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Technical Report

DRiWATER Plus, A New Product

(Crosslinked Carboxymethylcellulose Gel with Zinc and Acetic Acid)

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By

Jerald Wheeler, Ph.D
Kyle Peterson
Research Conducted
At
ACRE Inc.

Abstract

DRiWATER gel will deliver water to plants at a controlled rate. The addition of nutrients, fertilizers, and hormones to DRiWATER would be beneficial to plants. Preliminary experiments show that the addition of nutrients, fertilizers, and hormones negatively affect the viscosity of the DRiWATER gel. The objective of this experiment was to successfully incorporate a beneficial rooting compound into DRiWATER without negatively affecting the gel. A combination of zinc sulfate and acetic acid were incorporated into the polymer and were applied at various rates. Results demonstrated a rate of 0.167% (weight/weight) zinc sulfate and 0.07% (weight/weight) acetic acid in DRiWATER provided the greatest increase of rooting by pepper plants. An Increase of 208% to 284% greater root mass than treatments with original DRiWATER resulted.

Background and Theory

Original DRiWATER gel is a carboxymethylcellulose crosslinked polymer. The gel is degraded by microorganisms to yield free water. Cellulose degrading microorganisms can be found in all soil types and produce enzymes for breakdown of cellulose. This technology can be thought of as a slow release method for watering plants. Gelatinous water compound can also be used to control the rate of water release so as to not over-water any plant species. This product would be more beneficial to plants if it provided some value other than watering alone such as increasing roots. An increase in the root mass will result in more growth, better appearance, and improve nutrition uptake by plants.

Zinc is essential to many enzyme systems in plants with three main functions including catalytic, co-catalytic, and structural integrity. Zinc contributes to the production of important growth regulators which affect photosynthesis, new growth, and development of roots *(3)*. Zinc promotes the cell growth needed for increasing root development, formation of new leaves and vigorous shoot growth. Zinc improves stress tolerance (4, 5). If zinc is in short supply, plant utilization of other essential plant nutrients such as nitrogen will decrease.

In the plant the plant growth hormone, indole-3-acetic acid (IAA), is a naturally occurring auxin. It also occurs in many bacteria, fungi, and algae. IAA regulates cellular elongation, phototropism, geotropism, apical dominance, root initiation, ethylene production, fruit development, parthenocaarpy, abscission, and sex expression, all of which are necessary for normal plant growth (1).

To maintain plants normal growth, IAA must be produced and regulated by the plant. Zinc is a co-factor in the transformation of the amino acid tryptophan to the auxin IAA. Zinc will help maintain IAA levels in the plant and promote growth, rooting, and health.

The selection of zinc sulfate as the source of zinc was based on scientific literature. Many sources of zinc have been tested to see which compound would be utilized more efficiently by plant species. Zinc sulfate is the most readily available form for plants (2). Zinc sulfate also contains a sulfate ion. The sulfate ion (SO_4^{2-}) is a beneficial nutrient and naturally occurring in soils. Sulfur is used to bind amino acids together by sulfide bridging to create enzymes and proteins, the building blocks of life.

Research indicates that the presence of acetic acid will improve the uptake of minerals. Acetic acid is also known as a preservative and will aid in preserving the gel's viscosity as well as help protect the gel from microorganism degradation.

It is essential to note that without the correct molar combination of the zinc sulfate and acetic acid components, the gel viscosity will dramatically decrease to the point at which it would provide little or no benefit for any plant species.

Materials and Methods

Materials: Sodium carboxymethylcellulose (CMC), alum, preservatives, surfactants, zinc sulfate heptahydrate, acetic acid, distilled water.

Alum, preservatives, surfactants, zinc sulfate heptahydrate, and acetic acid were poured into 400mL beaker and were mixed for approximately 20 minutes or until all solids were dissolved. The solution was then poured into a 10 speed Osterizer blender and set to “Ice Crush”, with a maximum output of 450 watts. The blade speed was 1100 RPM.

CMC was then poured into the blender. CMC was added at a consistent rate over 15 seconds while the blender was mixing. Mixing was continued for an additional 70 seconds, for a total mix time of 85 seconds. Approximately 300mL of gel were formed and a viscosity reading was taken approximately 15 minutes after formation to allow gel to cool to room temperature. The gel volume measured was of approximately 200mL in a 250mL beaker analyzed with a Brookfield HADV-II+ viscometer. The viscosity was measured in units of centipoises (cP) to ensure the gels stability. Nine oz. of the gel were then weighed and inserted into a plastic casing to limit air exposure and contamination. The gel was then allowed to stabilize in plastic casings for a minimum of 3 days to achieve a viscosity that represents that of the consumer product. Five different formulated gels labeled Gel 1 through Gel 5 were made. Each gel formulation was tested using 3 replications of each. The original DRiWATER gel was used as the control (3 replications).

