HUMIC ACID EFFECTS ON POTATO RESPONSE TO PHOSPHORUS

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ABSTRACT

Humic substances are a mixture of naturally occurring organic materials that arise from the decay of plant and animal residues that are broken down by soil organisms. The remaining products serve as building blocks of humic substances. Humus is a generic term describing humic substances, which are comprised of three distinct groups, namely: humic acid, fulvic acid, and humin. Plant growth and health is favorably impacted as soil humus levels increase. Soils with low humus levels often benefit from the addition of humic substances. A recent three-year study at the University of Idaho evaluated the effect of three rates of phosphorus (0, 60, or 120 lbs P_2O_5/acre) applied in the mark-out band with and without humic acid at a 10:1 v/v ratio. Petiole phosphorus (P) concentrations during tuber bulking increased by an average of 0.03% P with the addition of humic acid. Humic acid treatment increased yields of U.S. No. 1 tubers greater than 10 oz in 2 of 3 years of the study. Averaged across years and P rates, humic acid application increased total yield by 18 cwt/acre, U.S. No. 1 yield by 22 cwt/acre, and gross return by $152/acre. Humic acid treatment did not affect specific gravity.

INTRODUCTION

Humic substances are a heterogeneous mixture of naturally occurring organic materials that arise from the decay of plant and animal residues. These organic materials contain carbon, which serves as a food source for soil organisms such as bacteria, algae, fungi, and earthworms. These soil organisms break the chemical bonds in the residues as they digest the carbon. The remaining by-products serve as building blocks of humic substances, which are not easily decomposed by soil organisms.

These humic substances in soil are commonly referred to as organic matter or humus. Humus is comprised of three distinct groups, namely: humic acid, fulvic acid, and humin. Technically speaking, fulvic acid is defined as the fraction of humic substances that are water soluble at all pH levels. Humin is the fraction that is not water soluble at any pH. Humic acid is the remaining fraction that is soluble, but only at pH > 2.

In general, increasing levels of soil humus has a number of potential benefits for plants:

*increased water and nutrient holding capacity
*increased reserve of slow release nutrients
*enhanced solubility of phosphorus, zinc, iron, manganese, and copper
*increased resistance to soil pH change
*increased soil warmth (dark color absorbs light energy)

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*improved soil aggregation (acts as a "glue" to improve soil tilth)
*decreased erosion
*enlarged root system (deeper and greater mass)
*increased stimulation of plant-growth due to hormones.

Soils naturally contain large quantities of humus, typically ranging from 10 to 50 tons per acre. Soils with low organic matter percentages (< 2%) are most likely to benefit from the addition of humic substances. Amending soil with several hundred pounds per acre of manure, compost, etc. generally has a beneficial effect on soils low in humus. Alternatively, many growers have found that addition of small quantities of humic and/or fulvic acids can result in increased plant growth on soil with low organic matter percentage.

MATERIALS AND METHODS

The study was conducted at the University of Idaho Aberdeen R&E Center over a three-year period (2000-2002). The soils were a Declo sandy loam with pH ranging from 8.0 to 8.2. The soils were calcareous (4 to 9% free lime) with medium soil test P levels (15 to19 ppm) and low organic matter levels (1.1 to 1.3%). The properties of the soils used in this study are typical of those commonly observed in potato-producing regions of Idaho.

Individual plot size was four rows wide (12 ft.) by 40 ft. in length. The treatments were arranged in a randomized complete block design with five replications. Three rates of P, with and without added humic acid, were applied in the mark-out band three inches to the side of the seed piece. Phosphorus was applied at 0, 15, or 30 gallons of 10-34-0 per acre, which corresponds to about 0, 60, or 120 lbs P_2O_5 per acre. The 10-34-0 and humic acid materials were applied together at a 10:1 volume-to-volume ratio (0, 1.5, or 3 gallons of humic acid per acre). The source of humic acid was Quantum H (Horizon Ag). Russet Burbank potatoes were planted at 12-inch seed piece spacing and grown according to University of Idaho guidelines.

