January 1989

Evaluation of Algrow as a Binder in Hydromulch and Preliminary Determination of the Influence of Algrow on Germination and Seedling Growth

C. Earl Israelsen

Gilberto Urroz

Ronald V. Canfield

EVALUATION OF ALGROW AS A BINDER IN HYDROMULCH AND PRELIMINARY DETERMINATION OF THE INFLUENCE OF ALGROW ON GERMINATION AND SEEDLING GROWTH

Report to ALGEA PRODUKTER A/S

C. Earl Israelsen, Gilberto Urroz, and Ronald V. Canfield

Utah Water Research Laboratory
Utah State University
Logan, Utah 84322-8200

April 1989

ALGEA PRODUKTER A/S

Report

EVALUATION OF ALGROW AS A BINDER IN HYDROMULCH AND PRELIMINARY DETERMINATION OF THE INFLUENCE OF ALGROW ON GERMINATION AND SEEDLING GROWTH

Utah Water Research Laboratory
Utah State University
Logan, Utah 84322-8200

April 1989

Introduction

The application of mulch during or immediately following seeding provides the minimum following advantages: energy dissipation of falling raindrops which decreases or eliminates erosion, prevention of surface-soil crusting, decreased water loss, and surface temperature modification.

To better hold mulch in place, chemical binders are added to it during manufacture or just before it is applied to the soil. Sometimes a binder is applied as an overspray after the mulch is in place. (This overspray is generally referred to as a tackifier.)

Algea Produkter A/S, Drammen, Norway, produces a product called ALGROW which may have utility as a mulch binder and may enhance germination and growth of plants. The Utah Water Research Laboratory contracted to perform preliminary tests using ALGROW both as a binder in hydromulch and as an enhancer for barley seed germination and growth. More definitive tests of ALGROW's growth enhancement capabilities are being performed in the Plant Science Laboratory of Utah State University. These results will be reported separately.

Materials and Methods

Description of Testing Facility

Rainfall simulator. Since its construction in 1973, the rainfall simulator has been extensively tested and used in research. The rainfall simulator is a drip-type device in which individual raindrops are formed by water emitting from the ends of small-diameter brass needles. The rate of flow is controlled by fixed-diameter orifice plates which admit water into manifold chambers under constant hydraulic pressure. Five separate inlet orifices are used in each chamber, or simulator, module. The ratios of the areas of the orifices are 1:2:4:8:16. By controlling the flow to each orifice with an electrically operated solenoid valve, it is possible to vary flow in on-off increments with 31 steps, producing rain at rates of one to 31 inches per hour.

The outlet from the modules is through uniform, equally spaced brass needles. Each module is a two-foot square enclosed box which is about one-inch deep. It is oriented so that the ends of the needles form a horizontal plane to let water drip vertically toward a tilting flume which contains soil-filled test plots. Each module has 672 needles spaced on a one-inch triangular grid. There are 100 modules which are spaced and supported to form a continuous 20-foot square simulator.

Each module has separate electronic control switches so that a spatially moving storm with time-changing intensities can be simulated. These switches can be controlled by a computer program if desired.

Tilting test flume. The test flume can be tilted hydraulically to any slope up to 43° from horizontal. It is square and measures 20-feet on each side. The rainfall simulator is positioned directly over the flume so that rain falls directly onto the soil in the test plots. The soil is approximately one-foot deep and is supported in the tilting flume by a metal grating. The grating is covered with a filter cloth through which water can drain.

The flume is divided into six test plots, each measuring two by 19.5 feet. Each set of two plots is separated from adjacent sets and from the flume side-walls by two-foot wide walkways. Runoff from each plot is captured in a cone-shaped filter. The runoff is then dried and weighed to determine the exact amount of soil and mulch erosion.

Sunlight simulator. The sunlight simulator, consisting of incandescent and fluorescent lamps, provides the balance of radiant energy needed for good plant growth. It measures 20 feet on a side and mounts over the tilting flume by means of wheels on rails. When in position, it is about three feet above the test plot surface and provides illumination at a photon flux density (400-700 nm) of $216 \mu E \cdot m^{-2} sec^{-1}$ (measured with a Li-cor 190 S quantum sensor on a model LI-185 quantum radiometer/photometer).

