# Affects of Organic Fertilizers on the Growth and Biomass Production of Agricultural Crops

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**Introduction:** Organic agriculture is increasing steadily each year in the United States. Certified organic cropland more than doubled from 1992 to 1997 (6). Many farmers are switching from the conventional methods to organic for many reasons such as lower input costs, decreased reliance on nonrenewable resources, and to boost farm income (4). The United States Department of Agriculture defines organic agriculture as "... an ecological production management system that promotes and enhances biodiversity cycles and soil biological activity. It is based on minimal use of off-farm inputs..." (3). For a food to be certified organic there are many regulations that it must meet, one of them is that the land and plants can not have any prohibited substances applied to them for at least three years (10). Many of the prohibited substances are synthetic substances or chemicals (7). Organic animal and crop wastes are recommended to be used in their place (9). That is why for this experiment three different organic fertilizers are being analyzed to see which one, if any, produces better results on four different plant species.

**Methods:** To determine which organic fertilizer is the best, the experiment was set up using four different agricultural crop species. The crops were: *Hordeum L. vulgare* (barley), *Avena sativa* (oats), *Medicago sativa* (alfalfa), and *Glycine max* (soybeans). The crops were planted in different soil and fertilizer concentration mixtures. One kilogram of potting soil was placed in a pot, then either zero, 250, or 125 grams of a fertilizer was mixed with the soil to make the fertilizer concentration zero, 20 or 11 percent respectively. Three different organic fertilizers were used; they are chicken manure, cow manure, and organic compost. The fertilizers had been processed and commercialized.

The Organic Conversion Corporation manufactures the composted cow manure, it

contains one percent from cattle and other animal manure packinghouse byproducts, and it may contain peat, forest products and/or other organic ingredients. Total available nitrogen is 0.2%, with 0.12% of that being water insoluble, there is also 0.2% available phosphoric acid ($P_2O_5$), and 0.2% available soluble potash ($K_2O$). The chicken manure is Sup'r Green 3-2-2, and is made by D. Stutzman Farms. It is derived from chicken manure; it has 3% total available nitrogen, with 2% being water insoluble. There is 2% available phosphoric acid ($P_2O_5$), and 2% soluble potash ($K_2O$). EKO Systems, Inc manufactured the EKO Compost. For the organic compost the nutrient availability was not given by the manufacturer and could not be determined, it was composed of composted wood products, and digested and composted biosolids. Nitrogen, phosphorus, and potassium are often the limiting nutrients for plants, so it is important to know the amount that the fertilizers will provide the plants (1).

The potting soil that was used was processed commercially from Swiss Farm Products, Inc., which is based out of Nevada. The potting soil is said to be regionally formulated from organic materials, (derived from one or more of the following: hypnum peat, forest products, or compost), sand and perlite.

Once the soil-fertilizer mixtures had been made, the seeds were then planted. Each species were planted in six treatments along with the control. There were four replicates of each treatment for each plant species, which made a total of 112 pots. Once planted the seeds were promptly watered. This was the only time that fertilizer was added to the soil during the experiment. The seeds could not be planted outside due to the environmental conditions; instead they were grown in a greenhouse. Most of the conditions in the greenhouse were kept fairly constant. The thermostat was constantly set

at 27 degrees Celsius, but due to conditions outside influencing the conditions in the greenhouse, inside the temperatures ranged from 12 °C to 35 °C. It was typically cooler at night and warmer during the day. The relative humidity remained more constant; it varied between 80% and 90%. The plants were watered three times a week, they were all watered at the same time and were all watered to field capacity. They also all recieved treated city water which is what they would not normally recieved in the field. With the exception of the kind and amount of fertilizer if any was used on the plants, all other variables were kept the same for all the plants.

Every time that the plants were watered their vertical height was measured and recorded. After a couple of months the plants were harvested. The alfalfa was harvested 95 days after they were planted. In the field, alfala is typically harvested when the plants start to bloom ( 5), due to time constraits the alfalfa had to be harvested before any blossoms formed. The alfalfa plants were harvested by hand; the entire plant was cut off three centimeters above ground level. The plants were then dried and weighed for analysis.

When barley is normally harvested in the field it is after the spikelets have dried and turned a pale yellowish brown color, not caused from wilting (8). For the experiment this was not the case for some of the plants. The barley was harvested at three different times. The control plants and the plants grown in both of the chicken manure concentrations were harested on day 108, before they had a chance to dry. All the other plants were dried and mature before they were harvested, either on day 102 for all the plants grown in cow manure or on day 85 for the compost grown plants. The plants were harvested and thrashed by hand, the new seeds were separated from both the bristles

growing out of he seed and from the central stem that the kernals grew out of. After all the kernels were dry, they were then weighed. Farmers often use the stalks of the barley plants as hay, but nothing was done with them after harvesting the kernels.

