IMPROVING ONION PRODUCTIVITY AND N USE EFFICIENCY WITH A POLYMER COATED NITROGEN SOURCE

Dan Drost and Rich Koenig
Utah State University
Department of Plants, Soils and Biometeorology
Logan, UT 84322-4820

ABSTRACT

Nitrogen losses from irrigated onion can be substantial when fertilized with leachable N sources. Polyon, a polymer coated urea, may reduce N losses and result in an increase in productivity. In this study, we investigated the effects of different rates and blends of urea and Polyon on onion yield and nitrogen use in two years. Nitrogen was applied at 100, 150 and 200 lb N/acre as Polyon or urea. In addition, Polyon/urea blends equal to 200 lb N/acre were compared. Plant growth, soil nitrate levels and yields were evaluated each year. Onion yields decreased significantly as the proportion of urea in the blend increased. Yield increases were the result of a greater percentage of larger sized bulbs and fewer mediums in the Polyon compared to the urea treatments. Soil sampling indicated that more N was retained in Polyon treated onion beds than in urea treated beds. Nitrogen use efficiency improved as a result of better nitrogen management. In addition, N use efficiency improved when there was more Polyon in the blend and when Polyon was compared to urea at the same rate. We conclude that the use of Polyon can dramatically improve N use efficiency and productivity in direct seeded onions.

INTRODUCTION

Onions are grown on approximately 2500 acres in Utah with a reported value of $8-9 million. Bulb development in onions is primarily promoted by long photoperiods and high temperatures (Brewster, 1994). Nitrogen (N) also plays an important role in this process. This is due in part to the role N plays in controlling leaf growth. Early applications of N accelerate (Riekels, 1977), or have little effect on (Brewster, 1994) crop maturity while low N levels can delay maturity (Henriksen, 1987). Late season applications of N or high residual N levels in the soil often delay or prevent bulbing under marginal photoperiods but have no influence when photoperiods are ideal (Scully et al., 1945). Excessive N applications have also increased leaf blade growth late in the season (Brewster, 1990) which delays crop maturity (Schwartz and Bartolo, 1995) and contributes to increased storage losses (Brewster, 1994).

Nitrogen application rates in Utah vary from 200 lb/acre to over 350 lb/acre. These rates are substantially higher than the 150-250 lb N/acre recommended by the University of Idaho (Brown et al., 2000), Oregon State University (Mansour et al., 1983) or Colorado State University (Schwartz and Bartolo, 1995). Growers tend to over apply N to compensate for excessive irrigation applications or from fear that yields will be less than needed to maintain profitability. When high N applications are combined with excessive irrigations, nitrate leaching can occur (Drost et al., 1997; Ells et al., 1993; Feibert et al., 1993). Leaching of NO_3-N ultimately leads to the movement of nitrate into ground water sources, posing a potential threat to the quality of the water resource. Therefore, using N sources that are less prone to leaching (slow release N) or timing N applications (multiple applications) to plant growth stage are possible ways of minimizing N loss.

Presented at the Western Nutrient Management Conference, Salt Lake City, UT, March 8-9, 2001

Fertilization of onions with Polyon, a slow release polymer coated N source, could increase onion bulb yield and improve bulb quality through better N use efficiency compared with a non-coated, urea based N fertilizer. Therefore the objectives of this study were to assess the effects of N source (Polyon or Urea) and N rate on the growth and productivity of onion.

MATERIALS AND METHODS

Experiments comparing a slow release N source to urea were conducted in commercial onion fields in 1998 and 1999. Sweet Spanish onions were seeded on March 25, 1998 and March 15, 1999. The experimental design was a randomized complete block with nine nitrogen treatments and four replications. Plots were 25 feet long and six beds wide. Bed configuration varied and onions were seeded at 140,000 and 184,000 per acre in 1998 and 1999, respectively.

Standard grower production practices for fertility, irrigation, and pest and weed control practices were followed. Prior to bed formation in the fall, the growers applied some N, 140-150 lbs of P_2O_5/acre, 50 lbs of K_2O/acre, 40 lbs of sulfate-sulfur/acre and 6 lbs of zinc/acre. No additional N was applied to our test sites other than that applied the previous fall and that supplied with the selected N treatments. Polyon (43% N) or Urea (46% N) separately or as different blends were applied to the test plots as listed in Table 1. Treatments were applied on May 27, 1998 and May 28, 1999 with a Gandy Applicator calibrated to deliver the required amounts of nitrogen. For those treatments that received both Polyon and urea-N, the amounts were delivered separately to ensure that the correct amount was applied.