Products included in tests. The following products were used in the tests: ALGROW, produced by Algea Produkter; Silva-Fiber®, a commercial wood-fiber mulch produced by Weyerhaeuser (Silva-Fiber® has been widely used in the erosion control industry for hydromulching); and Hordeum vulgare L. cv Schuyler barley seed.

Test Description and Procedures

Plot preparation. Each of the six test plots was filled with a sandy loam soil consisting of the following approximate composition: total sand = 63 percent; total silt = 24 percent; total clay = 13 percent; and total organic matter = 1.41 percent. The plots were cultivated with a garden tiller to a depth of approximately six inches. They were then screeded level, compacted with a water-filled lawn roller, and raked smooth in preparation for the mulch application.

After each test run, the top layer of soil and mulch was removed down to the depth that erosion had occurred; then it was discarded. New soil was added to replace the soil that had been removed, and each plot was prepared for the next test run, as described above.

Determining ALGROW application rate. When a binder is specified for a particular job it is generally stated as a percentage (weight of binder to weight of dry mulch). Occasionally, however, it is given as a weight of binder to a particular volume of water, or even to an amount of land, such as 100 lbs./per acre. Some commercial binders, currently on the U.S. market, are added to wood fiber mulches during the time the mulches are being manufactured. These are generally added at a rate of three percent (weight of binder to weight of dry mulch). When added to a hydromulch tank, binders are generally increased to five percent.

Determining an optimal percentage of ALGROW application is an important consideration. The percentage may not have been determined by these tests because data are not currently available to compare ALGROW with other binders on the market. The basic product may be more or less potent or concentrated than others--this should be the subject of additional research.

Initially for this research, batches of hydromulch were prepared containing ALGROW in concentrations of one, two, three, four, and five percent (weight of ALGROW to weight of mulch). These concentrations were applied through a hydromulcher to separate sections of metal screen and then allowed to dry. By feeling and pulling the mulch, one could detect that the tenacity of the fibers increased with higher concentrations of ALGROW.

To provide additional data and verify the validity of the initial test results, there was a review of the erosion control industry's practices. The review indicated that a one to five percent range was the most frequently used binder concentration. Thus, these concentrations were selected for the final tests; one ALGROW application was made at one percent, one at three percent, one at five percent, and a control plot at zero percent. Seed was applied with every test, and three replications were made of each.

Mulch and seed application. Mulch was applied through a laboratory-size hydromulcher at the rate of 1800 kg/ha, and barley at the rate of 220 kg/ha. The mulch and seed were mixed thoroughly in a water slurry, and then applied to the plots individually while they were in a horizontal position. The plots were drained overnight before they were tilted and rain was applied.

Rain application. The modules over the walkways of the test flume were removed for these tests, and the electronic switches for the modules were manually controlled. The test flume containing the mulch-covered plots was tilted to a 22° slope and covered with a sheet of plastic. The rainfall simulator was turned on at full capacity to purge the air from the system. (During this purging, the rain fell onto the plastic and ran into a drain without wetting the plots.)

When the purging was complete, the rainfall rate was adjusted to approximately eight inches per hour and allowed to stabilize. (The eight-inch per hour rate was selected because of a mechanical problem within the simulator--it was the lowest rate that would provide a uniform distribution across the plots.) The plastic covering on the plots was quickly removed, allowing the rain to fall directly onto the plots; then the time clock was started. Total time was recorded from the instant that rain began falling onto the plots until enough material had been eroded from the plots to fill the catchments. As each plot failed, rainfall to that plot was stopped so that no additional soil, seed, or mulch would be lost. The catchment from each plot was thoroughly dried and then weighed.