Petiole samples were taken during mid-tuber bulking to evaluate plant P status. Petioles were dried at 40°C, ground to pass a 20-mesh screen, and analyzed for total P concentration. Two 35-foot sections from the middle two rows in each plot were harvested for yield determinations. Tuber quality was determined by evaluating size, grade and specific gravity of each sample. Treatment effects and mean separations were determined by standard analysis of variance procedures using SAS.

RESULTS AND DISCUSSION

Banded fertilizer P increased yields compared to the zero P treatments consistently, but the differences were generally not significant at $p=0.10$ (Table 1). Addition of humic acid to the fertilizer band tended to increase total yield at both the high and the low P levels, but again, differences were generally not significant at $p=0.10$.

Similarly, U.S. No.1 yields generally increased as P was added at both rates, with a tendency for further yield increases occurring when humic acid was included in the fertilizer band. The primary effect of P and humic acid treatment on U.S. No. 1 tuber yields was to increase tuber size. Yields of U.S. No. 1 tubers greater than 10 ounces increased in 2001 and 2002 with the application of P in combination with humic acid.

The tuber yield and grade data are combined across years in Fig. 1, showing an average increase in total yield of 5% (18 cwt./a) and an increase in greater than 10 oz tubers of 20% (23 cwt./a) with humic acid application.

Addition of P with humic acid increased specific gravity in one of the three years of the study compared with the untreated check (Table 1) but generally the effects on specific were negligible.

The reasons why humic acid applications resulted in tuber yield and size increases could be multifaceted. However, as mentioned previously, one of the potential advantages of humic acid is the enhanced solubility of P in the soil. Table 1 shows generally higher petiole P concentrations with the addition of P fertilizer, with further increases resulting from the addition of humic acid. The petiole P concentrations for the zero P treatments were marginal to sufficient, based on University of Idaho guidelines (marginal level is 0.17-0.22%). Although not always statistically significant, addition of P fertilizer generally increased the petiole P concentrations to levels that were above the marginal range. Addition of humic acid resulted in further increases (an average of 0.03%) in petiole P concentrations to levels greater than the marginal range in all three years and at both rates. It is likely that these increases in petiole P were at least partially responsible for the increased tuber yield and size observed in this study.

Regardless of the reasons, the Quantum H humic acid product consistently resulted in improved yield and quality. These yield and quality increases resulted in increased gross revenues at an average of $152 per acre, based on incentive adjusted prices from local processing contracts. Average costs of humic acid application are approximately $10-20 per acre. Based on the data in this study, application of humic acid to calcareous, low organic matter soil shows potential as a profitable management tool.

However, unlike conventional fertilizer materials, no guaranteed analysis is required for humic acid soil amendments. Recent analytical standards for humic acid amendments have been adopted by soil scientists and the Humic Substances Society. However, these standards are not widely known or utilized and the industry is not required to have the material analyzed. Growers wishing to apply humic acid amendments should work with reputable companies that can provide a consistent material with documented, non-biased data showing their product to work under local growing conditions.