Table 1. Nitrogen rates and sources applied to direct seeded onion in 1998-1999.

Treatments	Treatment Code	POLYON	UREA-N
1) 200 lb N/acre	100P-0U	100%	0%
2) 200 lb N/acre	75P-25U	75%	25%
3) 200 lb N/acre	50P-50U	50%	50%
4) 200 lb N/acre	25P-75U	25%	75%
5) 200 lb N/acre	0P-100U	0%	100%
6) 150 lb N/acre	75P-0U	75%	0%
7) 100 lb N/acre	50P-0U	50%	0%
8) 150 lb N/acre	0P-75U	0%	75%
9) 100 lb N/acre	0P-50U	0%	50%

Plant growth and nitrogen status was evaluated periodically each year. After measuring leaf area and number, plants were dried at 70C, weighed, ground, and later analyzed for N content. Soil N status was assessed before the initial N application in May. Initial soil samples indicated the soil contained 10 and 157 lbs of residual nitrate-nitrogen/acre in the surface 0-12 inch depth in 1998 and 1999, respectively. The bulk of this N came from N applications made by the grower in fall and mineralized N from organic sources. Additional soil samples were collected at monthly intervals during the year. In early August 1999, beds from one replication of the 100% Polyon and 100% urea treatments were sampled using a cross section method. Separate soil cores from the 0-6, 6-12, 12-18, and 18-24 inch depths and at five equally spaced positions across the bed were collected. The transect began with the center of a furrow on one side of the bed and continued in 10 inch increments to the center of the furrow on the opposite side of the bed. Based on these results, beds from the first three replications of five selected treatments (100 and 200 lb N/acre, 100% Polyon or urea treatments; 200 lb N/acre, 50% Polyon-

50% urea treatment) were sampled in cross section on August 24, 1999. All soil samples were extracted with 0.12-M ammonium sulfate and analyzed for nitrate-nitrogen (NO_3-N) with ion selective electrode. Nitrate-nitrogen values were converted to pounds of N/acre by assuming a soil bulk density of 1.30 g/cm^3 and multiplying the nitrate-nitrogen concentration in each 6 inch depth increment by a factor of 2. A nitrogen budget was calculated by adding the N recovered from the plant tissue and the soil assuming minimal volatilization. Nitrogen not accounted for was assumed to be leached from the root zone. Nitrogen uptake (NUPE), utilization (NUTE) and N use efficiency (NUE) were calculated from final yield, tissue N, plant population and plant biomass each year.

Onion maturity was assessed beginning in mid-August to determine loss of plant vigor and time of 50% top down. Onion maturity occurred on approximately September 17, 1998 and September 4, 1999. Onion bulbs were lifted, cured in the field for 5 days, and then hand topped before removal from the field. Onions were cured for an additional 10 days before assessing bulb size and weight. Bulbs were graded into culls (rots, diseased, splits, <2¼ inch diameter bulbs), medium (2¼-3 inch), jumbo (3-4 inch) and colossal (+4 inch) grades then counted and weighed. Yield comparisons taken adjacent to the test site were 1392 bags/acre in 1998 and 1464 bags/acre in 1999. The remainder of the bulbs were bagged and stored until early January when they were evaluated for storage potential (weight loss, rotting, breakdown, etc).

RESULTS AND DISCUSSION

Yield: Nitrogen source and rate had a significant effect on onion bulb yield in both years. The greatest yield occurred in treatments with either 100% or 75% Polyon alone or in a mix with urea (Figure 1). As the percentage of urea in the mix increased (Trt 1-5), total yield decreased linearly. Yield increases associated with Polyon were due mainly to an increase in the yield of colossal and jumbo bulbs and a decrease in the medium yield (Figure 1). Increasing the amount of urea in the mix resulted in fewer colossal onions and increased the number of medium bulbs. Since bulb numbers harvested per plot were not different for any of the treatments (data not shown), excessive N losses or poor N use efficiency may be responsible for the lower yields in those treatments with more urea in the mix.