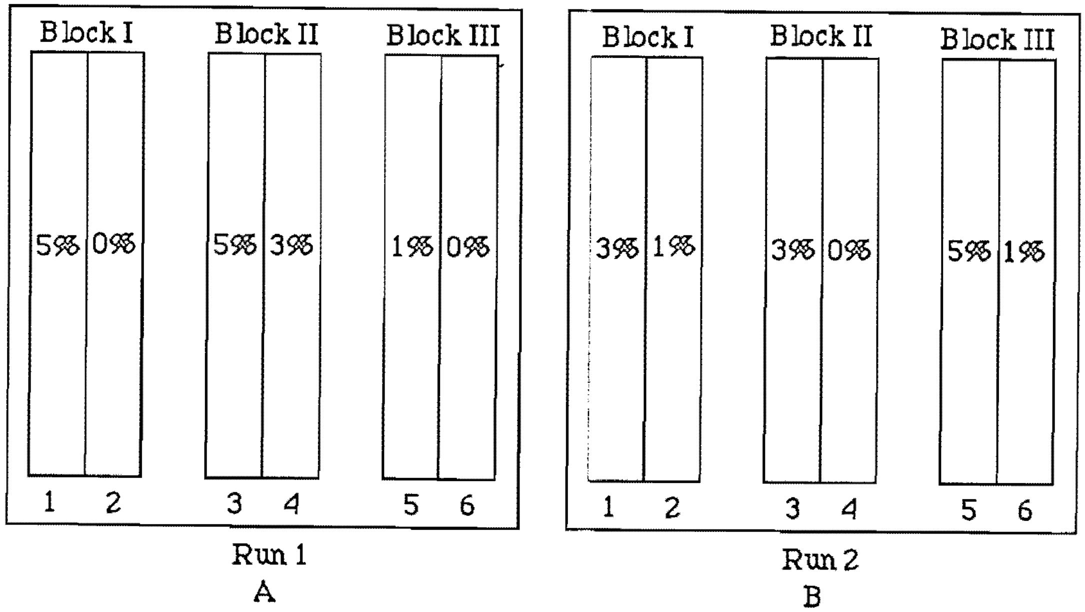
Sunlight application. When rainfall ceased, the flume was lowered to horizontal, the sunlight simulator was rolled into position over the plots, and the entire assembly was again tilted to a 22° slope. Sunlight was applied to the plots for 12 hours each day for a seven-day period.

Harvesting the crop. When the seven-day test period had elapsed, the test bed was returned to a horizontal position and the sunlight simulator was removed. Using a metal template of approximately one-square-foot in area, three sample areas were randomly selected on each plot--one at the top of the slope, one near the center, and another towards the bottom. Within each of these areas, a count was made of the total number of plants and also of the seeds that did not germinate. The height of each plant was measured; all of the plants within each sample area were then cut off at the soil surface, dried, and weighed.

Results and Discussion

Two complete runs of the rainfall simulator were performed. Each run provided runoff data from six plots; this data was used to determine effectiveness of the various binder percentages. Other data collected included counts of germinated and non-germinated seeds, plant heights, and weight of dried plant matter. These latter data give indications of effects of ALGROW on plant germination and growth.

Experimental Design. Plots beneath the rainfall simulator were arranged for Runs 1 and 2 as indicated in Figure 1.



Test Plot Configuration and Treatments (concentrations of ALGROW) Beneath the Rainfall Simulator
Figure 1

The plot pairs were physically separated to create a natural blocking factor so that the effect of spatial variation of rainfall rate could be accounted for in the data analysis. Prior experience with the equipment has provided a strong indication of the repeatability of rainfall rates. Therefore, although there may be some spatial variability, the rates do not change significantly from run to run. This has permitted the use of efficient, incomplete block designs for conducting the experiments.

Unfortunately, after the first run it was evident that the equipment had deteriorated since the last period of activity; the spatial variability of rainfall rate was clearly unacceptable for reliable analysis of the data. This problem was evidenced by the within-block variability of elapsed time that it took for the sediment catchments to fill with the runoff from the plots. For the first test run the average within-block time difference was 33.3 seconds. These large differences in time greatly affect measurement of erosion rate because the rate does not appear to be constant in time. It was also difficult to control the uniformity of flow over time, thereby reducing the repeatability of conditions from run to run.

The equipment was then modified in an effort to improve performance. For the second test run, the average within-block time difference was reduced to 15.7 seconds, but the problem of repeatability was not resolved. However, the design that was used does permit useful comparisons of within-block erosion rates on Run 2. Between-block rates can be inferred by standardizing. This computation is demonstrated in the following section.

