EVALUATION OF N UPTAKE ANALYSIS AS A TOOL FOR DETERMING POTATO N STATUS

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ABSTRACT

Plant tissue testing has become the primary method for evaluating nitrogen availability for potatoes during the growing season. This study was conducted to determine if plant N uptake rates referenced to absorbed solar radiation could also be used as a tool to quantitatively assess plant N status of different potato varieties. Nitrogen fertilizer, as NH_4NO_3 (34-0-0), was applied to Russet Burbank, Gem Russet, Bannock Russet and Summit Russet at three rates (0, 100, or 300 kg N/ha) using two seasonal N application patterns, either 1) 2/3 pre-plant plus 1/3 in-season (early treatment), or 2) 1/3 pre-plant plus 2/3 in-season (late treatment). Cumulative N uptake curves for tubers, vines and the total plant were developed for each of the variety/N treatment combinations and plotted as a function of radiation absorbed to determine N uptake parameters. Increasing the N rate increased the amount of radiation absorbed at the point of maximum canopy N for all varieties, although Bannock Russet and Summit Russet both required substantially more absorbed radiation to reach maximum canopy N. However, most of the differences in seasonal N uptake occurred prior to the point of maximum canopy N and differences among varieties and N treatments after this point were relatively small. Nitrogen timing had little effect on the amount of absorbed radiation required to reach maximum canopy N. These results indicate that vine and tuber N uptake rates prior to maximum canopy N accumulation will provide the most useful information for assessing potato N status.

INTRODUCTION

Proper N fertilization is critical for optimizing potato yield and quality. Insufficient available N leads to reduced growth and light interception (Millard and Marshall, 1986), early crop senescence (Kleinkopf et al., 1981) and reduced yields (Westermann and Kleinkopf, 1985). Excessive available N can result in delayed tuber set (Kleinkopf et al. 1981), reduced yields (Lauer, 1986) and reduced tuber dry matter content (Millard and Marshall, 1986). Excessive N also increases the potential for environmental problems associated with nitrate leaching or runoff (Westermann et al. 1988).

Tissue testing has become the primary method for determining the need for in-season N applications for potatoes (Love et al. 2005). The most commonly used method of tissue testing for N involves frequent determination of petiole nitrate-N concentrations, which are compared to locally calibrated sufficiency levels to assess plant N status. However, these sufficiency levels vary considerably by variety, location, growth stage and management system and some have questioned whether petiole nitrate concentrations really provide an accurate reference for assessing the adequacy of potato N nutrition. Recently, Eric Allen of the University of Cambridge has proposed using seasonal changes in total plant N and tuber N uptake rates to characterize potato N status. He proposed that by relating tuber and plant N uptake rates to cumulative absorbed solar radiation, standardized N uptake curves for an adequately fertilized potato crop can be developed. These standard curves can then be used to establish a system of reference with which N uptake rates from subsequent potato crops can be compared.

OBJECTIVES

This study was undertaken to determine whether changes in plant and tuber N uptake rates during the growing season could be referenced to cumulative solar radiation to provide a tool for quantitatively assessing N status of different potato varieties.

MATERIALS AND METHODS

Experiments designed to determine the response of four potato varieties to different N rates and timings were conducted at the Aberdeen Research and Extension Center in 1999, 2000 and 2001. Nitrogen fertilizer, as NH_4NO_3 (34-0-0), was applied to Russet Burbank, Gem Russet, Bannock Russet and Summit Russet at three rates (0, 100, or 300 kg N/ha) using two seasonal N application patterns. Nitrogen was applied either 1) 2/3 pre-plant plus 1/3 in-season (early treatment), or 2) 1/3 pre-plant plus 2/3 in-season (late treatment). All preseason N applications were broadcast with a Barber spreader and mechanically incorporated, while all in-season N applications were hand applied in 6 equal increments at 1 week intervals during tuber bulking and incorporated with ¾ inch of sprinkler irrigation. All experiments were arranged as a split-plot design with fertilizer rate and timing as main plots and variety as subplots, and five replications. Individual plots were 3.6 m (12 ft) wide and 12.1 m (40 ft) long.