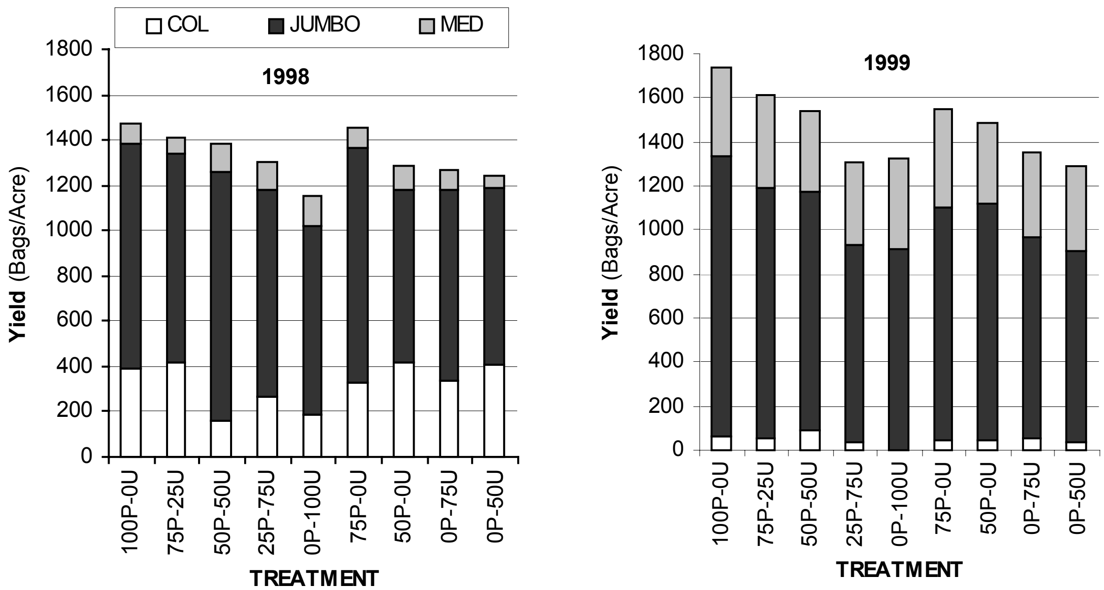

Figure 1. The effect of nitrogen source (P=polyon, U=urea) and rate (100-200 lb N/acre) on onion bulb yield (colossal, jumbo, medium) in 1998 and 1999. See Table 1 for treatment details.

Reducing the rate of N applied from 100% to 50% resulted in a yield decrease when N was supplied by Polyon alone (Trt 1, 6, 7). Research in Utah and other western states has shown that onion requires N levels near 150 lbs/acre for optimal production. When nitrogen was supplied by urea alone (Trt 5, 8 and 9), decreasing the rate of applied N had little or no effect on yield. The mean yield for the Polyon (Trt 1, 6 and 7) only treatments was nearly 200 and 270 bags/acre greater than when all N was supplied as urea only (Trt 5, 8 and 9) in 1998 and 1999, respectively. In addition, when evaluating the effects of the different N sources at the same rate, yields were significantly greater when applying Polyon compared to urea at the 100% (Trt 1 & 5) level for the total and colossal yields in both years. The improved yields when applying Polyon compared to urea at the 100% level suggests greater N use efficiency with a slow release N form. Since yields were not significantly different between the 100% and 75% N rates regardless of the source, the use of lower N levels by onion producers should not affect onion productivity but would increase NUE. These findings are in agreement with reports from Colorado, Idaho and Utah that show that onions can be grown with 150 lbs. N/acre and still achieve high yields (Drost et al., 1997; Mansour, et al., 1983; Swartz and Bartolo, 1995). However, further N reductions to 100 lbs/acre will result in yield reductions regardless of the N source used.

Nitrogen source and rate had no effect on the percent usable bulbs or overall quality of the bulbs at harvest (Table 2). After 3 months storage, there were only small differences in weight loss between the different nitrogen treatments (Table 2). Production season and grower plant population apparently impacts the bulb size and storage potential more than N source or rate. This can be seen in the percentage of colossal, jumbo and medium onions produced in the different years and N treatments. Generally, the use of Polyon increased the percentage of larger sized bulbs thereby reducing the number of smaller, less profitable onions.

Table 2. The effect of nitrogen source (P=Polyon; U=urea) and rate on the % bags/acre of colossal, jumbo and medium onions, % usable bulbs at harvest, and % weight loss after storage in 1998 and 1999. See Table 1 for treatment details.