Erosion Results

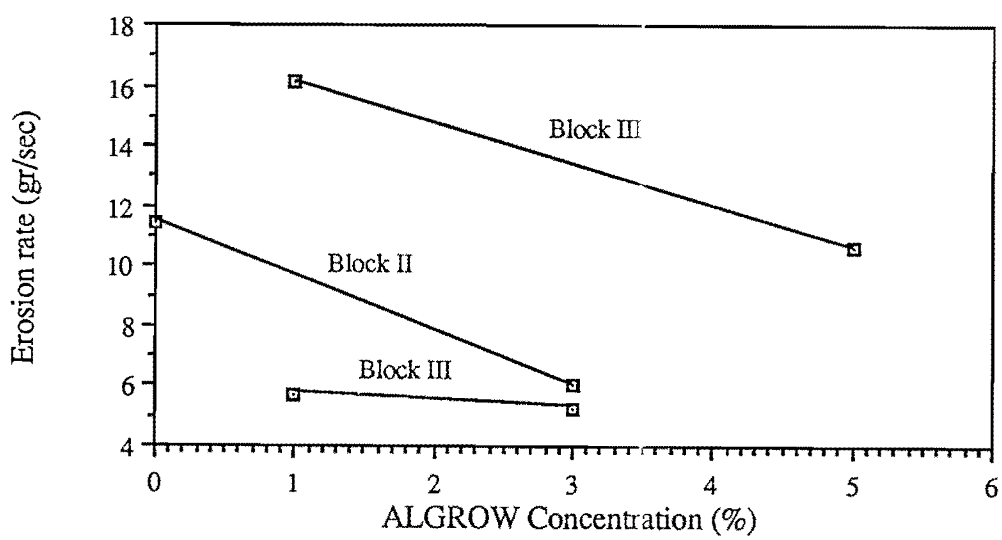
Run 1. Because of mechanical discrepancies within the simulator, the erosion data from the first run could not be used, so the data were discarded.

Run 2. Treatments for test Run 2 were applied to plots as shown in Figure 1, Run 2. Within-block treatment comparisons are made as follows: the effect of one percent and three percent levels of concentration are compared in Block I; control (zero percent) and three percent levels are compared in Block II; and one percent and five percent levels are compared in Block III. Table 1 contains the data for Run 2,which includes total eroded soil weight, elapsed time, and erosion rate.

Table 1
Data from Test Run 2

Plot	Treatment	Block	Soil Weight (gm)	Elapsed Time (sec)	Erosion Rate (gm/sec)
1	3%	1	744.6	141	5.28
2	1%	1	834.5	147	5.68
3	3%	2	1056.3	176	6.00
4	0%	2	2098.9	183	11.47
5	5%	3	1702.5	160	10.64
6	1%	3	3136.6	194	16.17

The comparisons of rates are shown in Figure 2. Treatments which occur in the same block are connected.



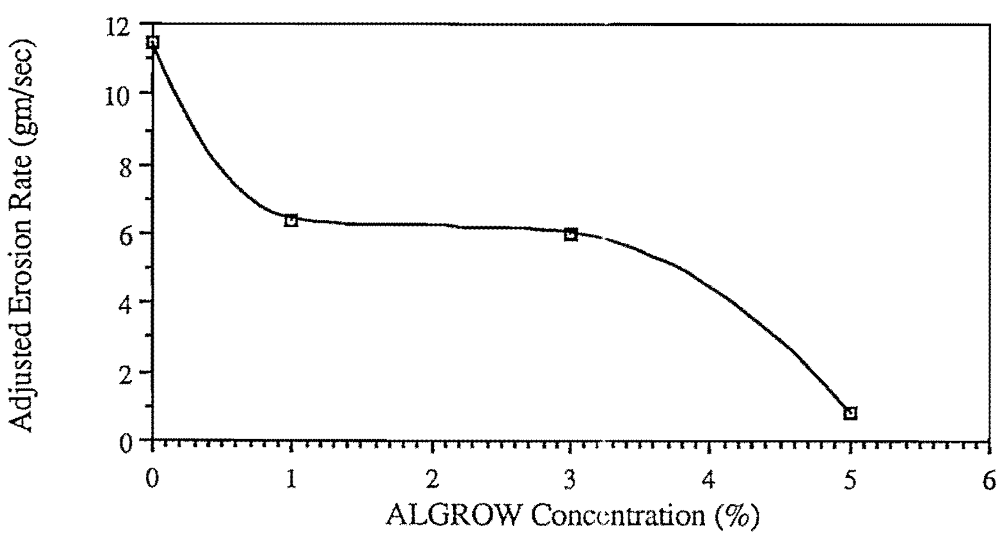
Within-Block Comparison of Erosion Rate
Figure 2

From Block I there appears to be little difference between one and three percent concentrations. Block III indicates a large reduction in erosion rate when comparing one and five percent concentrations. This implies a similar effect between three and five percent concentrations. Block II shows a large reduction in erosion due to a three percent concentration of ALGROW in plot three, as compared to no binder in plot four.