During tuber development, a 1.5 m (5 ft) section of row was harvested from each plot at 2 week intervals and divided into vines and tubers. Vine and tuber samples were dried at 40 C to determine dry weight per unit ground area. The samples were subsequently ground to pass a 40 mesh screen and analyzed for total N. Total plant and tuber N uptake per unit ground area were related to cumulative absorbed solar radiation using regression analysis and slopes of the resulting curves were used to characterize the changes in plant and tuber N uptake as a function of cumulative absorbed solar radiation. The product of total solar radiation collected from a nearby weather station and weekly measurements of percent ground cover was used to estimate cumulative absorbed solar radiation.

RESULTS AND DISCUSSION

Cumulative N uptake curves for tubers, vines and the total plant were developed for each of the variety/N treatment combinations and plotted as a function of radiation absorbed. An example is presented in Figure 1 for Russet Burbank fertilized with 100 kg N/ha using the late season application timing. Slopes of the regressions for total plant N uptake and tuber N uptake vs. radiation absorbed were used to develop uptake rate functions, as illustrated in Figure 2 for that same treatment. Tuber N uptake rate curves were linear during tuber bulking, while total N uptake rate curves were curvilinear. The point of intersection between these two curves for each treatment is the point of maximum canopy N. The total N rate curve was also used to estimate how much more N would be taken up by the vines and tubers after the point of intersection.

The results of the analysis are presented in Tables 1-4. Maximum total yields for all varieties were achieved with the 100 kg N/ha treatment. In general, increasing the N rate increased the amount of radiation absorbed at the point of intersection (maximum canopy N) for all varieties. Bannock Russet and Summit Russet both required substantially more absorbed radiation to reach maximum canopy N. The total amount of N taken up by the crop was also appreciably greater for Bannock Russet and Summit Russet. Overall, N application timing had little effect on the amount of absorbed radiation required to reach maximum canopy N for Russet Burbank, Bannock Russet and Summit Russet. However with the late N application treatment at the 100 kg N/ha rate, Gem Russet reached maximum canopy N at a much lower level of radiation absorbed than with the early application treatment.