Oat plants are also normally harvested after the plant becomes dry and yellow and the seed hardens (2). There are many varieties of oats, the kind used in the experiment were the common oat, it contains a hust around the seed that must be removed before the seed can be processed or used for other purposes. Once again the oats were harvested by hand, the husk was removed and the seed was detatched from the stem. The oats were all harvested at the same time on day 108, even though none of them were ready yet. However, due to a time constraint they had to be harvested. The seeds were allowed to dry and then they were weighed. Again the rest of the plant was not used after harvest.

**Results**: The final height of the plants and the amount of biomass of the seeds or the entire plant that was produced were compared. For the alfalfa grown in both the 11% and 20% chicken manure and all of the soybeans, there is no data to be analyzed. The plants either never germinated from the seed or the plants died partway through the growing season. For the plants that did grow and were able to be harvested there were considerable differences between the different fertilizers used.

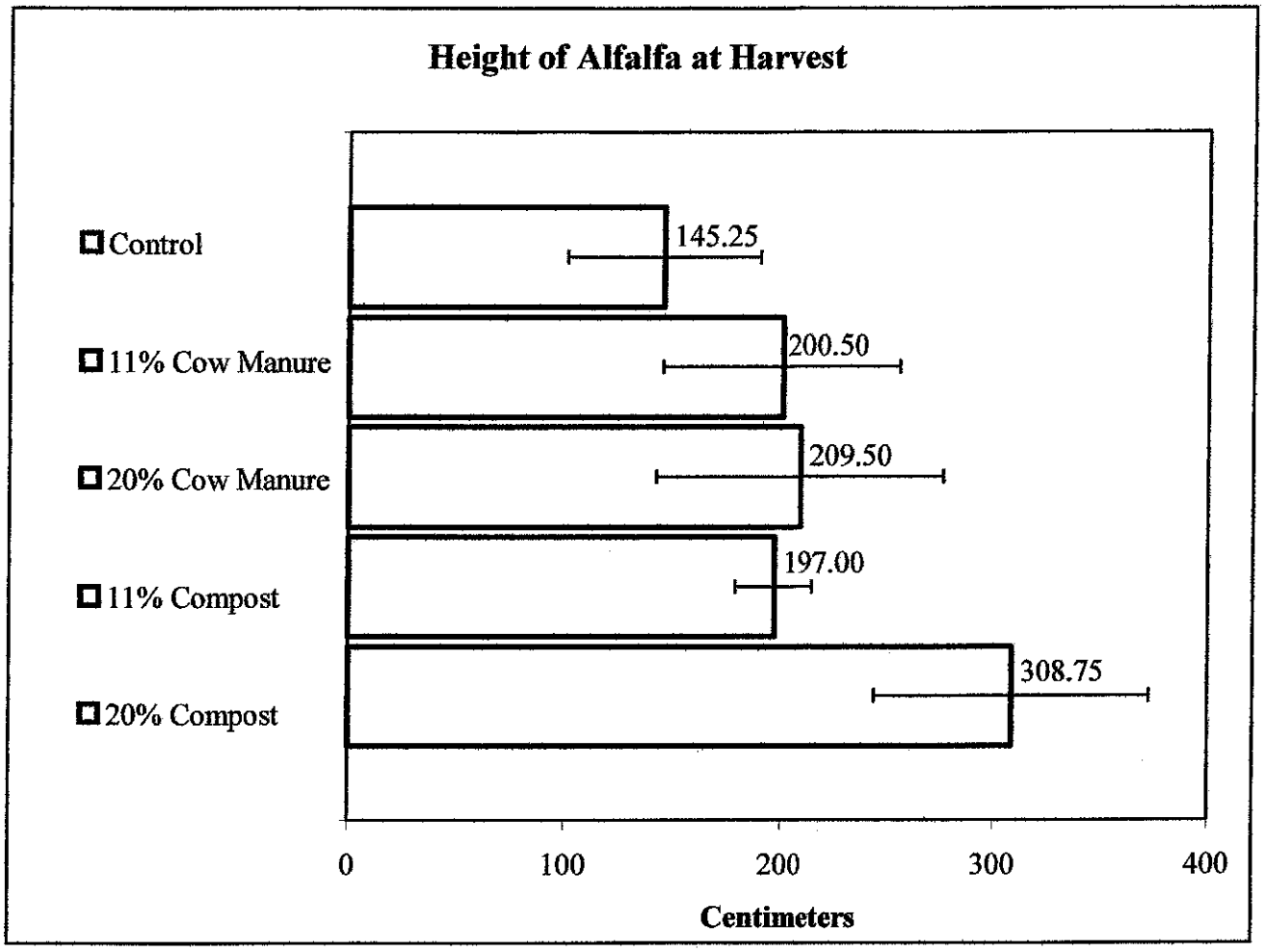