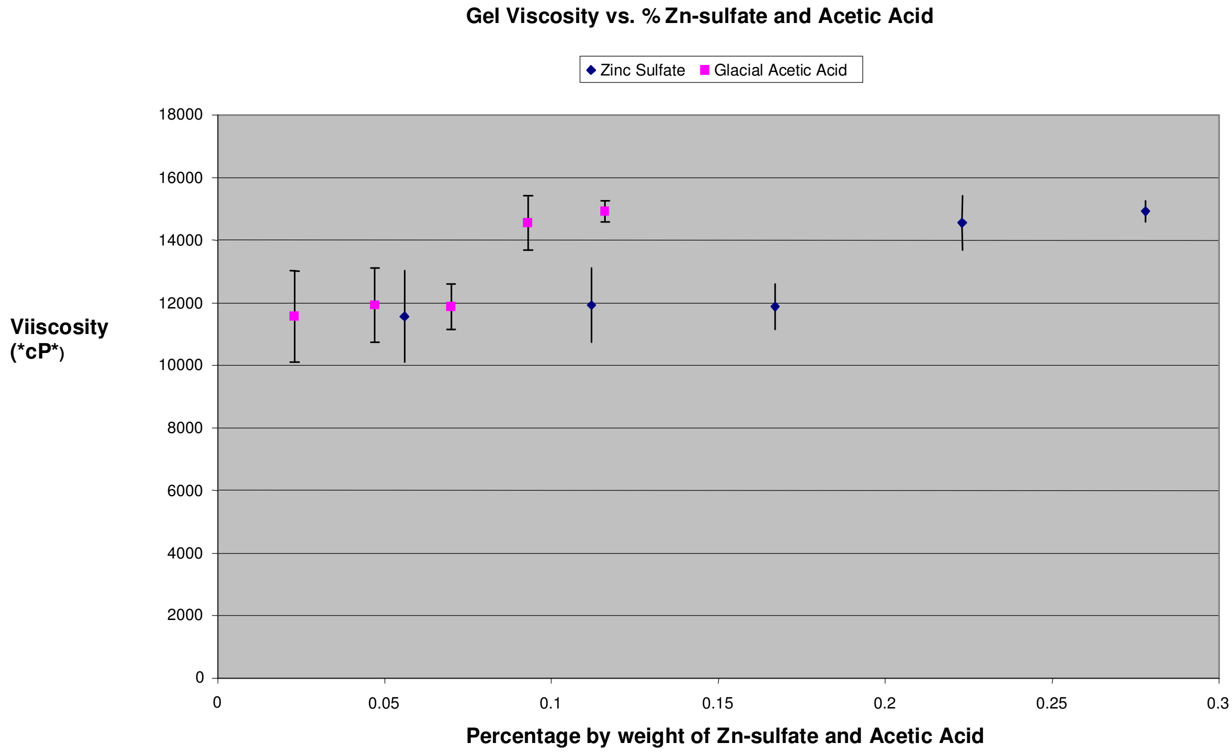
Anaheim peppers were planted in a defined native Arizona soil grown for approximately three weeks. Anaheim pepper plants used were selected to be of similar height and stem size for the tests.

Approximately a 12-15 centimeter slit was made on each gel casing. Each gel casing was opened slightly to expose the gel to soil. Exposed gel in the casing was laid on the soil in which the Anaheim pepper plants were growing. Each plant was watered thoroughly on first day of treatment.

No watering was done for a period of 30 days. Plants were grown in a greenhouse with an approximate daily temperature of 65°F. Observations were made daily. On day 30 of the experiment, plants were removed from soil. Roots were cleaned and pictures were taken. Then plants were cut at the cotyledonary nodes and the fresh weight of the root mass and hypocotyls was measured. Plants were then cut at the crown of roots and the fresh weight of the root mass was measured. Fresh weight was measured and compared for all formulations.

Results and Observations

Graph 1. *Viscosity changes resulting from the addition of zinc sulfate and acetic acid to the gel*



centipoises (cP)

Table 1. Average Gel pH and Viscosity

Gel #	Zn-sulfate % (w/w)	Acetic Acid % (w/w)	Average gel Viscosity (cP)	Standard Deviation (cP)	Average gel pH
1	0.056	0.023	12829.91	608.81	5.28
2	0.112	0.047	16614.11	777.26	5.13
*3	0.167	0.07	17700	843.15	5.08
4	0.223	0.093	20470.83	905.34	4.95
5	0.278	0.116	24297.65	1134.79	4.9
Control	0	0	0	N/A	N/A

Red asterisk represents best results.

