IMPLICATIONS FROM "SPOON-FEEDING" POTATO PLANTS WITH NITROGEN-15 FERTILIZER[1]

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"Spoon-feeding" or applying increments of N on crops during the season usually by injections into sprinkler water helps minimize potential loss of N from sandy soil by leaching and may delay senescence or early dying of the potato plant. The Russet Burbank potato is a heavy user of N, but there may be some question about the effectiveness of frequent applications of small increments of N. At first the potato plant uses a large amount of N for vegetative top growth. As time goes by there is a slackening of top growth followed by accelerated tuber production. If the N demand for tuber production exceeds the capacity of the plant to take up N then it begins to draw-down the N reserve in the plant. An optimum N nutritional status of the plant is essential in order to maintain a productive plant canopy over an extended period to insure a high potato yield. The purpose of this study was to spoon-feed plants with ^{15}N tagged fertilizer to determine the effect of time and rate of application on the efficiency of fertilizer utilization in growth of plant tops and production of tubers.

Most of the N in nature is present as ^{14}N (99.6%) with 0.4% in the form of ^{15}N. Our approach was to use specially prepared ^{15}N enriched NH_4NO_3 fertilizer which facilitates tracing ^{15}N through plant and soil transformations. A crop which takes up only fertilizer N with 10% ^{15}N enrichment should also show 10% ^{15}N enrichment upon analysis by mass spectrograph. If plant N has been diluted 50% and shows only 5% enrichment, then half of the N came from another source.

This research was done from 1981 to 1983 at an experimental site on sprinkler irrigated sandy soil 5 miles west of Plymouth, Washington. Russet Burbank potatoes were planted in 34-inch rows around April 20 each year. The experimental treatments included a portion of the N applied as a broadcast spray and sprinkled-in early in May (Table 1). Additional small increments of N were applied in a similar manner at weekly or 10-day intervals from June to August. Each treatment with a different rate and time of application was applied on individual mini-plots three rows wide, 4 to 6 ft long. Potato petioles were samples from each plot every week or 10 days, and whole plants were sampled three or four times during the season for ^{15}N analysis.

Potato yields obtained in the three year study are summarized in Table 2. Partial results from these experiments were presented as proceedings of this conference in 1981 and 1982. In these reports increments of tagged N applied during June, July and August were taken up rapidly by the plants. The ^{15}N contents of petioles were usually highest within 10 days after treatment with enriched NH_4NO_3 and then decreased rapidly with time and with addition of un-enriched fertilizer.

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1 Paper presented at the 23rd Annual Washington State Potato Conference, Moses Lake, January 31-February 2, 1984. Research partially supported by a grant from the Washington State Potato Commission.

2 Soil Scientists at Prosser and Pullman, respectively. Our thanks to S. C. Smith and F. O. Farrow, Research Technicians at Prosser and Pullman, respectively, for help with the study.

This Presentation is part of the Proceedings of the 1984 Washington Potato Conference and Trade Fair.

Whole plants analyzed 7 to 10 days after treatment with increments of tagged N showed an accumulation of ^{15}N in plant tops with some translocation into the tubers (Fig. 1, 2, 3). Treatments in July (Fig. 2) gave a higher plant content of ^{15}N than corresponding treatments in June or August. The plant ^{15}N values following N treatments in August were low because there was only limited time for N uptake before the end of the season.

The effect of 1983 N treatments (Table 1) on potatoes is illustrated in Fig. 4. The treatment with 200 lb N/a produced slightly lower yield of both plant tops and tubers at the later sampling than the other treatments. The most plant tops were produced with 300 lb N/a using variable incremental N applications. The variable treatment (Table 1) had less N pre-emergence leaving more N to stimulate crop cover later in the season. The most tubers were produced with 300 lb N/a where standard 20 lb increments of N were applied each week (Table 1 and Fig. 4).

Analysis of whole plants July 27 showed nearly twice as high a concentration in tops as in tubers (Table 3). The maximum N uptake in tops and tubers combined was 200 lb/a. The uptake of N was not complete on this date and no doubt the season total N uptake was higher at a later plant sampling date.