Treatments	% bags/acre						% Usable at Harvest		Storage wt loss (%)	
	Colossal		Jumbo		Medium					
	1998	*1999*	*1998*	*1999*	*1998*	*1999*	*1998*	*1999*	*1998*	*1999*
100P-0U	26.7	3.8	67.1	73.1	6.2	23.1	98	98	22	5
75P-25U	29.7	1.2	65.2	70.7	5.2	26.3	100	97	16	11
50P-50U	11.4	5.6	79.9	70.1	8.6	23.7	98	97	16	11
25P-75U	20.2	2.5	70.0	68.8	9.8	28.6	98	97	20	20
0P-100U	15.8	0	72.5	69.1	11.6	30.9	97	97	17	15
75P-0U	22.7	3.0	71.1	68.0	6.2	28.8	98	98	18	11
50P-0U	32.8	3.2	59.1	72.2	8.2	24.6	98	98	25	10
0P-75U	26.8	3.9	66.3	67.4	6.9	28.7	99	98	17	14
0P-50U	33.1	2.6	62.5	67.5	4.4	27.9	98	97	20	15

Soil Nitrogen: Cross-section soil sampling indicated significant differences in positional availability of NO_3-N across the onion beds in the Polyon and urea treated soils (Figures 3 and 4). Sampling indicated that more NO_3-N was confined to a zone of soil in the center of the bed for the Polyon treatment compared to the urea treatment. Additional samples collected on August 24 illustrated significant variability in NO_3-N levels between replications (data not shown). This variability was likely due to the furrow irrigation system and location of replications. Replicates near the head end of the field generally had higher NO_3-N levels than those near the tail end where more leaching would occur.

N-Use Efficiency: Application of different combinations of Polyon and urea (alone or in blends) had variable effects on leaf N levels in both years of the study (data not shown). Leaf N tended to increase until early August then decrease as plants matured or as leaching of N occurred in the furrow irrigated onions. Single degree of freedom contrasts were used to test for treatment differences in tissue N patterns. The lack of significant differences is due to variability between the samples and the high initial levels of N in the soil in 1999. Prior to our fertilizer applications in 1999, soil NO_3-N levels were 157 lb N/acre and reflect the high fall applications of the grower.

Nitrogen uptake efficiency (NUPE) increased and nitrogen utilization efficiency (NUTE) decreased as the season progressed (Table 3). Improved NUPE by onion is due to increased root development during the season that allows better uptake but not necessarily better utilization. The decrease in utilization reflects potential leaching losses that occur with furrow irrigation (Ells, et al., 1993), a lack of demand as leaf initiation slows and poor recovery of applied N by the shallow, sparse root system (Brewster, 1994). By September, NUE decreased as more urea was introduced into the fertilizer mix. NUE was generally greater in those treatments receiving less N either as urea or polyon. Since onions require approximately 150 lb N/acre (Schwartz and Bartolo, 1995; Mansour et al., 1983), improved NUE would be expected in those treatments where lower amounts of N were applied. Single degree of freedom comparisons of the different forms of N applied at the same rate (100P vs. 100U; 75P vs. 75U; 50P vs. 50U) shows that in all cases, application of polyon improved NUE compared to urea. We noted similar trends in 1999 although overall NUE was lower due to the high fall application of N by the grower (data not shown).

Table 3. Changes in nitrogen uptake efficiency (NUPE), nitrogen utilization efficiency (NUTE) and nitrogen use efficiency (NUE) on different sampling dates in 1998 as affected by Polyon/Urea additions to onions.

	NUPE			NUTE†			NUE*
Treatments	**July 1**	**Aug 2**	**Sep 1**	**July 1**	**Aug 2**	**Sep 1**	**Sep 1**
100P-0U	0.108	0.848	1.236	7.13	0.92	0.63	0.78
75P-25U	0.077	0.427	1.408	9.24	1.70	0.51	0.72
50P-50U	0.062	0.711	1.293	11.01	0.95	0.54	0.70
25P-75U	0.043	0.593	0.841	13.30	0.98	0.70	0.59
0P-100U	0.039	0.526	0.953	14.89	1.11	0.62	0.59
75P-0U	0.073	1.097	1.579	11.84	0.81	0.56	0.89
50P-0U	0.099	1.144	1.563	11.67	1.03	0.80	1.24
0P-75U	0.054	0.967	1.272	14.26	0.79	0.62	0.79
0P-50U	0.106	1.256	1.590	9.54	0.79	0.64	1.02

* NUE = NUPE x NUTE

† NUTE = Final Yield/(plant dry wt x plant N content x plant population)

CONCLUSIONS

Yield results from this study suggest that the use of Polyon is beneficial for onions. Adoption of Polyon use by growers will depend on ease of application, cost of the product, nutrient savings considerations, projected crop returns and other crop management factors. Since onion yields with a 75% Polyon and 25% urea mix were comparable to that of 100% Polyon, blends of these materials may be a way to encourage use at a reduced cost to the onion producer. It could be argued that the yield increase associated with using the 100% Polyon compared to the 75%P-25%U might easily offset the additional cost of the slow-release N source. Further research with Polyon/urea blends is warranted for onions. Detailed cost-benefits analysis is also needed to determine the feasibility of using this more expensive N source.