It is useful to adjust each treatment for block-effect by establishing a standard block and then measuring treatment effects as a deviation from the standard within each block. Let the standard be the control plot in Block II. The erosion rate is 11.47, and the standard rate for three percent concentration is 6.00. From Block I, the adjustment rate for one percent concentration becomes 6.00, plus the deviation of the one percent rate from the three percent rate in Block I (6.40), etc. The adjusted erosion rates are given in Table 2 and plotted in Figure 3.

Table 2
Adjusted Erosion Rates

Treatment	Adjusted Rate
0%	11.47
1%	6.40
3%	6.00
5%	0.87



Plot of Adjusted Erosion Rates Vs. Concentration
Figure 3

As shown in Figure 3, the erosion rate decreases as the amount of binder in the mulch increases.

Germination and Growth Results

After twelve hours of sunlight had been applied to the mulched test bed for seven consecutive days, counts were made in plot sample areas of the germinated and non-germinated seeds. Measurements were also made of the plant heights and of dried plant matter in each plot. By approximating number of seeds that were initially applied to each plot, calculations were made of the percentages of seeds germinated and not germinated in each plot, along with the average weights and heights of plants produced. All of these data are listed in Tables 3, 4 and 5, and plotted in Figures 4 through 7.

Table 3
Plant Heights Measured an Each Plot (Runs 1 and 2)

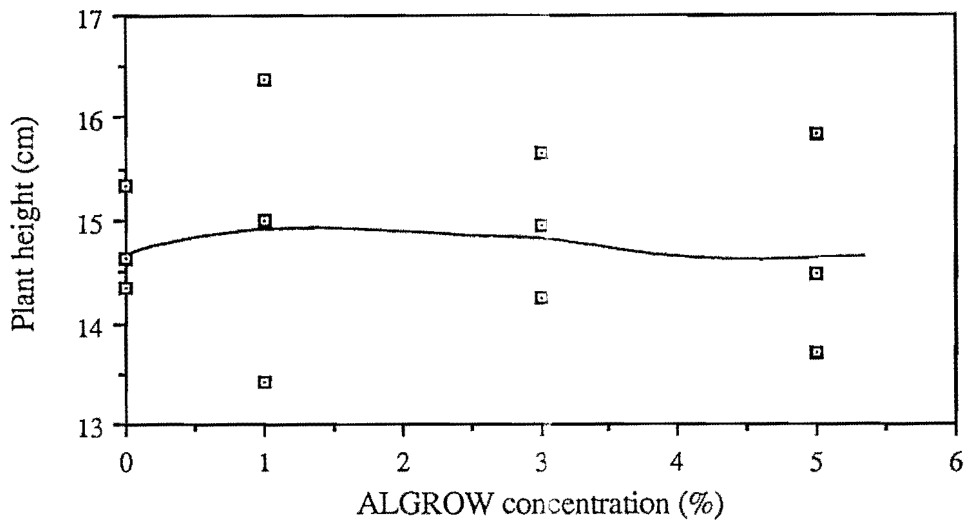
Run No.	Plot No.	ALGROW Concentr. (%)	Plant Height (cm) Top	Middle	Bottom
1	1	5.0	14.47	12.13	11.66
1	2	0.0	15.34	13.18	12.31
1	3	5.0	13.71	11.92	11.15
1	4	3.0	14.96	13.39	12.42
1	5	1.0	13.42	12.42	11.32
1	6	0.0	14.34	13.81	10.56
2	1	3.0	15.66	14.57	13.58
2	2	1.0	15.01	12.58	12.65
2	3	3.0	14.24	11.07	13.75
2	4	0.0	14.63	13.67	12.75
2	5	5.0	15.83	13.04	13.36
2	6	1.0	16.37	13.42	12.97

Table 4
Seed and Plant Data (Runs 1 and 2)