**Figure 1**. Shows the height of alfalfa plants at the time of harvest after the alfalfa was cultivated in various media for 95 days. The standard deviation for the four replicates of each treatment is also shown.

In Fig 1. It is apparent that medium mixed with 20% compost produced the tallest alfalfa followed by the 20% cow manure mixture. The media that contained 11% cow manure and 11% compost yielded similar results, however the 11% cow manure had a the greatest standard deviation of all the plants, while the 11% compost had the smallest standard deviation of all the plants. The control media produced the shortest plants.

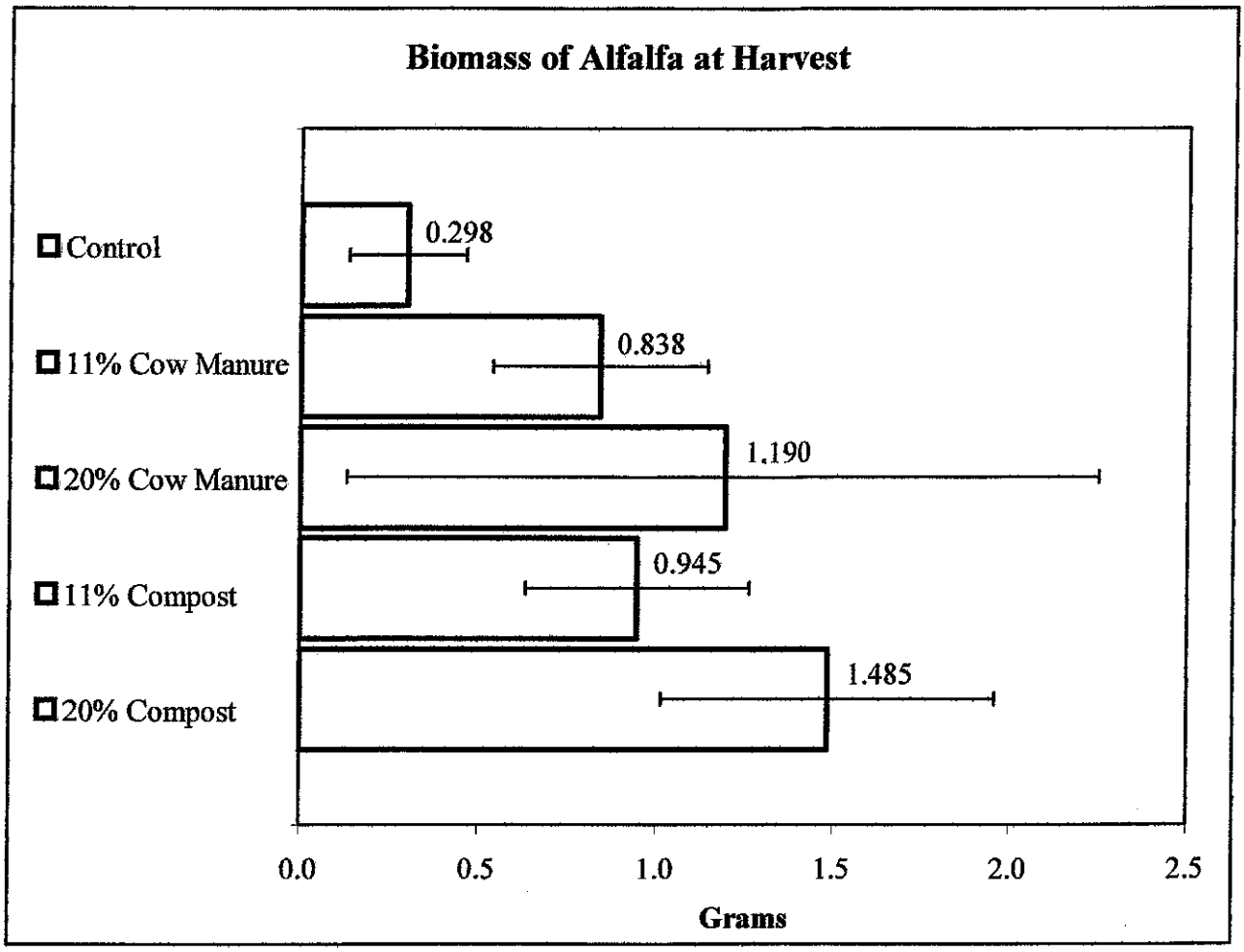


**Figure 2.** Shows the dry biomass of alfalfa plants after being harvested and dried. The plants were cultivated and grown in various media for 95 days. The standard deviation for the four replicates of each treatment is also shown.