Residual soil NO_3-N values depend on the grower's individual N management practices. This confounded the study in 1999 and may have masked any treatment effects on soil NO_3-N amounts, nitrate distributions and nitrogen use efficiencies. Additional effort in soil sampling for N determination and correlating that information to onion yields would be useful. This approach which has been successful with other crops could lead to lower N applications, reduce the potential for N leaching, and improve crop profitability.

LITERATURE CITED:

Brewster, J.L. 1994. The physiology of crop growth, development and yield. pg. 63-92. In: J.L. Brewster (ed.). Onions and Other Vegetable Alliums. CAB International, Wallingford, United Kingdom.

Brown, B. 2000. Southern Idaho Fertilizer Guide: Onions. Univ. of Idaho Current Information Series No. 1081.

Drost, D., P. Grossl, and R. Koenig. 1997. Nutrient management of onions: a Utah perspective. Proceeding of the Western Nutrient Management Conference. 2:54-59.

Ells, J.E., A.E. McSay, P.N. Soltanpour, F.C. Schweissing, M.E. Bartolo, and E.G. Kruse. 1993. Onion irrigation and nitrogen leaching in the Arkansas Valley of Colorado, 1990-1991. HortTechnology 3(2):184-187.

Feibert, E., C. Shock and M. Sanders. 1993. A comparison of sprinkler, subsurface drip and furrow irrigation of onions. Malheur County Crop Research Report #936. Oregon State University, Corvalis, OR.

Henriksen, K. 1987. Effect on N- and P- fertilization on yields and harvest time in bulb onions (Allium cepa L.). Acta Horticulturae 208:207-215.

Mansour, N.S., J. Burr, H.J. Mack, E.H. Gardner, and T. Doerge. 1983. Fertilizer Guide: Onions - Mineral Soils. Oregon State University Extension Service. Corvalis, OR.

Riekels, J.W. 1977. Nitrogen-water relationships of onions grown on organic soil. J. Amer. Soc. HortScience. 102:139-142.

Scully, N.J., M.W. Parker, and H.A. Borthwick. 1945. Interaction of nitrogen nutrition and photoperiod as expressed in bulbing and flower-stalk development of onion. Botanical Gazette 107:52-61.

Swartz, H.F. and M.E. Bartolo. 1995. Colorado Onion Production and Integrated Pest Management. Extension Bulletin 547A. Colorado State University, Fort Collins, CO.