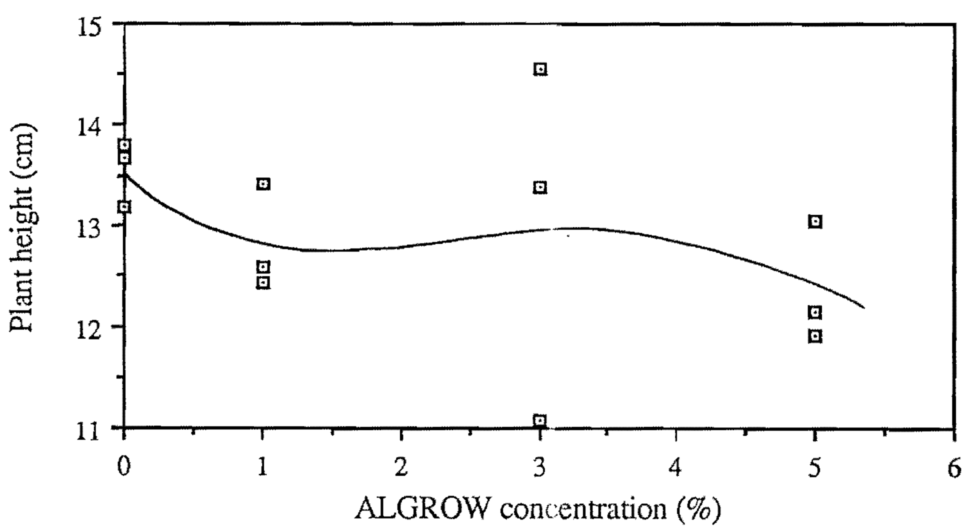
Run No.	Plot No.	ALGROW Concentr. (%)	Seeds Washed Away	Percentage of Seeds Germinated	Non-Germinated	Mean Plant Height (cm)	Mean Dry Weight Per Plant (gm)
1	1	5.0	0	81	19	12.47	0.0111
1	2	0.0	39	37	24	13.50	0.0133
1	3	5.0	27	31	42	12.12	0.0120
1	4	3.0	2	61	37	13.93	0.0136
1	5	1.0	27	55	18	12.08	0.0114
1	6	0.0	6	75	19	12.69	0.0117
2	1	3.0	36	51	13	14.41	0.0172
2	2	1.0	28	47	25	13.45	0.0166
2	3	3.0	33	43	24	13.08	0.0114
2	4	0.0	50	33	17	13.43	0.0159
2	5	5.0	28	45	27	14.16	0.0165
2	6	1.0	30	52	18	14.41	0.0154

Table 5
Summary of Seed and Plant Data

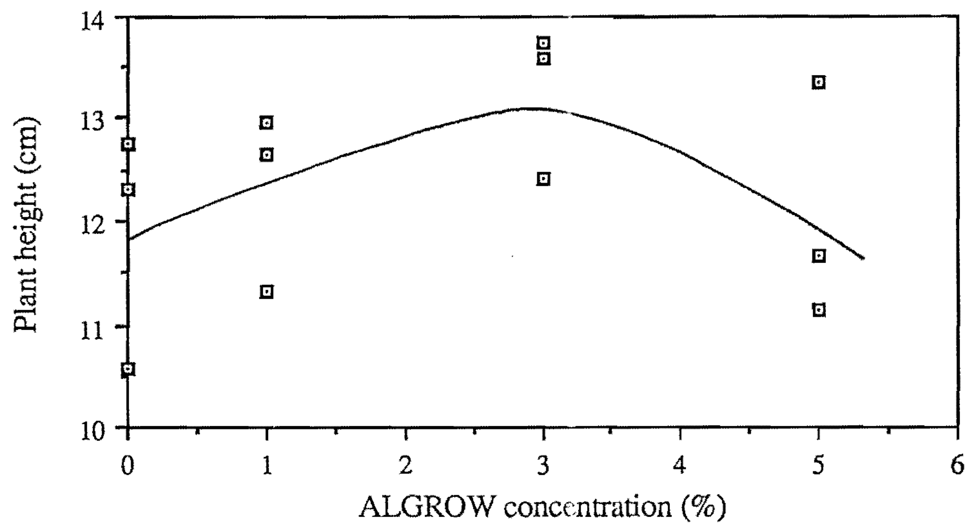
ALGROW Concentr. (%)	Seeds Washed Away	Percentage of Seeds Germinated	Non-Germinated	Mean Plant Height (cm)	Mean Dry Weight per Plant (gm)
0.0	32	48	20	13.20	0.0136
1.0	28	51	21	13.31	0.0145
3.0	24	52	24	13.80	0.0140
5.0	18	52	30	12.91	0.0132