In Fig. 1. The medium mixed with 20% compost produced the most biomass, followed by the 20% cow manure. The 20% cow manure had the highest standard deviation; some of the plants grow well while others did not grow very well. The control plants produced the least amount of dry plant biomass; it also had the least amount of variation between the replicates.

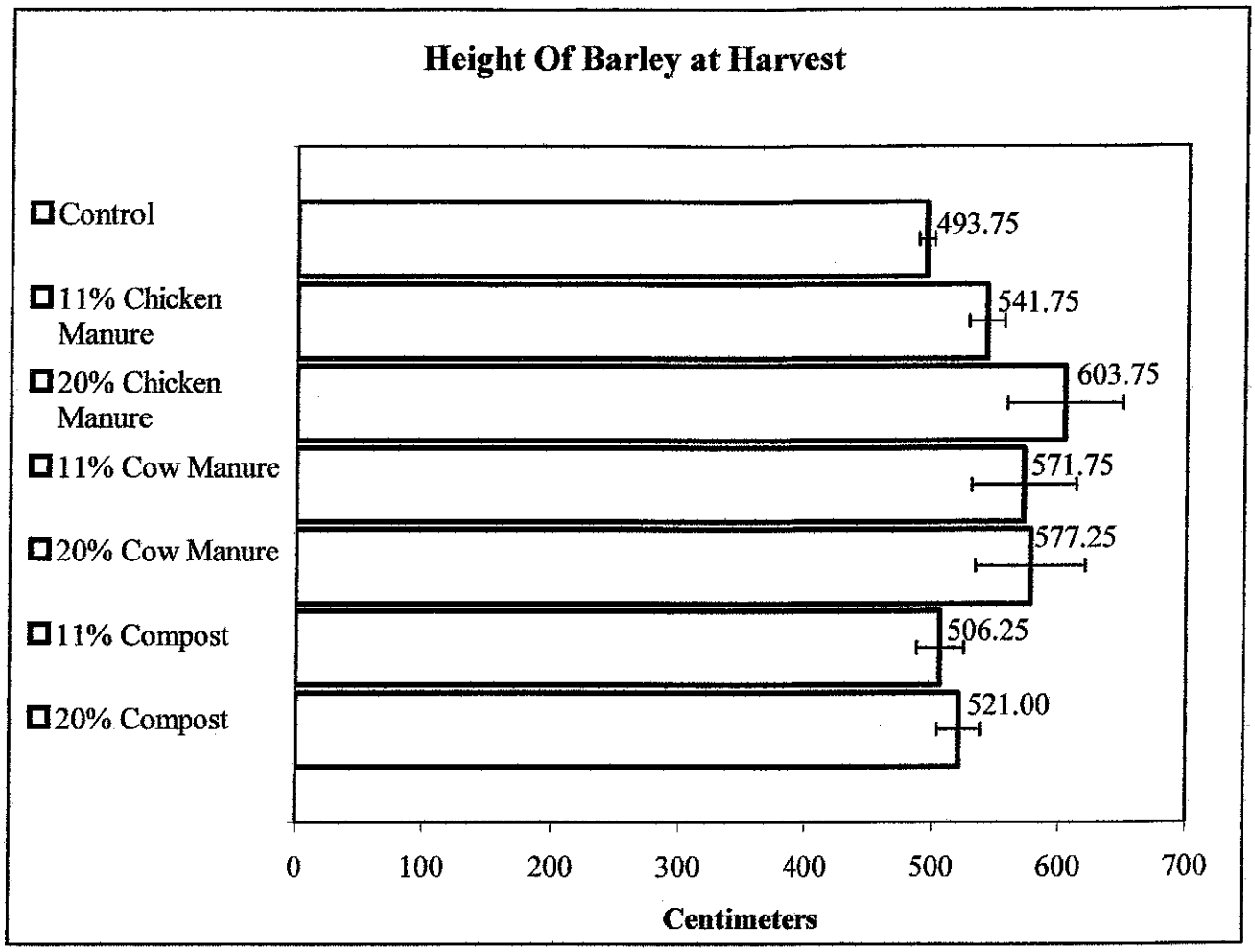


**Figure 3.** Shows the height of barley plants at the time of harvest. The plants were grown in the compost mediums for 85 days, in the cow manure mediums for 102 days, and 108 days in the control and chicken manure mediums. The standard deviation for the four replicates of each treatment is also shown.

