Microwave sterilization of weed seeds

by Stanley Mark Gliko

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Electrical Engineering
Montana State University

Abstract:
The subject of this thesis is to determine the amount of microwave energy needed to kill cereal grains such as spring wheat under harvest conditions. In order to determine the behavior of the cereal grains under microwave exposure the dielectric constant, loss tangent, attenuation constant and reflection coefficient were measured as functions of moisture content. From the experimental data, it was determined that the dielectric constant, loss tangent, attenuation constant and reflection coefficient were all functions of moisture content. Once this information was obtained, the seeds were exposed to a high power pulse microwave system and to a continuous wave cavity oven. From the high power pulse tests, no kill point was found for spring wheat. From the microwave oven tests, a kill point was determined as a function of moisture content for spring wheat.

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Date *14 Jan. 1982*

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ABSTRACT

The subject of this thesis is to determine the amount of microwave energy needed to kill cereal grains such as spring wheat under harvest conditions. In order to determine the behavior of the cereal grains under microwave exposure the dielectric constant, loss tangent, attenuation constant and reflection coefficient were measured as functions of moisture content. From the experimental data, it was determined that the dielectric constant, loss tangent, attenuation constant and reflection coefficient were all functions of moisture content. Once this information was obtained, the seeds were exposed to a high power pulse microwave system and to a continuous wave cavity oven. From the high power pulse tests, no kill point was found for spring wheat. From the microwave oven tests, a kill point was determined as a function of moisture content for spring wheat.

CHAPTER I

INTRODUCTION

Because "saline seep" is becoming an increasing problem in the farm lands throughout the world, several methods of alternate farm practices are being adapted to minimize the saline seep problem. One such practice is to eliminate summer fallowing (unseeded plowed land). With this change, cereal grains which have fallen off the tail board of a combine will grow in the unplanted area. This volunteer recropped grain is undesirable and must be eliminated in order to successfully stop summer fallowing. Due to the impracticality of removing the seeds from the straw which have fallen from the tailboard of the combine, an alternate method which would expose the seeds and straw to high energy microwaves in order to kill the seeds was proposed by Dr. Jim Sims (1). The purpose of this thesis is to investigate Dr. Sims' theory by determining the necessary microwave parameters of various cereal grains and the amount of energy needed to kill the seeds. This project was divided into two major areas:

* Low Power Measurements
* High Power Measurements

In the Low Power Measurements, the amount of energy reflected and absorbed as a function of moisture content was determined for wheat, oats and barley. In addition, the relative dielectric constant and loss tangent was determined for wheat, oats and barley as a function of moisture content.

In the High Power Measurements, a pulsed system and a continuous wave system were used to find a kill point for the seeds. In the pulsed system the duty cycle, power, pulse width and time of exposure were varied to find the optimum kill point as a function of grain moisture content. In the continuous wave system, a microwave oven was used to find the kill point as a function of exposure time and percent moisture. By these tests, the amount of energy needed to kill the seeds was determined.

CHAPTER II

LOW POWER MEASUREMENTS

In determining the microwave properties of the seeds, it is desirable to take into account the moisture content of the seeds. This is necessary because the high loss and highly polarizable nature of water (2) causes attenuation and concentration of the electromagnetic fields. Due to this consideration, the low power tests were completed as functions of moisture content of the seeds.

In order to maintain a standard in determination of moisture content throughout the following experiments, drying tests were performed on spring wheat (Levi type). The procedure for the tests was as follows:

(1) Measure the weight of the container

(2) Measure the weight of the seeds and the container before drying (wet weight)

(3) Put $CaSO_4$ Anhydrous (a desiccant) in the oven to absorb the moisture.

(4) Put seeds into the oven and maintain temperature between 100-110 ^oC for several hours.

(5) Measure the weight of the seeds and container at different time intervals.

When these procedures were completed, the following equation was used to calculate the percent moisture content:

$$\%\text{moisture} = \frac{(\text{wet weight of the seeds})-(\text{dry weight of the seeds})}{\text{wet weight of the seeds}}\times 100$$

Figures 1 and 2 on pages 5 and 6 shows the drying process for two different samples of spring wheat. As can be observed from the two figures, very little drying takes place after the twenty-fourth hour. With this in mind, the following criterion to determine percent moisture will be used:

