30 YEARS OF RESEARCH DOCUMENTS THE INFLUENCE OF HUMIC SUBSTANCES ON SOIL HEALTH, FERTILIZER AND WATER-USE EFFICIENCY

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ABSTRACT

In continuation of my 30 years of on-farm studies on soil organic matter from different humates and compost, I have documented quantitative improvements in soil health and water-use efficiency. Research trials were established to evaluate the efficacy of different commercial humates products derived from Leonardite *(highly oxidized lignite)* in crop production. Data from humic acid *(HA)* trials showed that different cropping systems responded differently to different products in relation to yield and quality. The consistent use of good quality products in our replicated plots resulted in a yield increase *from 6% to 30%* over several decades.

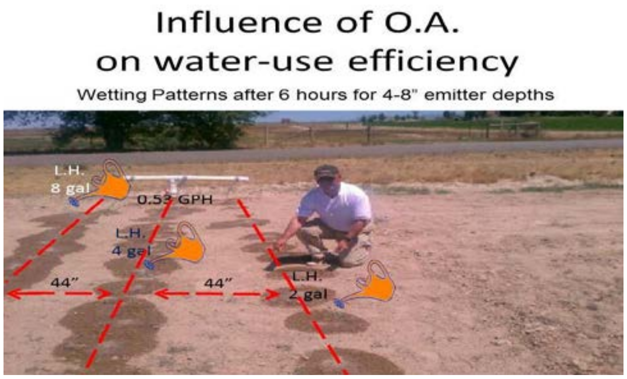
INTRODUCTION

According to a study for the International Food Policy Research Institute, each year an estimated 10 million hectares of cropland worldwide are abandoned due to soil erosion and diminished production caused by erosion. Another 10 million hectares are critically damaged each year by salinization, largely as a result of irrigation and/or improper drainage methods. Malnutrition has increased to an estimated 3 billion people according to FAO *(Food and Agricultural Organization).* Since the world population continues to increase at a rate of 1.3% per year and the quantity of food produced worldwide has decreased since 1984, soil erosion and salinity have become major environmental threats. According to Pimental and Lang, "The economic impact of soil erosion in the United States costs the nation about $37.6 billion each year in productivity losses. Damage from soil erosion worldwide is estimated to be $400 billion per year."

METHODS AND MATERIALS: ON-FARM APPLIED RESEARCH

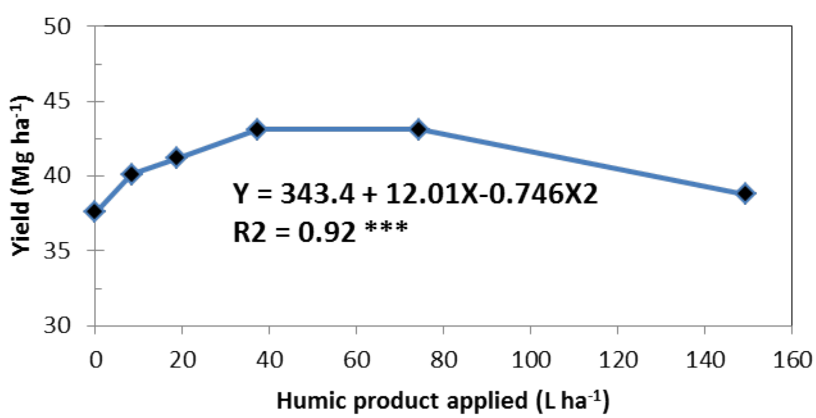
In Southwest Idaho, we have conducted numerous applied on-farm research using compost, humic and fulvic acids and other soil amendments with varied percentages of humic and fulvic acids. The studies over the past 30 years have emphasized their influence on soil's physical, chemical, and biological properties. The ability of soil organic matter to bind water has become an important theme for research in past years. In each of these trials, humate products were used in a randomized complete block design.

We conducted a three-year study using liquid humus on several fields in Elmore County, Idaho. We evaluated the influence of liquid humus on potato fields, evaluating water sequestration and decreased tare dirt during the harvest. This study showed that it enhanced water sequestration by *6-11.2%*, enhanced yield increases, and helped with yield quality and tare dirt during the harvest. The use of humic substances creates strong organo-mineral complexes *(aggregation)*, chelation, as well as buffering capacities. We evaluated data from 3 fields and compared the results. *Our observation and field demonstrations indicated there was a marked increase in water retention, less tare dirt and uniform potatoes.*



We conducted experiments at Saylor Creek, Idaho, using fields with minimal soil fertility, to evaluate the effects of different rates of humic product application on potato yield and quality. Climatic conditions were similar in the three areas, as both sites are semi-arid, with an annual rainfall of *152.4-203.2 mm.* The soil in these fields was calcareous *(5-7% free lime*) pH was *8.0-8.2*, and organic matter content was *0.9-1.0%.* In these experiments, Russet Burbank seed pieces were planted by hand, *spaced 25.4 cm apart*. *Each individual plot was 3.65-m wide and 7.6-m long and included four rows. The humic product used at the Saylor Creek fields had 6% HA by weight*. At Mountain Home, granular humate and liquid HA were applied. Liquid humic products were side-dressed, and granular humic product was top-dressed.