This experiment afforded an excellent opportunity for comparing uptake of $^{15}NH_4^+$ with $^{15}NO_3^-$ when both were supplied at the same equivalent rates of NH_4NO_3. The % of ^{15}N fertilizer recovered on July 27 was just slightly higher for $^{15}NO_3^-$ than for $^{15}NH_4^+$ with the 300 N (variable) treatment (Table 4). The percent ^{15}N recovery reached peaks on June 29 and July 6. Similar results were noted for the comparative uptake of $^{15}NH_4^+$ and $^{15}NO_3^-$ with 200 N and 300 N (standard) treatments in Table 5. In 1982, early petiole samplings showed higher petiole $^{15}NO_3^-$ with $^{15}NO_3^-$ fertilizer than with $^{15}NH_4^+$. This is not surprising because there was not time for nitrification of $^{15}NH_4^+$ to $^{15}NO_3^-$ in the soil before plant uptake.

Spoon-feeding of N is practical for maintaining available N in sandy soil where N applied pre-emergence on potatoes may be lost early in the season by leaching. In this study the percent recovery of ^{15}N was slightly higher with 100 lb/a of pre-emergence N than with only 50 lb. The percent recovery of ^{15}N by plants remained high the latter part of June and first part of July even when as planned the incremental applications of N were exceptionally large. In future work we will use these results as a basis for combining optimum pre-emergence N rates with suitable time and rate of incremental N applications to get maximum N use efficiency.

Table 1. Total N in plant tops and tubers of potatoes treated with different rates of N during the 1983 season.

	Plants sampled 7/27/83				
N applied lb/a	Total N in tops %N	Total N in tops lb N/a	Total N in tubers %N	Total N in tubers lb N/a	Total lb/a
200	2.7	85.6	1.3	83.7	169.3
300 Std	3.0	110.3	1.5	82.5	192.3
300 Var	3.3	132.5	1.6	67.8	200.3

Table 2. Russet Burbank potato treatments with tagged NH_4NO_3.

	Total N lb/a	Spray after planting lb/a	Spray 10 times June to Aug.
1981	(300)	100	25 lb/10 days
1982	(300)	100	20 lb/wk
	(500)	200	30 lb/wk
1983	(200)	100	10 lb/wk
	(300)	100	20 lb/wk (Standard)
	(300)	50	10 - 40 lb/wk (Variable)

Table 3. Russet Burbank potato yields.

	N applied lb N/a	Total yield t/a
1981	300	32
1982	300	31
	500	29
1983	200	30
	300 Std	35
	300 Var	31

Table 4. % of ^{15}N-fertilizer recovered from 300N applied as variable increments on potatoes sampled July 27, 1983.

$^{15}N_4NO_3$ applied lb N/a†		Tops + tubers % of ^{15}N	$NH_4{}^{15}NO_3$ applied lb N/a		Tops + tubers % of ^{15}N
5/10	50	30.8	5/10	(50)	31.8
5/31	20	37.0	6/07	20	38.5
6/14	30	37.4	6/22	30	37.3
6/29	40	46.8	7/06	30	53.8
7/13	30	36.2	7/20	20	43.6
7/27	20	--	8/03	10	--
% of total recovered		39.7			42.2

† 300N variable treatment (Table 1).

Table 5. % of ^{15}N-fertilizer recovered by potatoes (tops + tubers) from two N rates in 1983.

	% of ^{15}N in tops and tubers sampled July 27				
	$^{15}N_4NO_3$ applied			$NH_4{}^{15}NO_3$ applied	
	200N†	300N (Std)†		200N†	300N (Std)†
5/10	38.8	36.4	5/10	43.0	38.5
6/14	49.5	40.7	6/07	46.2	46.1
6/29	46.9	43.7	6/22	69.2	47.4
7/13	38.4	31.0	7/06	55.3	66.5
7/27	--	--	7/20	44.9	59.3
8/10	--	--	8/03	--	--
% of total recovered	42.5	38.5		49.2	47.2

† 100 lb N/a pre-emergence (5/10) followed by increments of 10 lb/a and 20 lb/a on successive dates for 200 and 300 N, respectively.