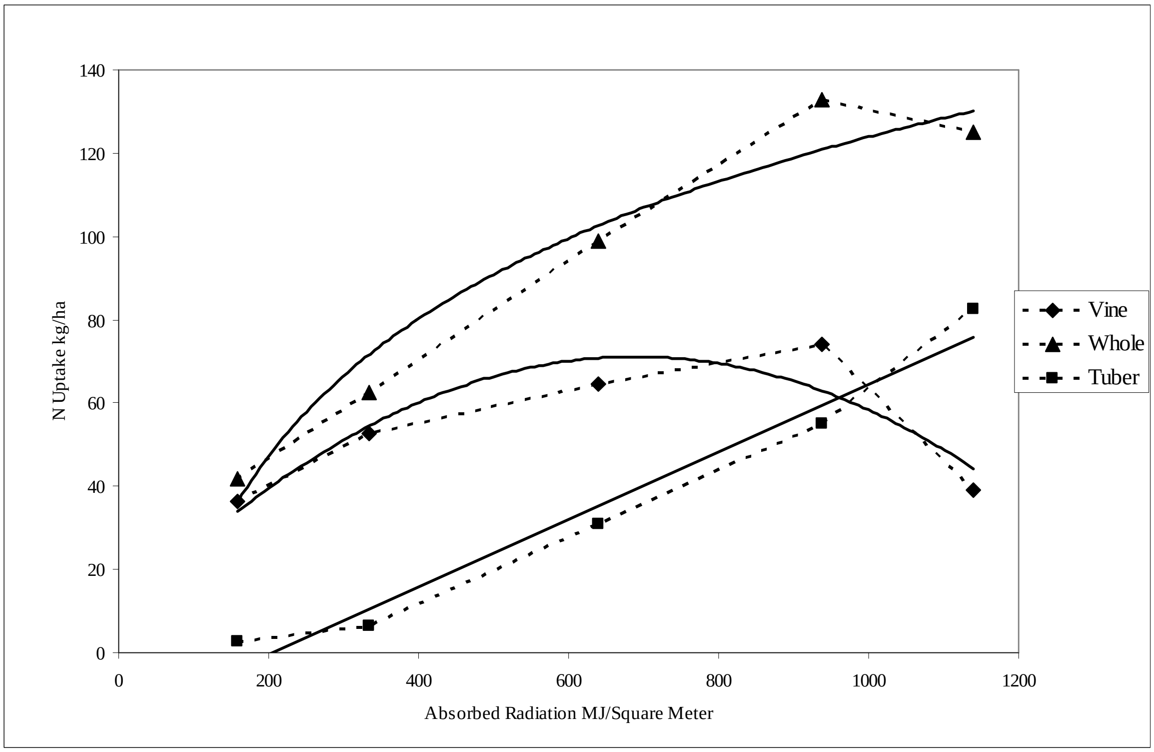

Figure 1. Relationship between N uptake and cumulative radiation absorbed for Russet Burbank potatoes receiving 100 kg N/ha with the late application treatment.

Nitrogen uptake after the point of maximum canopy N varied considerably with N treatment. With late N application, Gem Russet took up significantly more N after reaching maximum canopy N than did the other varieties. However, in most other cases, late season N uptake for the check treatment was equal to or greater than that for the fertilized treatments. Thus most of the differences in seasonal N uptake occurred prior to the point of maximum canopy N. Nitrogen in the canopy at harvest also increased with increasing N rate but was generally not affected by N timing. As with total N uptake, the amount of N in the canopy at harvest was substantially greater for Bannock Russet and Summit Russet than for Russet Burbank and Gem Russet. The point at which cumulative vine N uptake equaled tuber N uptake followed a similar pattern, with Bannock Russet and Summit Russet requiring a greater amount of radiation absorbed than Russet Burbank and Gem Russet.

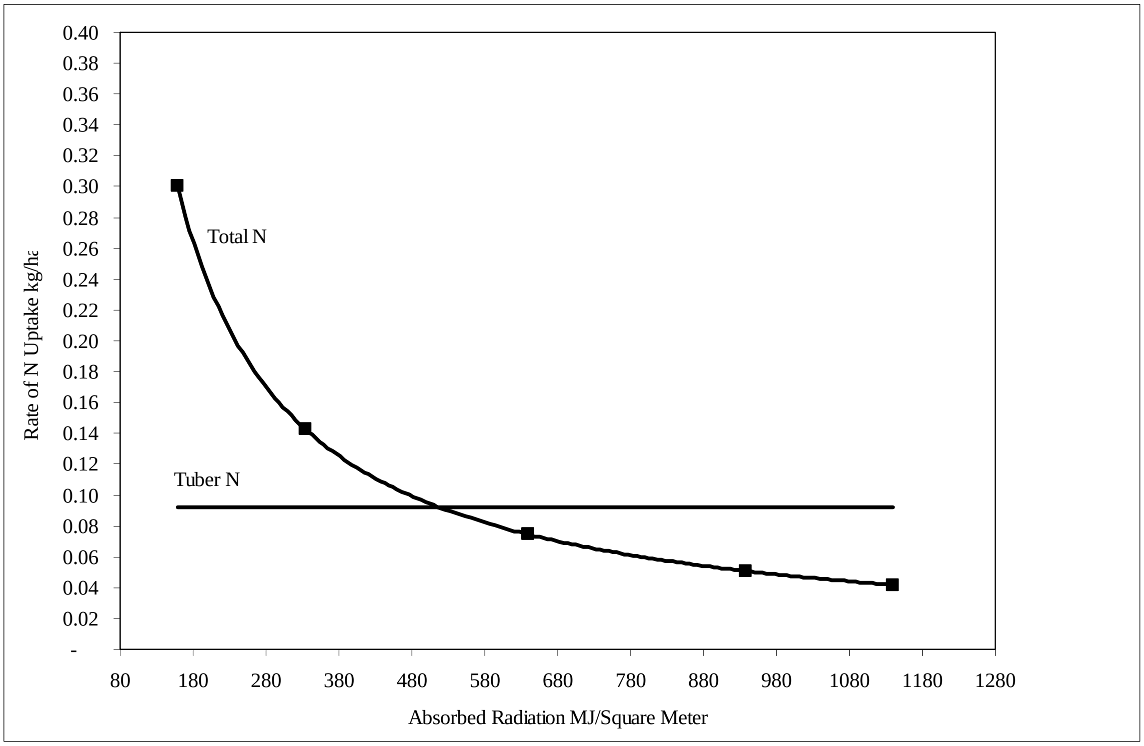

Figure 2. Relationship between total and tuber N uptake rates and cumulative radiation absorbed for Russet Burbank potatoes receiving 100 kg N/ha with the late N application treatment.