Fig. 1 summarizes the effects of product application rates on potato yield at three fields at Saylor Creek, ID. These data are the average yields of three experimental fields. Evaluation of stand and vigor showed that plots treated with humic product rated very high (*8 out of 10*) in comparison with control plots (*5 out of 10*). The Russet Burbank tuber yield increased from 37.6 to 43.1 T ha-1 (*i.e. Mg ha-1*) from the control to product application at the rate of 37 L ha-1. Yield declined when the application rate applied exceeded 75 L ha-1. The non-linear relationship implies the mechanism of humic product impact is quite complicated.

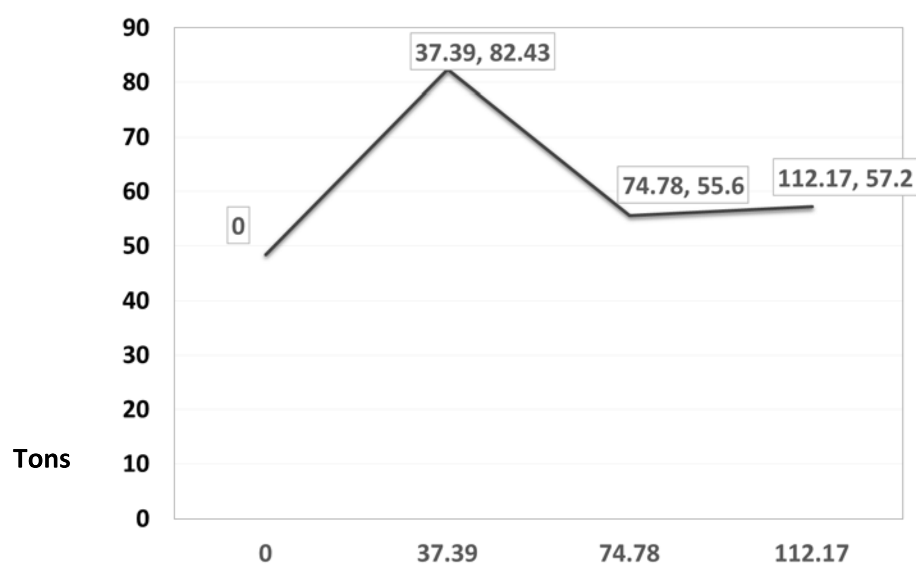


Fg. 1. ***<u>Average potato yield affected by humate application at 3 sites in the Saylor Creek, ID experiment. Adapted.</u>***

In this experiment, humate products were applied under minimal soil fertility. Moreover, the positive impacts of HA application observed in this study are consistent with Dr. Chen's laboratory research under controlled conditions on HA application and plant growth. In this study the product performed better in poor soil with high Ca (*3500 to 5000 ppm, i. e. 5-7% free lime*) than in more fertile soil (*data not shown*). The humic product used in this study seemed to enhance fertilizer and water-use efficiency by increasing complexation, chelation and buffering. *On the other hand, the HA could have had effects directly on the plant, not on soil nutrients. More research is needed to elucidate the mechanism of the humic product's role.*

LIQUID HUMATE TRIALS: 2014 POTATOES

In 2014, we conducted field trials in potato in Hammett, Idaho, utilizing Norkotah potatoes in sandy loam soil with a pH of 7.9 and 1.4% O.M. We did four replications of each treatment: *Control, 1X, 2X, & 3X, 0, 37.39, 74.78, and 112.17 liters/ha respectively. The plots were 50 feet rows and 8 rows each*. We applied humic acids as a foliar spray, using backpack sprayers on plants 4-6 inches in diameter with dry soil conditions on top. The objectives were to evaluate the influence of humic acids on crop yield and quality. The potatoes were hand- harvested and weighed. *Our data showed that the potatoes from row 1X had a 26.8% difference in yield compared to the control rows. (Figure 2)*



<u>Fig.2: Effects of Different Rates of Humic Acids (L ha-1) on Potato Yield</u>

<u>Findings:</u>

The following *(Tables 4 & 5, and Fig. 2)* are the trial results. The regression graph shows the statistically significant difference between control and 1 x (*37.39 liters/hectare*). At 2X *(74.78 liters/hectare)* and 3X *(112.17 liters/hectare)* there was not a statistically significant control.