The tallest plants were produced by the 20% chicken manure, followed by the 20% cow manure, and then closely by the 11% cow manure. The control plants produced the shortest plants, but they were the most consistent by having a very small standard deviation. The standard deviations for the 20% chicken manure, 11% cow manure and 20% cow manure were all within 5 cm of each other. However, the 20% chicken manure did have the highest largest standard deviation of all.

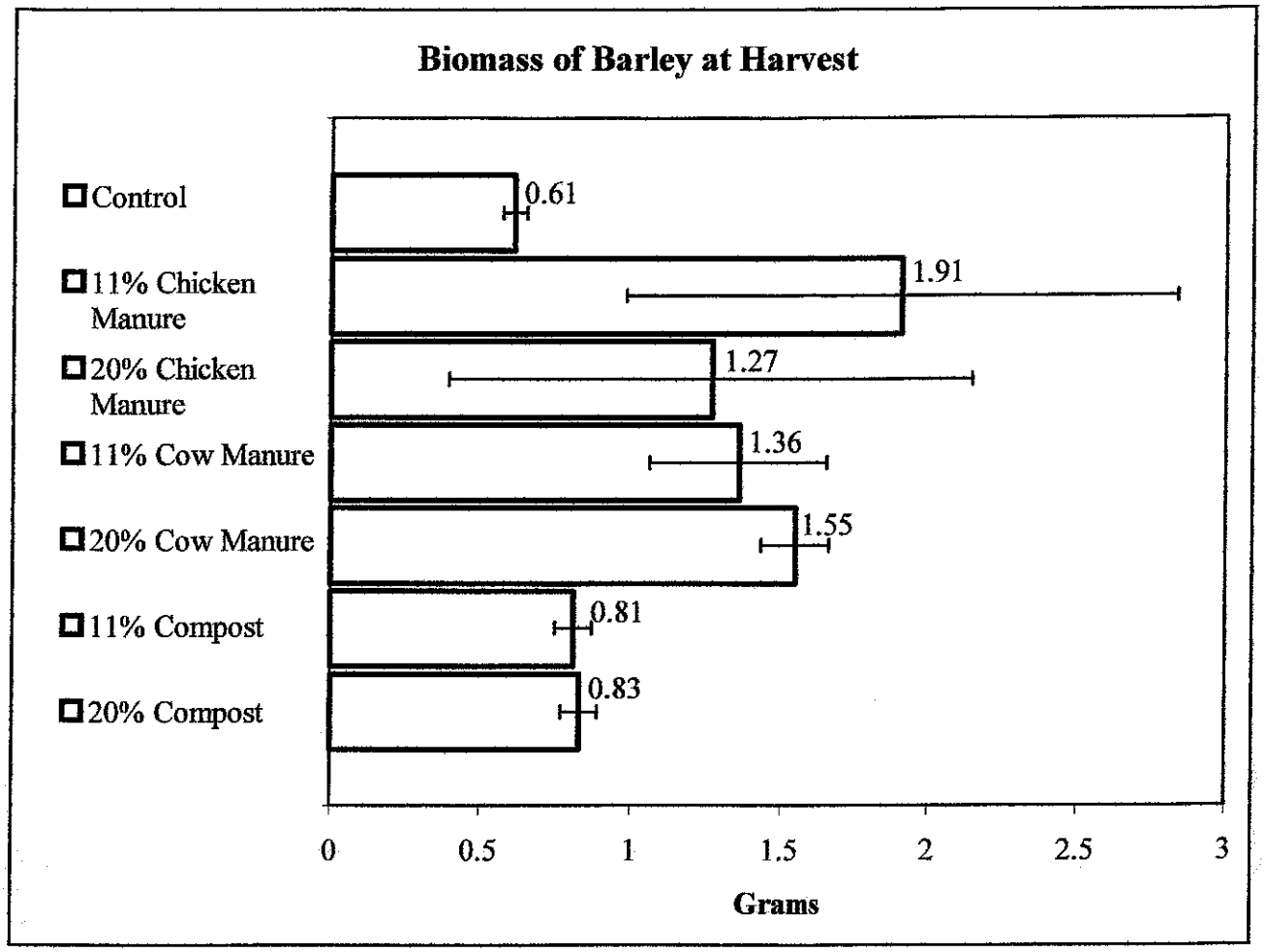


**Figure 4.** Shows the dry biomass of the barley kernels after being harvested. The plants were grown in the compost mediums for 85 days, in the cow manure mediums for 102 days, and 108 days in the control and chicken manure mediums. The standard deviation for the four replicates of each treatment is also shown.