Table 1. Calculated N uptake parameters and total yield for Russet Burbank potatoes as influenced by N fertilization treatment.

	Russet Burbank					
	0 none	100 late	300 late	100 early	300 early	units
Intersection of plant and tuber N uptake rates	328	530	791	540	765	kgN/Ha/MJ/m^2
Vine N at intersection	45	68	112	77	110	kg N/ha
Tuber N at intersection	14	22	45	21	43	kg N/ha
Total N at intersection	59	90	157	98	153	kg N/ha
N uptake after intersection	30	43	16	24	19	kg N/ha
Maximum plant N uptake	89	133	173	122	172	kg N/ha
N in canopy at last sampling	21	39	73	41	85	kg N/ha
Intersection of vine and tuber N	682	959	1234	1059	1262	MJ/meter^2
Total tuber yield	28	35	36	36	35	t/ha

Table 2. Calculated N uptake parameters and total yield for Gem Russet potatoes as influenced by N fertilization treatment.

	Gem Russet					
	0 none	100 late	300 late	100 early	300 early	units
Intersection of plant and tuber N uptake rates	364	386	788	547	639	kgN/ha/MJ/m^2
Vine N at intersection	56	68	68	95	143	kg N/ha
Tuber N at intersection	14	13	51	28	37	kg N/ha
Total N at intersection	69	81	119	122	181	kg N/ha
N uptake after intersection	36	68	72	24	4	kg N/ha
Maximum plant N uptake	105	149	191	146	184	kg N/ha
N in canopy at last sampling	32	50	83	42	65	kg N/ha
Intersection of vine and tuber N	842	974	1248	1056	1158	MJ/meter^2
Total tuber yield	29	37	37	37	38	t/ha

Table 3. Calculated N uptake parameters and total yield for Bannock Russet potatoes as influenced by N fertilization treatment.

	Bannock Russet					
	0 none	100 late	300 late	100 early	300 early	units
Intersection of plant and tuber N uptake rates	396	630	1302	576	1177	kgN/ha/MJ/m^2
Vine N at intersection	61	100	117	106	151	kg N/ha
Tuber N at intersection	15	32	60	27	54	kg N/ha
Total N at intersection	76	133	177	133	206	kg N/ha
N uptake after intersection	34	26	31	18	21	kg N/ha
Maximum plant N uptake	109	158	207	150	227	kg N/ha
N in canopy at last sampling	42	69	124	59	131	kg N/ha
Intersection of vine and tuber N	930	1173	1494	1162	1480	MJ/meter^2
Total tuber yield	34	39	36	39	36	t/ha

Table 4. Calculated N uptake parameters and total yield for Summit Russet potatoes as influenced by N fertilization treatment.

	Summit Russet					
	0 none	100 late	300 late	100 early	300 early	units
Intersection of plant and tuber N uptake rates	354	620	1006	637	1033	kgN/ha/MJ/m^2
Vine N at intersection	57	98	136	104	141	kg N/ha
Tuber N at intersection	16	33	57	34	57	kg N/ha
Total N at intersection	73	131	192	138	198	kg N/ha
N uptake after intersection	23	21	15	21	20	kg N/ha
Maximum plant N uptake	96	152	207	159	217	kg N/ha
N in canopy at last sampling	37	70	107	69	117	kg N/ha
Intersection of vine and tuber N	817	1135	1335	1127	1351	MJ/meter^2
Total tuber yield	27	33	34	33	31	t/ha

These results indicate that tuber and vine N uptake rates determined prior to the point of maximum canopy N should provide the best opportunity for assessing the adequacy of the N fertilization program and the need for any additional N.

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