UPTAKE AND MOBILITY OF NUTRIENTS AS INFLUENCED BY POTATO IRRIGATION

by
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It is economical to obtain high uptake efficiency from fertilizer. Low uptake efficiency of fertilizer with mobile nutrients can occur because of leaching. Nitrate (NO3), sulfate (SO4) and borate (BO3) are mobile forms of N, S and B which are subject to leaching with deep drainage of soil water. Although Bromide (Br) ion is not regarded as an essential plant nutrient, it is highly mobile, and it has been used as a tracer for movement of N and water in soil leaching studies. The timing and rate of applying soluble nutrients and the amount of excess soil water influence leaching. Applying more N than the crop needs under irrigation usually increases leaching potential. It is generally believed that a majority of potato roots are found in the surface foot of soil which limits uptake of nutrients leached into the subsoil. An important factor is to provide adequate, timely irrigation with a minimum of deep drainage.

An experiment was conducted with potato each year in 1989 and 1990 at Prosser. These experiments were designed to study nutrient uptake and mobility under irrigation. The purpose of the experiments was to obtain information to improve the efficiency of both water and nutrients for potato production. The results covered in this report are primarily on irrigation and N from the first experiment with some reference to the second experiment. The stated objective of these experiments were 1) to determine crop response and N uptake by selected cultivars grown with different N and irrigation treatments, and 2) to follow water and NO3 distribution patterns in irrigated soil by analysis for NO3 and Br tracer applied as potassium bromide.

Experiment 1 had low, medium and high levels of irrigation for potato grown on Warden silt loam in a rotation following wheat. Pretreatment soil tests showed 40 lb mineral N/a 3 ft of soil, and 0.25 ppm B in the surface 1 ft. Experiment 2 was conducted on Hezel loamy sand following alfalfa, with two treatments to give a medium and a high level of irrigation. The irrigation schedule for both experiments called for normal irrigation to the first week in June with low, medium and high (approximately 0.7, 1.0 and 1.4 times pan evaporation through the main part of the irrigating season. Experiment 1 was planted solid with Russet Burbank, and Experiment 2 included this cultivar plus Century Russet (CR) and Frontier Russet (FR).

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Blocks with water treatments (Experiment 1) received different fertilizer rates of 200N, 300N (with and without B and S) and 500 lb N/a as NH_4NO_3. In Experiment 2 the N rates were a control without added N and 90, 270 and 450 lb N/a applied to three cultivars CR, FR and RB. In both experiments the N treatments were applied in three equal split applications. The split applications of N were scheduled in May, the first week of June and the first week of July. Toward the end of August when plants were starting to mature, samples of plant tops and tubers were collected and analyzed for total N. Total uptake of N was calculated from dry matter yield and the concentration of N in plant tissue. Selected samples were analyzed for total B.

There is potential for controlling yield of dry matter in both tops and tubers with adjustments in irrigation and fertility. In 1989 the moisture stress from the low level of irrigation reduced the average total tuber yield significantly at final harvest (Table 1). The total tuber yield increased with each increase in irrigation from low to medium and from medium to high. The yield percent of U.S. No. 1 tubers also showed an increase from the medium to the high level of irrigation (Table 2). There were so many undersized tubers produced at the low level of irrigation that the grade was not determined for tubers from the low water treatment. There was no tuber yield response for total or No. 1 yield with increased N from 200 to 500 lb N/a. Likewise there was no beneficial yield increase from including S and B along with N (Data not shown). In 1990 for Experiment 2, the plowed-down alfalfa was expected to supply considerable N, and therefore slightly lower rates of N were used. Yields in Experiment 2 were lower than in Experiment 1 averaging from 20 to 25 t/a (Data not shown). At this yield level there was little N stress with any of the N treatments. Likewise there was no differential response between the medium and high irrigation treatments for Experiment 2. It was not apparent why the yields were so low, unless it was related to the residual effects of alfalfa. Both CR and FR had acceptable grade of U.S. No. 1 tubers, but CR was probably the only cultivar where hollow heart (H-H) incidence was acceptable (Table 3). There were probably some unrecognized stress factors present. Water stress dominated fertility in the dry matter production in total plant tops in Experiment 1 (Table 4). Samples of mature plants taken in August showed that averaged over fertilizer treatments, dry matter yield of tops with low water was significantly less than medium or high water treatments. Medium irrigation gave significantly higher tuber/top ratio than the others (Table 4). Applying N rates in excess of 200 lb N/a gave no significant increase in dry matter production. The addition of S and B to fertilizer treatment had no effect on dry matter production (Data not shown). Experiment 2 showed a wider range of dry matter in plant tops among cultivars (Table 4,5) than among irrigation or fertilizer treatments.

Tuber specific gravity remained nearly constant and decreased from 1.088 down to 1.084 as available moisture increased in Experiment 1 (Data not shown). Average specific gravity values were considerably lower in Experiment 2 than in Experiment 1. For example, average specific gravity values averaged over N rates of 90, 270 and 450 lb/a never exceeded 1.073 (Table 6).