In Fig.4 it is evident that the 11% cow manure produced the greatest amount of dry plant biomass. It was followed by the 20% cow manure treatment. It did not seem to make a substantial difference on the outcome of the biomass with the different concentrations of compost treatments. They both produced almost the same amount of biomass and the standard deviations were exactly the same. The control media produced the least amount of biomass and it also had the smallest standard deviation.

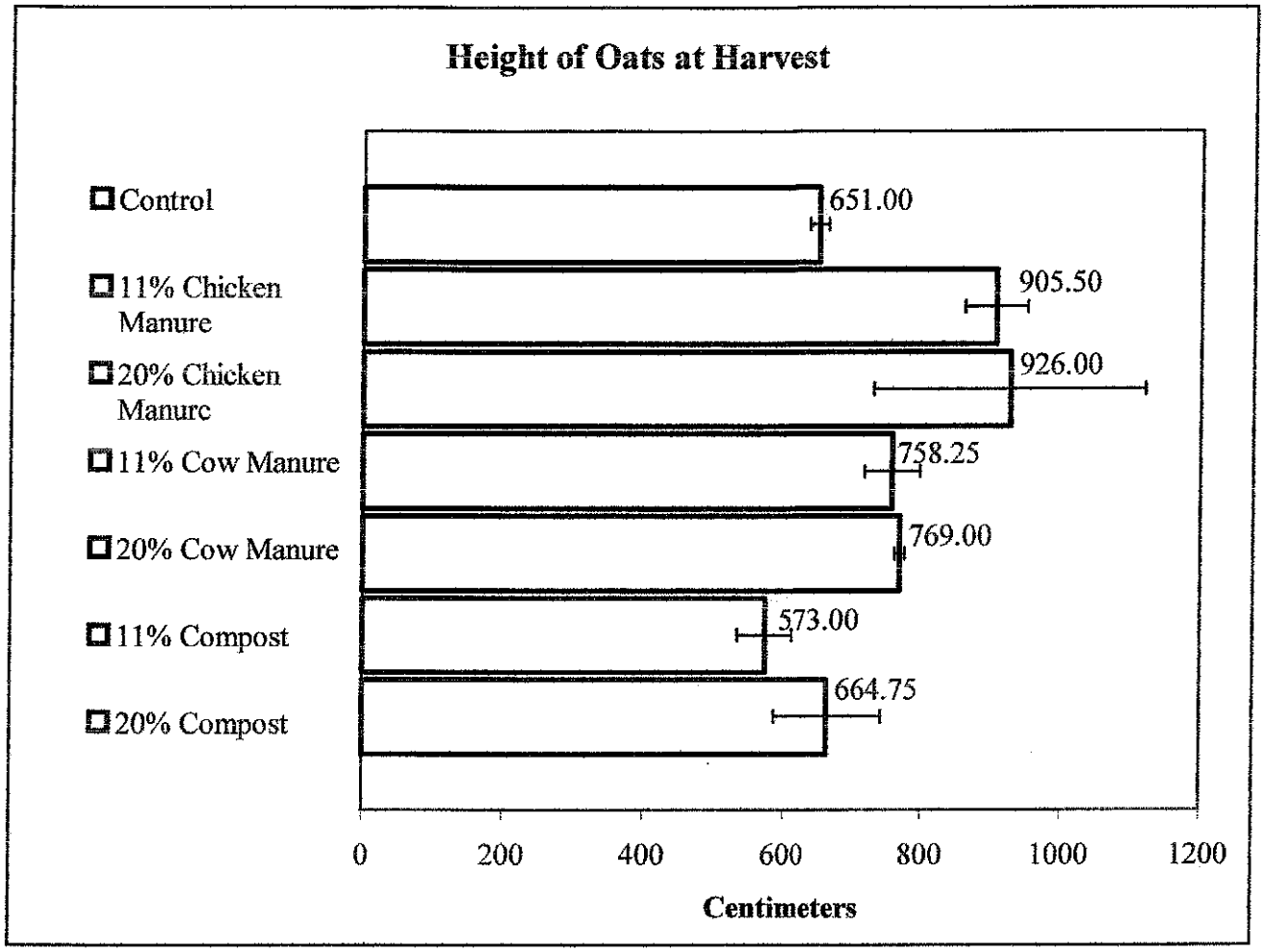


**Figure 5.** Shows the height of the oat plants at time of harvest. The oats were cultivated in various media for 108 days. The standard deviation for the four replicates of each treatment is also shown.