Fig. 1. % ^{15}N uptake in June after applying 25 lb/a of tagged N in 1981 and 20 lb/a in 1982 and 1983.

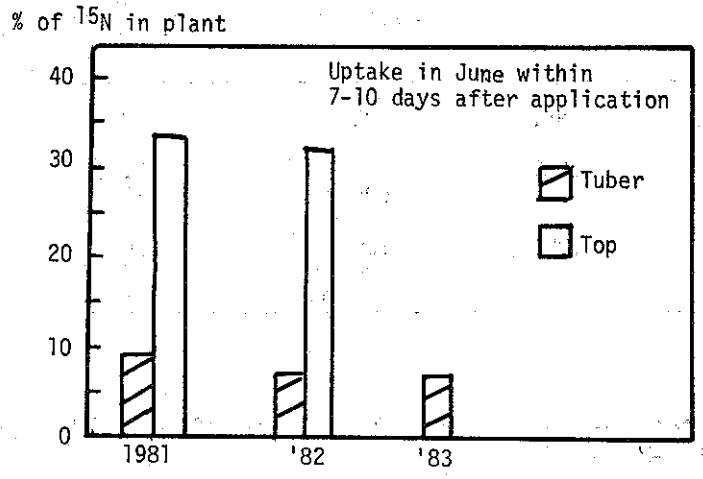

Fig. 2. % ^{15}N uptake in July after applying 25 lb/a of tagged N in 1981 and 20 lb/a in 1982 and 1983.

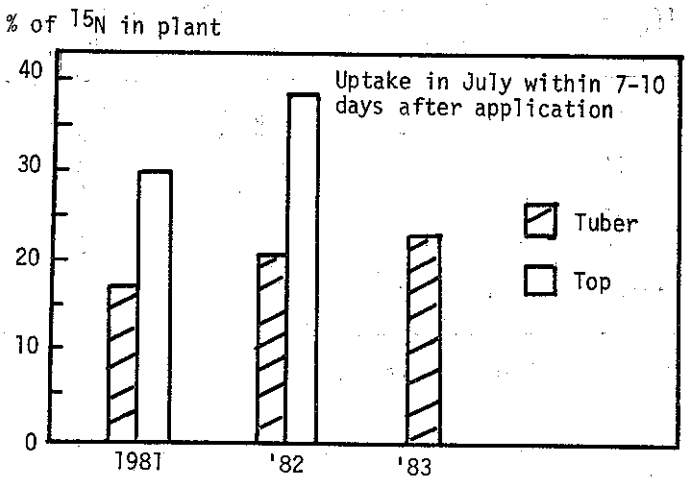

Fig. 3. % ^{15}N uptake in August after applying 25 lb/a of tagged N in 1981 and 20 lb/a in 1982 and 1983.

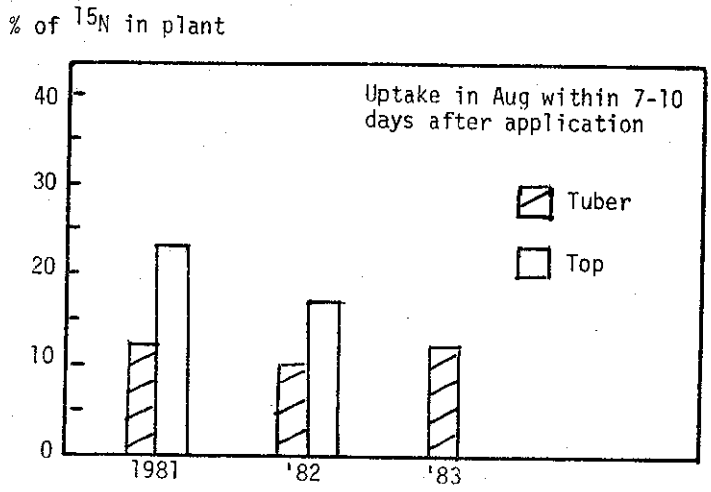

Fig. 4. Effect of three N treatments on yield of whole potato plants on different sampling dates.