Moisture stress had very little effect on the average N concentration in plant tops and tubers in Experiment 1, in 1989 (Table 7). Moisture stress decreased total N uptake in tops and tubers the same as it did dry matter production (Table 8). Table 9 shows the effect of rates of applied N on total N uptake averaged over treatment levels irrigation for Experiment 1. The N status of potato plants for cultivars of Experiment 2 has not been determined at this time. Total N uptake averaged approximately 150 lb N/a in plant tops plus tubers from residual N in alfalfa without N fertilization for Experiment 2 in 1990 (Data not shown). Increasing water treatment levels decreased B concentration in potato plant tops which was probably a dilution effect (Table 10). In Experiment 1 the concentration of B in tubers averaged under 10 ppm as compared to 37 to 77 ppm in plant tops (Table 9). Total B uptake was higher for medium and high irrigations than for low irrigation (Table 11). Applying B increased plant B substantially. Plant tops without applied B averaged 30 ppm. Previous work showed that plant tops with this minimum of B were probably adequately supplied with B. Therefore it is not surprising that no yield response was obtained from applying B.

We wanted to obtain some measure of the downward movement of NO3 in the soil profile. Soil was sampled by 1 ft increments in the preseason and again after harvest and analyzed for mineral N. Table 12 gives a strong indication for downward movement of N. The second foot for example had higher NO3 levels at the end of the season than initially. Results for mineral N are difficult to interpret in N mobility studies because there is potential for N mineralization in position in the soil profile. The use of Br as tracer overcomes this problem because the residual Br level in most cases is very low or insignificant. Some preliminary studies using Br tracer in Experiment 1 showed leaching of Br into the subsoil.

Table 1. Effect of low (0.7 ET), medium (1.0 ET) and high (1.4 ET) irrigation on harvest yield of Russet Burbank potato averaged over N rates, Experiment 1, 1989.

Irrigation Effect on Yield (t/a)

Low	Medium	High
12 a	29 b	32 c

(Different letters are differences at 5% level)

Table 2. Effect of low, medium and high irrigation on yield of U.S. No. 1 tubers RB potatoes averaged over N rates in Experiment 1, 1989.

Irrigation and US No. 1 Yield (%)		
L	M	H
Not determined	83 a	87 b

Table 3. Grade and prevalence of hollow-heart (H-H) of three cultivars Century Russet (CR), Frontier Russet (FR) and (RB) averaged over two irrigation treatments and three N rates Experiment 2, 1990.

Potato Grade and H-H		
	US No. 1 %	H-H %
CR	79	3.2
FR	84	7.4
RB	61	8.3

Table 4. Effect of irrigation on dry matter yield of potato tops and tuber/top ratio for August 30 sampling averaged over N rates for Experiment 1, 1989.

Irrigation Effect on DM (t/a)			
	Low	Medium	High
DM in Tops	1.4 a	2.0 b	2.9 c
Tuber/Top Ratio	2.3	3.3	2.2

Table 5. Dry matter yield of plant tops for three cultivars CR, FR and RB averaged over three N rates and medium and high levels of irrigation treatments in Experiment 2, 1990.

DM Yield of Plant Tops (t/a)

	CR	FR	RB
Mean N90 270, 450	3.1	1.2	2.3

Table 6. Specific gravity values for three cultivars averaged over medium and high levels of irrigation and three rates of N Experiment 2, 1990.

Potato Specific Gravity

	CR	FR	RB
Mean N90 270, 450	1.073	1.066	1.072

Table 7. The effect of low, medium and high irrigations on the concentration of N in RB potato plant tops and tubers Experiment 1, 1989.

Irrigation Effect on Plant N Concentration (%)

	L	M	H
Top	3.2	3.2	2.9
Tuber	1.6	1.5	1.4

Table 8. Effect of low, medium and high irrigations on N uptake by RB tubers and whole plants averaged over three rates of N in Experiment 1, 1989.

	Irrigation Effect on N Uptake (lb/a)		
	L	M	H
Tuber	108 a	195 b	188 a
Whole Plant	198 a	322 b	364 c

Table 9. Total N uptake by RB potato tubers and whole plants for three rates of N averaged over three levels of irrigation for Experiment 1, 1989.

	N Uptake in Tubers and Whole Plants		
N Rate	200N	300N	500N
Tubers	170	159	165
Whole Plants	270 a	292 ab	318 b

Table 10. Effect of Low, medium and high irrigation treatments on the concentration of B in tops and tubers of RB potato in Experiment 1, 1989.

	Irrigation Effect on Plant B (ppm)		
Tops	77 a	65 b	37 c
Tubers	8.5	9.5	8.8

Table 11. Total uptake of B in potato plant tops and tubers at low, medium and high irrigation treatments averaged over fertility treatments.

	Irrigation Effect on Plant B (g/a)		
	L	M	H
Tubers	27 b	58 a	52 a
Whole Plants	123 b	164 a	151 a

Table 12. Movement of mineral (NH_4NO_3) N into the second foot of soil with surface fertilization and sprinkler irrigation of RB potato on Warden silt loam in Experiment 1, 1989.

	Soil Mineral N (1-2 ft) After Harvest		
	L	M	H (lb N/a)
200N	35	15	13
300N	46	22	49
500N	86	140	78