Table 4: 2014 Potato research: Total yield per treatment

	Treatment	Rate/ha	<4	4-6	6-8	8-10	10-12	12-14	14-16	>16	TOTAL
1	CONTROL	0.00	11	12	17	15	9	8	6	8	86
2	CONTROL	0.00	10	13	16	13	7	8	5	7	79
3	CONTROL	0.00	12	14	17	14	8	7	6	6	84
4	CONTROL	0.00	14	12	16	14	6	5	4	6	77
5	HUMIC A-1X	37.39	28	22	23	15	9	10	8	14	129
6	HUMIC A-1X	37.39	19	19	27	20	14	9	10	14	132
7	HUMIC A-1X	37.39	18	18	30	28	11	12	12	12	141
8	HUMIC A-1X	37.39	12	16	29	25	14	8	14	16	143
9	HUMIC A-2X	74.78	20	12	18	11	10	9	4	11	95
10	HUMIC A-2X	74.78	22	14	17	12	11	8	5	10	99
11	HUMIC A-2X	74.78	21	14	17	10	9	7	8	8	94
12	HUMIC A-2X	74.78	19	10	20	9	10	9	4	11	92
13	HUMIC A-3X	112.17	22	17	19	10	13	7	7	9	104
14	HUMIC A-3X	112.17	20	18	20	8	11	8	8	8	101
15	HUMIC A-3X	112.17	23	19	19	10	12	7	7	8	105
16	HUMIC A-3X	112.17	24	18	17	8	12	6	7	7	99

Table 5: 2014 Potato research: Total tubers/yield per treatment.

	Treatment	Total Tuber #	TT# <4	Total Yield per ha	Total Yield (-<4)
1	CONTROL	205622.56	2236.86	**53142.43**	**50905.57**
2	CONTROL	188885.84	2033.51	**47855.30**	**45821.79**
3	CONTROL	200840.64	2440.21	**49346.55**	**46906.33**
4	CONTROL	184103.92	2846.92	**43313.79**	**40466.88**
5	HUMIC A-1X	308433.84	5693.83	**73952.03**	**68258.20**
6	HUMIC A-1X	315606.72	3863.67	**80933.76**	**77070.09**
7	HUMIC A-1X	337125.36	3660.32	**86695.37**	**83035.05**
8	HUMIC A-1X	320388.64	2440.21	**88118.83**	**85678.62**
9	HUMIC A-2X	227141.20	4067.02	**56260.48**	**52193.46**
10	HUMIC A-2X	236705.04	4473.73	**57141.67**	**52667.95**
11	HUMIC A-2X	224750.24	4270.37	**53955.84**	**49685.46**
12	HUMIC A-2X	219968.32	3863.67	**55108.16**	**51244.49**
13	HUMIC A-3X	248659.84	4473.73	**59310.75**	**54837.03**
14	HUMIC A-3X	241486.96	4067.02	**57683.94**	**53611.92**
15	HUMIC A-3X	251050.80	4677.08	**58226.21**	**53549.14**
16	HUMIC A-3X	236705.04	4880.43	**53802.27**	**48939.84**

Conclusion

Our studies continue to show that various humic acids provide different results because of the complex nature of humates and the manner in which they're manufactured and processed. We also need to consider the way they react with various soil mineralogies. However, our studies and others show that humic substances positively impact soil's physical, chemical, and biological dynamics. They translate into fertilizer and water-use efficiency, as well as soil health. In addition, Dr. Yonah Chen has conducted studies on the major benefits of humates' direct modes of action on plant growth, some of which we have observed and quantified. These include *effects on plant cell membranes that result in improved transport of nutritional elements; enhanced protein synthesis; plant hormone-like activity; enhanced photosynthesis and effects on enzyme activities. Indirect modes of action benefit plant growth through solublization of micro-elements (e.g. Fe, Zn, Mn) and some macro-elements (e.g. K, Ca, P); reduction of active levels of toxic elements and increased microbial populations.*

We quantified and observed that the crop response might have been affected by the rate of humic acids used in relation to other soil macro/micronutrient availability. In our experiments, humate product efficacy is responsive for P, N, potash, and K fertilization. As we documented with calcareous soil, it solubilizes Ca and doesn't allow P to precipitate with Ca. They are also important for creating better consistency to standardize humic analyses methods, as well as establishing a good scientific baseline for different products and rates/hectare in various soils.

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