Table 2. Soil pH Values after 30 days of DRiWATER treatment

Plant #	Trial	pH of soil after gel treatment	Average pH of soil after gel treatment	Std. Dev. pH
Control 1	1	7.15	7.00	0.13
	2	6.91		
	3	6.94		
1	1	7.06	6.76	0.36
	2	6.37		
	3	6.86		
2	1	6.9	6.82	0.09
	2	6.73		
	3	6.83		
*3	1	6.56	6.52	0.08
	2	6.43		
	3	6.56		
4	1	6.81	6.63	0.16
	2	6.6		
	3	6.49		
5	1	6.74	6.59	0.16
	2	6.42		
	3	6.6		

The pH of the native soil prior to testing was 5.8.

Table 3. Fresh weight roots and hypocotyls

Plant Treatment	Repetition	Fresh Root Weight of roots and hypocotyls Grams (g)	Average Fresh Root Weight of roots and hypocotyls Grams (g)	Std. Dev. Grams (g)	Increased Percentage of root/hypocotyl compared to control
Control	1	0.516	0.620	0.090	N/A
	2	0.677	0.620	0.090	N/A
	3	0.667	0.620	0.090	N/A
gel 1	1	0.253	0.399	0.131	64.355
	2	0.505	0.399	0.131	64.355
	3	0.439	0.399	0.131	64.355
gel 2	1	0.949	1.009	0.128	162.742
	2	0.922	1.009	0.128	162.742
	3	1.156	1.009	0.128	162.742
*gel 3	1	1.447	1.287	0.339	207.634
	2	0.898	1.287	0.339	207.634
	3	1.517	1.287	0.339	207.634
gel 4	1	0.997	0.863	0.126	139.194
	2	0.846	0.863	0.126	139.194
	3	0.746	0.863	0.126	139.194
gel 5	1	0.447	1.198	0.650	193.172
	2	1.592	1.198	0.650	193.172
	3	1.554	1.198	0.650	193.172

**Red asterisk represents best results.*

Table 4. Fresh weight of roots

Plant Treatment	Repetition	Fresh Weight of roots Grams (g)	Average Fresh Weight of roots Grams (g)	Std. Dev. Grams (g)	Increased Percentage of roots compared to control
Control	1	0.186	0.271	0.074	N/A
	2	0.305	0.271	0.074	N/A
	3	0.323	0.271	0.074	N/A
gel 1	1	0.132	0.193	0.056	71.341
	2	0.242	0.193	0.056	71.341
	3	0.206	0.193	0.056	71.341
gel 2	1	0.544	0.523	0.043	193.112
	2	0.474	0.523	0.043	193.112
	3	0.552	0.523	0.043	193.112
*gel 3	1	0.892	0.769	0.244	283.764
	2	0.488	0.769	0.244	283.764
	3	0.927	0.769	0.244	283.764
gel 4	1	0.552	0.448	0.101	165.191
	2	0.441	0.448	0.101	165.191
	3	0.35	0.448	0.101	165.191
gel 5	1	0.203	0.715	0.450	263.838
	2	0.892	0.715	0.450	263.838
	3	1.05	0.715	0.450	263.838

The Data stated in Table 3 and Table 4 was taken immediately after the Anaheim peppers were removed from the soil.

**Red asterisk represents best results*

Plant treated with original DRiWATER (Upper) and plant treated with DRiWATER plus (lower) 0.167% (w/w) zinc acetate and 0.07% (w/w) acetic acid.

Discussion and Conclusions

Gelatinous water with Zinc and acetic acid is a product that delivers water to plants at a controlled rate. The addition of nutrients, fertilizers, and hormones to the gel compound would be beneficial to plants. Preliminary experiments demonstrated that the addition of most nutrients and hormones negatively affect the viscosity of the gel (Graph 1). This will cause the gel to function improperly.

The objective of this experiment was to incorporate a rooting compound into the gel without destabilizing the gel's viscosity.

Zinc sulfate and acetic acid were found to stimulate the greatest root growth. A percentage of 0.167% zinc sulfate and 0.07% acetic acid provided the greatest increase of rooting on Anaheim pepper plants with an increase of 208% (Table 3) to 284% (Table 4, Lower Picture) more root mass when compared to original gel (Upper Picture).

Zinc and acetic acid are beneficial for plants if delivered in the proper rates. The results confirm that the median rate chosen was the most efficient in both fresh root weight tests. This demonstrates that the optimum rate for rooting with acetic acid and zinc sulfate was established. Based on results it can be concluded that rates of 0.167% zinc sulfate and 0.07% acetic acid clearly improve rooting. This technology is the new product DRiWATER plus.

References

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