In Fig. 5. It is clear that medium grown with 20% chicken manure produced the tallest plants, which was closely followed by the 11% chicken manure treatment. The 20% chicken manure also had the largest standard deviation; this was largely due to the fact that half of the plants never survived to harvest. The 11% compost grew the shortest plants, while the 20% cow manure grown plants had the smallest standard deviation there was very little varying between the heights of the plants.

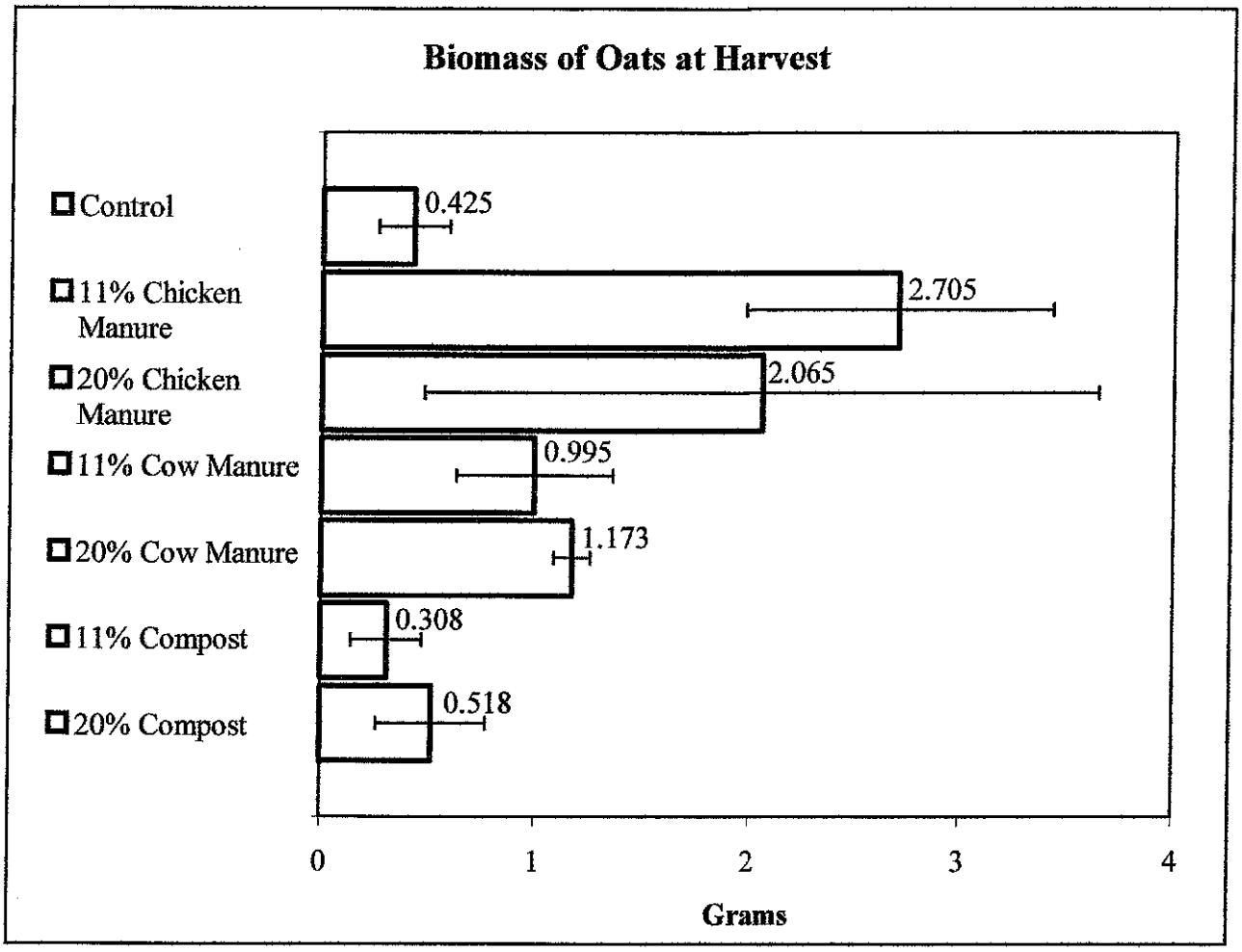


**Figure 6.** Shows the dry biomass of oat seeds after they were harvested and dried. The plants were cultivated in various media for 108 days. The standard deviation for the four replicates of each treatment is also shown.