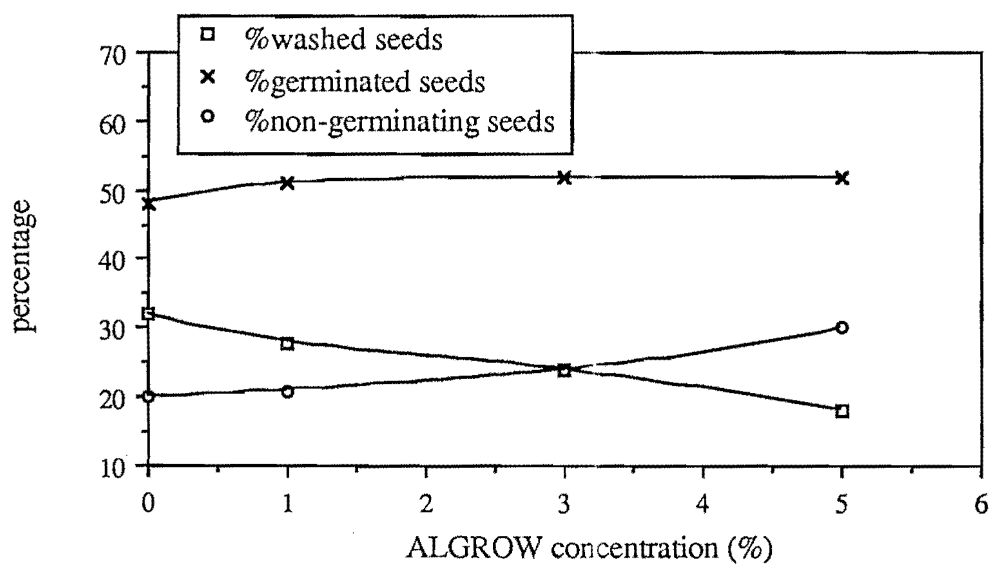
Plant Heights in Upper Ends of Plots (Data from Table 3)
Figure 4



Plant Heights in Center Portions of Plots (Data from Table 3)
Figure 5



Plant Heights at Lower Ends of Plots (Data from Table 3)
Figure 6



Summary of Seed and Plant Data
Figure 7

Discussion

The data shown in Table 3 and Figures 4, 5, and 6 indicate that ALGROW might have an effect on plant germination and growth. Numerous questions are raised by the data; for example, why is there an apparent decrease in plant height in a downslope direction? A possible explanation is that ALGROW may be washed from the seed by the falling rain and the overland flow of water. Plants at the top of the slope receive only the falling rain, but the overland flow of water progressively increases downslope. The wide range of heights at each location may be due to the fact that neither rainfall nor overland flow covers each square unit of land uniformly, so some seeds receive more water than others, even at the same location. This explanation does not, however, explain the height variation on the control plots that contain no ALGROW.

Tables 4 and 5 and Figure 7 show some apparent trends that may be attributed to ALGROW. There is a noticeable decrease in the number of seeds washed from the plots as the ALGROW concentration increases. This may be due to the fact that the ALGROW adheres the seeds to the mulch and soil so that fewer seeds are washed downslope. There may also be a slightly increasing trend in percentage of seeds germinated as ALGROW concentration increases. There is no readily apparent explanation as to why higher concentrations of ALGROW appears to slightly enhance the germination of some seeds while inhibiting the germination of others. This may be a topic for additional research.

Recommendations

Data gathered to date are only indicative of ALGROW's potential of as a binder and as an enhancement for seed germination and growth. So far the product has been tested only against itself; it has not been compared to existing commercial products. Thus, a recommendation was made to Dr. B. O. Gabrielsen that two more runs be made of ALGROW under to rainmaker to compare it with other products. These tests have already begun and will be reported during May, 1989.

Dr. Gabrielsen also expressed a desire to know more about what effect on plants another product from Algea Produkter, A/S--named ALGIFERT--would have when used in conjunction with ALGROW. Therefore, the tests currently underway contain three replications each of ALGROW, ALGROW and ALGIFERT, and two commercial binders, SENTINEL and AGROTACK MP.

Further recommendations are being withheld pending completion of these additional erosion tests and the germination and growth tests which are being performed by the Plant Science Laboratory at Utah State University.