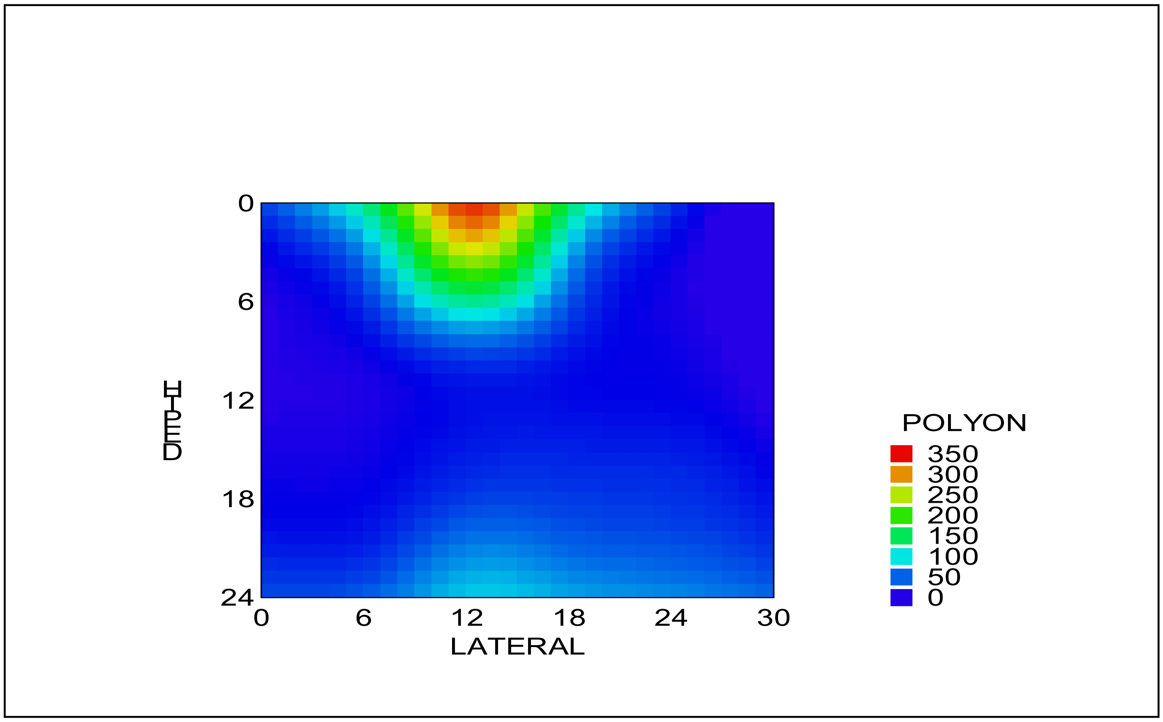

Figure 3. Spatial distribution of NO_3-N in early August 1999 across an onion bed treated with Polyon at 200 lb N/acre. Data in mg NO_3-N/kg soil at different depth and distances from the furrow.

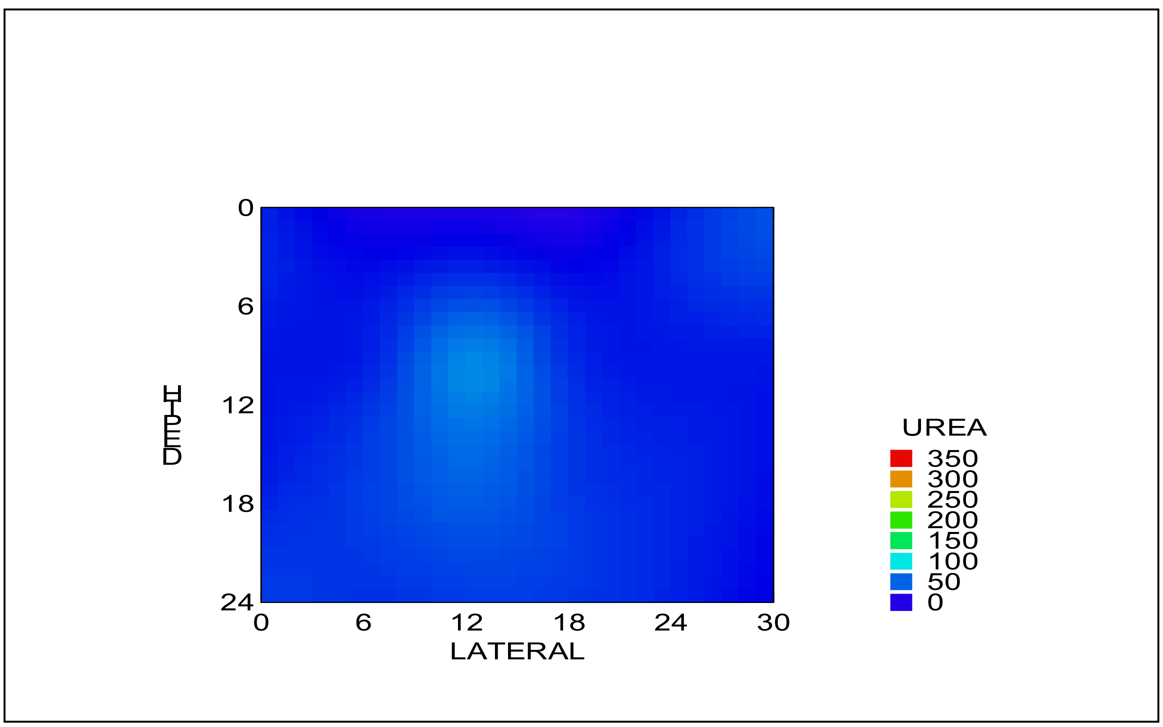

Figure 4. Spatial distribution of NO_3-N in early August 1999 across an onion bed fertilized with urea at 200 lb N/acre. Data in mg NO_3-N /kg soil at different depths and distances from the furrow.