they would be more evident. Timing comparisons included single applications versus 2- to 5-way splits, different proportions at different times, and different timing of the multiple splits. All plots received 30 lb N/a as a part of the starter fertilizer application. Table 1 shows the actual amounts applied on the respective treatment application dates. Emergence was 14 May, 21 May and 20 May in 1991, 1992 and 1993, respectively, whereas the hilling applications were made on 29 May, 9 June and 3 June in each of the respective years.

As shown in Table 1, results from 1993 are more like those from 1991 than those from 1992. The highest yielding plot was where the N was split into 5 separate applications. This treatment also resulted in one of the top percent A tubers and the highest crop values. Other treatments that performed well in 1993 included: half at emergence and half at hilling; one-third at emergence, one-third at hilling and one-third at hilling + 10 days; one-third at emergence and two-thirds at hilling; two-thirds at emergence and one-third at hilling; and one third at hilling, one-third at hilling + 10 days and one-third at hilling + 20 days. All of these splits allow for some later N so that leaching losses would be minimized. These data are not consistent with 1992 nor would we expect them to be as the growing seasons were quite different.

Viewing the results on a relative yield basis averaged across the three-year term of the experiment is shown in Table 2. From this table it is clear that the most consistent treatments for yield and quality are the 5 way split, the half/half, or one-third/two-thirds or two-thirds/one-third two way splits.

Table 1 Effect of N timing on Russett Burbank yield and quality Hancock, Wisconsin, 1991-1993.

N treatments					Total Yield			Grade A			US1A(6-13oz)			Value		
Emerge	Hill	H+10	H+20	H+30	1991	1992	1993	1991	1992	1993	1991	1992	1993	1991	1992	1993
					----- cwt/a -----			-------- % -------			----- cwt/a ------			------ $/a -------		
120	0	0	0	0	495	345	319	79	54	60	217	56	14	3081	1400	1107
0	120	0	0	0	549	311	342	72	59	65	220	82	23	3215	1490	1281
0	0	120	0	0	516	270	299	76	62	58	186	77	9	2934	1340	999
60	60	0	0	0	514	351	342	75	60	61	176	74	21	2855	1570	1223
40	40	40	0	0	526	312	338	80	51	64	208	38	9	3142	1170	1163
40	0	40	0	40	536	319	329	76	55	62	215	50	18	3180	1290	1177
40	20	20	20	20	555	323	372	78	56	65	223	54	20	3312	1340	1344
40	80	0	0	0	543	371	335	78	62	58	203	84	12	3151	1720	1134
40	0	80	0	0	528	325	308	77	59	55	198	60	10	3057	1400	1020
80	40	0	0	0	515	357	343	82	61	60	221	98	12	3200	1740	1168
40	0	0	0	80	507	250	332	75	56	59	178	30	17	2838	960	1155
0	40	40	40	0	--	308	346	--	63	66	--	89	27	--	1540	1307
Pr>F					0.46	0.11	0.23	0.01	0.37	0.04	0.11	0.13	0.14	0.27	0.26	0.10

1991-1993 treatment dates are: emergence = 14 May, 21 May, 20 May; hilling = 29 May, 9 Jun, 3 Jun; H+10 = 10 Jun, 19 Jun, 14 Jun; H+20 = 17 Jun, 29 Jun, 23 Jun; and H+30 = 26 Jun, 8 Jul, 6 Jul, respectively.
All plots received 30 lb N/a in the starter fertilizer each year.

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Table 2. Average relative Russet Burbank tuber yield, grade and value as affected by time of N fertilizer applications, Hancock, WI 1991-1993.

N treatments					Relative Yield	Relative Grade A	Relative Yield US1A 6-13 oz.	Relative Value
Emerge	Hill	H+10	H+20	H+30				
					%	%	%	%
120	0	0	0	0	89	81	69	85
0	120	0	0	0	92	93	89	93
0	0	120	0	0	82	93	57	80
60	60	0	0	0	93	93	78	89
40	40	40	0	0	90	92	55	83
40	0	40	0	40	90	91	71	86
40	20	20	20	20	96	94	76	92
40	80	0	0	0	96	94	74	93
40	0	80	0	0	89	91	62	83
80	40	0	0	0	94	96	81	95
40	0	0	0	80	82	90	58	76
0	40	40	40	0	88	100	95	93

Top value for each parameter in each year set at 100%.

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Surprisingly, the single application at hilling all did quite well.

Effect of Harvest Date on Norland N Need

As a part of the petiole nitrate calibration trial across several varieties, we observed that Norlands responded to the highest rate of N applied when they were harvested at the end of the season. The N rate by harvest-date for Norlands trial was established to determine if this trend existed when they were harvested at the more usual early season times. As shown in Table 3, although vinekill date clearly influenced the Norlands yield it also had some effect on responsiveness to N with all the vinekill dates responding to at least 180 lb N/a in 1993; however, in 1992 response was only observed to 120 lb N/a when the vines were killed on 10 July, but to 180 lb N/a for the later kill dates. In both years, the vines for the latest vinekill plots had died without spraying 10-20 days prior to the established spray date.