CONCLUSIONS

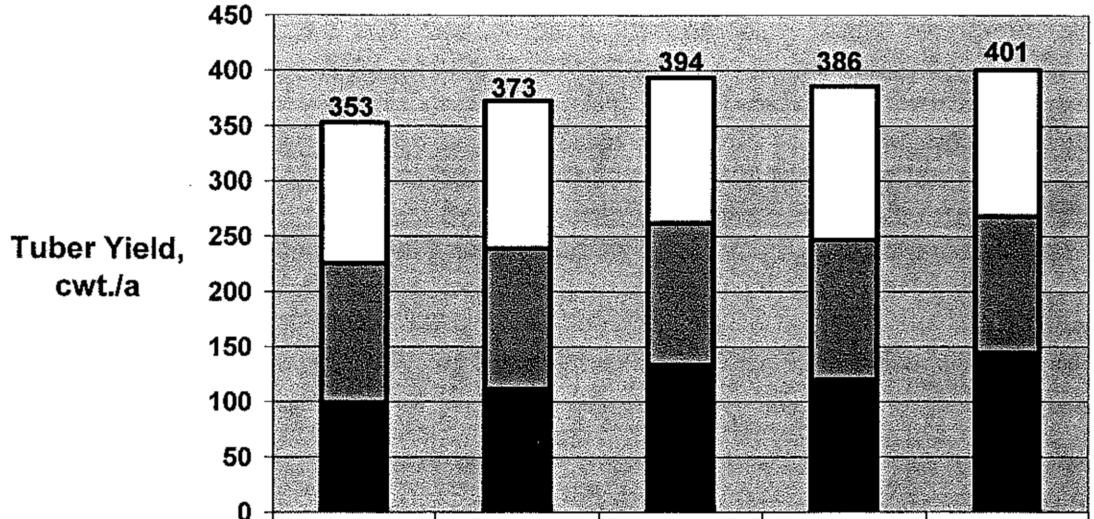
Application of humic acid in bands of liquid P fertilizer (10-34-0) applied at mark-out generally resulted in increased petiole P concentrations and higher yields of large No. 1

tubers compared with liquid P alone. Application of humic acid with P increased specific gravities compared with the untreated check in one of three years, but humic acid treatment did not affect specific gravities at either the low or high P rates. Application of humic acid resulted in substantial increases in gross returns each year. Combined across years and rates, the average increase in gross return for humic acid application was $152 per acre with an average application cost of $10-$20 per acre. Including humic acid as a component of the mark-out fertilizer band application in calcareous, low organic matter soil seems to be a good management practice worthy of potato grower's consideration.

Table 1. Yield, specific gravity, petiole P and gross returns for Russet Burbank potatoes with 10-34-0 banded at mark-out at 0, 60, or 120 lb P_2O_5/acre, with or without humic acid at a 10:1 (v/v) ratio.

Year	Treatment	Humic Acid	Total	U.S. No.1	>10oz	Specific Gravity	Petiole Phosphorus	Gross Return
	lb P_2O_5/A	gpa	----------cwt/acre----------				%	$/A
2000								
	0	0	327	242	50	1.075	0.22	1575
	60	0	333	230	45	1.074	0.24	1517
	60	1.5	338	226	56	1.075	0.25	1578
	120	0	347	245	61	1.075	0.27	1622
	120	3.0	364	255	94	1.075	0.30	1760
			ns	25	16	ns	0.03	
2001								
	0	0	337	211	103	1.076	0.20	1585
	60	0	354	229	113	1.075	0.21	1653
	60	1.5	401	283	159	1.077	0.27	2009
	120	0	374	235	120	1.078	0.23	1773
	120	3.0	393	272	146	1.078	0.26	1937
			34	31	31	0.003	0.04	
2002								
	0	0	394	225	146	1.077	0.24	1831
	60	0	431	260	177	1.079	0.29	2069
	60	1.5	444	279	186	1.080	0.31	2182
	120	0	438	261	179	1.079	0.30	2100
	120	3.0	446	278	193	1.079	0.32	2178
			48	33	23	0.003	0.03	

Numbers at the bottom of each column represent LSD 0.10 values.



	0	60	60+HA	120	120+HA
U.S. No.2	127	133	131	139	133
U.S. No.1 4-10 oz.	126	128	129	127	124
U.S. No. 1 > 10 oz.	99	111	133	120	144

lbs.-P2O5/a

Figure 1. Combined yields and grades for three years of data with added phosphorus at 0, 60, and 120 lbs P_2O_5/acre as 10-34-0, with and without humic acid (HA) at a 10:1 (v/v) ratio. Fertilizer was applied in a band three inches to the side of the seed.