In Fig. 6. It is apparent that the 11% chicken manure produced the greatest amount of dry seed biomass. The 20% chicken manure produced the next largest amount; there is such a large standard deviation because of the death of half the plants in that treatment before harvesting. The 11% compost and then the control plants produced the smallest amount of biomass. The plants with the smallest standard deviation were the 20% cow manure treatment.

**Discussion:** When the alfalfa was first planted, the seeds planted in the two concentrations of chicken manure never germinated. Since there was four replicas of each treatment the failure to grow was not caused by bad seeds; the problem had to be that the fertilizer was too strong for the small seeds. The fertilizer might have caused a critical nutrient to become limiting. For the height of the harvested alfalfa (Fig. 1), the plants grown in 20% organic compost produced the tallest plants at 308.75 cm. They were almost 100 cm taller that the next tallest plant, which was the plants grown in the 20% cow manure that reached 209.5 cm. However, height is not the most important factor for farmers, what they really care about is the quantity that is produced, the biomass of the plant. The treatment that produced the most plant biomass was the 20% compost, whch produced 1.485 grams/plant. As before the 20% cow manure produced the second highest amount of biomass at 1.19 grams/plant. For the most part it was consistant that the taller the plant correlated with a higher amount of biomass produced (Fig. 2). The only exception was the 11% cow manure treatment, it was taller than the 11% compost but the 11% compost produced slightly more that the cow manure, only 0.1075 grams/plant more (Fig. 2). In both terms of measurement the control plants responded the poorest, they were the shortest and produced the least amount of biomass. The fertilizers must have added nutrients that allowed the plants to grow faster and bigger.

Barley was the second plant to be analyzed. Based on the height of the plant at the time of harvest, the treatment of 20% chicken manure produced the tallest plant reaching 603.75 cm (Fig. 3). There was only a little over 100 cm difference between the tallest and shortest barley plants. Once again the control treatment produced the shortest plants. In reguards to the amount of biomass produced, the control plants also had the least biomass

in kernals at 0.61 grams/plant. While the 11% chicken manure produced the greatest amount of biomass at 1.91 grams/plant. The 20% cow manure came in second place with 1.55 grams/plant (Fig. 4). For the barley, neither any plants nor treatments had to be thrown out, all of the plants germinated and survived until harvest. When farmers choose which fertilizer to use they have to consider factors other than biomass production. A big factor is time, the different fertilizers caused the plants to mature and dry at various times. There was over three weeks between the time the first plants were ready for harvest until the final plants wer harvest due to a time constraint. I could have taken a couple of more weeks for the plants to be ready. The 11% chicken manure may have produced the greatest amount of biomass at 1.91 grams, but it was also the slowest. It, along with the plants grown in control and 20% chicken manure, were the plants that had to be harvested before they were ready. The plants that matured the quickest were grown in 11% compost and 20% compost, which produced only 0.81 grams and 0.825 grams respectively (Fig. 4). Farmers need to find a balance between time and yield that works the best for them. Even though these plants were all harvested within 108 days after being planted, chances are that they will not grow as fast in real life situations where environmental conditions can neither be predicted nor controlled.

The final heights of the oat plants when they were harvested varied by almost 350 cm (Fig. 5). The tallest were ones grown in 20% chicken manure at 926 cm; it is hard to say that those results are accurate though. Only half of those plants survived until harvest, the other half germinated and grew for 38 to 40 days and then they died. They were the only oat plants that did not survive. The next tallest plants were from the 11% chicken manure; they were 19 cm shorter at 907 cm. For the first time the control plants were not

germinate, so the 20% concentration may be on the border between the optimal level and the lethal level of some nutrients. However the plants that did grow still produced the most so the fertilizer worked the best. For the alfalfa plants the best fertilizer treatment was the 20% organic compost; it produced the tallest plants and the most biomass. In every case, with the exception of the 11% compost treatment with oats, any form of fertilizer was better than nothing at all. The control plants were the shortest and produced the least amount of biomass. Organic fertilizer helps the farmer get better yields from the crops and helps the environment rather than harming it.

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