As is noted by the statistically significant interaction term (vinekill time x N rate) for most of the measured parameters, different responses were apparent from N rate at the various kill dates. In 1993 this may have been due to the apparent response to the highest N rate (240 lb N/a) for the 10 August vinekill, but only to 180 lb N/a for both the first and third kill dates.

In part, this response to higher N levels may be done to the leaching that likely took place in 1993. Overall yields were much lower and general responsiveness was much higher.

Influence of Previous Crop on N Need

Previous research has shown that alfalfa preceding potatoes may provide about 125 lb/a nitrogen credit, whereas the credit from red clover is more in the range of 75-100 lb N/a (Kelling et al., 1992). For the past two seasons N rate experiments have been conducted as a part of the potato crop management experiments at Wallendahls near Grand Marsh, Wisconsin. In both 1992 and 1993 the previous crops were either sweetcorn, red clover or sorghum-sudan. The latter two were not harvested, but returned to the soil as a green manure.

Results of these experiments show that potatoes following both corn and sorghum-sudan tended to respond to at least 200-250 lb N/a in both years (Table 4). Potatoes following red clover had peak yields and quality with about 100 lb N/a added as supplemental N. This indicates the apparent N credit from the clover was about 100 lb N/a, which is very typical. No observed difference was seen between 1992 and 1993 indicating that rates of release were similar between years. Apparently the slower than normal release of organic N observed on medium and finer-textured soils in 1993 did not occur on the sandy, better drained soils.

In both 1992 and 1993 generally lower total yields were observed following sorghum-sudan than following either of the other crops. We have no obvious explanation for this observation, but it is consistent with observations from other potato rotation experiments.

Summary

Table 3. Effect of vinekill date on Norland tuber response to nitrogen rate at Hancock, Wisconsin, 1992-1993.

Treatment		Total Yield		Grade A		Yield US1A 6-13 oz.		Value	
Vinekill	N rate	1992	1993	1992	1993	1992	1993	1992	1993
	lb/a	-- cwt/a --		---- % ----		-- cwt/a --		--- $/a ---	
10 Jul	0	236	72	81	44	42	0	1106	208
	60	316	159	83	69	125	0	1905	541
	120	330	168	83	69	155	0	2135	572
	180	340	195	84	75	160	0	2212	683
	240	337	181	85	79	151	1	2149	654
10 Aug	0	305	104	80	66	113	0	1774	344
	60	390	176	80	82	206	0	2635	643
	120	396	251	75	86	188	7	2513	978
	180	439	280	77	87	227	6	2914	1084
	240	459	301	78	93	239	21	3064	1292
10 Sep*	0	270	124	82	58	70	0	1404	393
	60	381	181	88	72	207	2	2677	634
	120	422	251	86	80	224	7	2913	948
	180	422	307	85	82	224	26	2912	1256
	240	449	286	87	83	254	17	3207	1145
Significance									
Vinekill (T)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N rate (N)		0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00
T x N		0.01	0.00	0.28	0.15	0.00	0.00	0.00	0.00

*Vines died between 20 Aug and 1 Sep in both years.

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Table 4. Effect of previous crop on apparent potato nitrogen responses at Grand Marsh, Wi, 1992-1993.

Treatment		Total Yield		Grade A		Yield US1A 6-13 oz.		Value	
Previous Crop	N Rate	1992	1993+	1992	1993+	1992	1993+	1992	1993+
	lb/a	--- cwt/a --		---- % -----		--- cwt/a ---		--- $/a ----	
Sweet corn	0*	417	257	67	62	138	27	2228	999
	50	449	286	75	68	185	62	2685	1440
	100	466	273	71	68	173	64	2640	1315
	150	436	286	75	68	175	55	2585	1301
	200	431	316	73	67	173	63	2536	1431
	250	522	307	74	65	234	78	3227	1488
Red clover	0	393	233	66	65	121	28	2022	945
	50	425	257	72	66	170	47	2489	1138
	100	530	336	75	70	211	99	3119	1741
	150	452	238	74	69	188	36	2697	1028
	200	487	261	80	68	215	52	3042	1187
	250	487	314	78	69	223	101	3076	1667
Sorghum-sudan	0	373	214	74	64	131	29	2080	881
	50	459	245	75	64	176	27	2665	972
	100	403	266	75	71	157	48	2352	1203
	150	421	257	77	69	185	46	2609	1149
	200	430	264	75	67	178	51	2579	1186
	250	503	284	74	68	217	74	3049	1393

*In both years all plots received some N through the irrigation system (~60 lb/a in 1992 and 90 lb/a in 1993).

+Results from 1993 are averaged across 2- anal 3 year rotations.

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Although 1993 was an unusually wet year, the influences on potato soil fertility status was likely to be relatively minor. Clearly, excessive leaching occurred in 1993, but in most seasons the profile has been flushed of inorganic N by the end of the growing season. Any influences on the soil aeration status was relatively short-lived especially on the sandy soils. Somewhat higher rates of potash leaching probably occurred. It is our opinion that few adjustments are called for because of the wet 1993 season. What has been successful in the past will likely work well in the future.

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