(1) Dry seeds at 100-110^{o}C

(2) Dry seeds for 24 hours

Because percent moisture of storage grain is usually less than 10%, water must be added to some of the test seeds in order to obtain energy reflected and energy absorbed versus percent moisture characteristics that are desired. In order to do this, the following standard was used to increase the percent moisture for each data point. One gram of H_2O was added to 30 grams of seeds at storage value for each data point. That is to say, one data point would have one gram of H_2O per 30 grams of seeds; the next data point would have 2 grams of H_2O per 30 grams of seeds and etc. Once the water was added to the seeds, the seeds would be placed into a sealed container and allowed to absorb the water. Because it was observed that after the twenty-fourth hour the seeds above 30% moisture would begin to germinate, the seeds would remain in the sealed containers at most twenty-four hours before any tests were performed on them. This procedure would allow maximum time for the seeds to absorb the water without introducing the extra factor

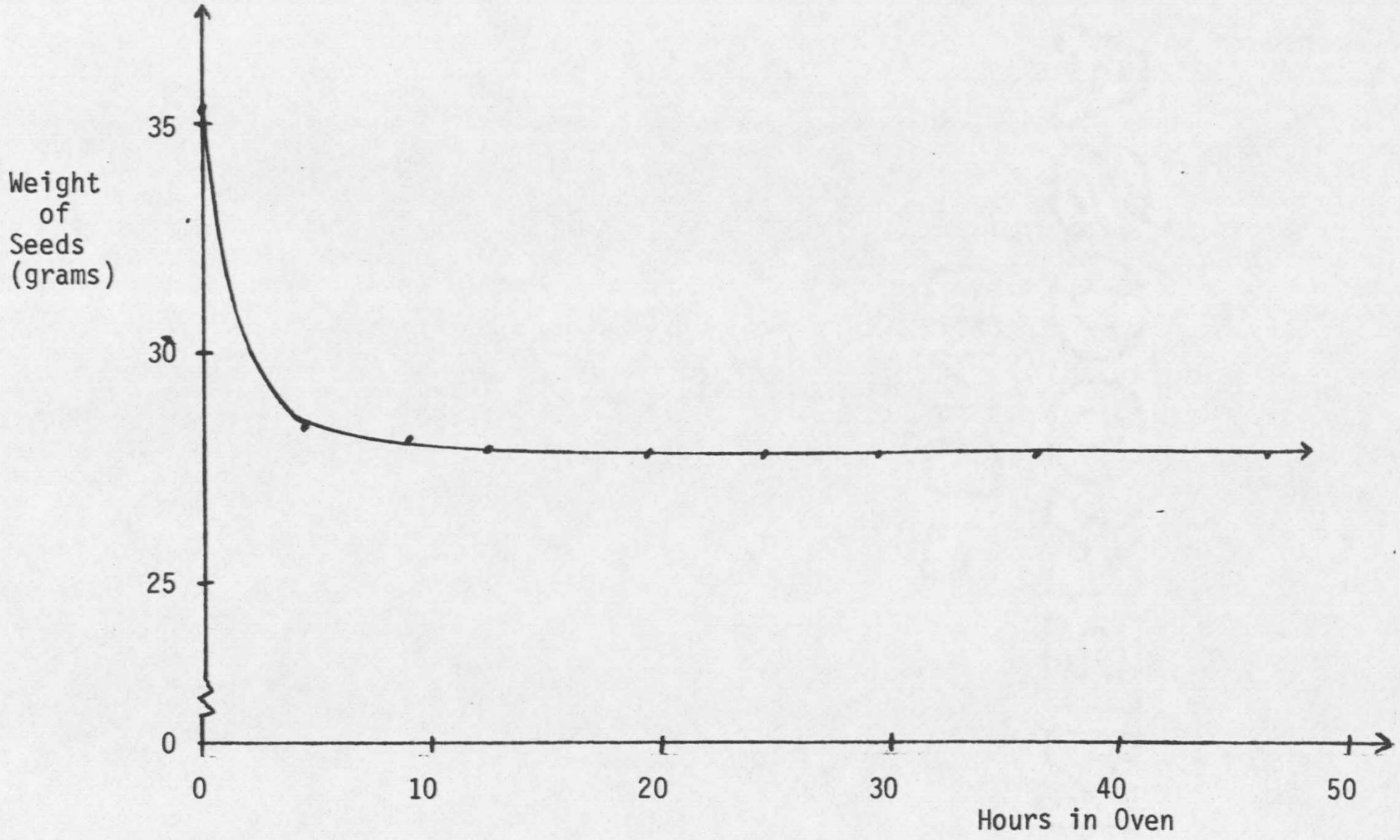

Figure 1 Drying Curve for Spring Wheat

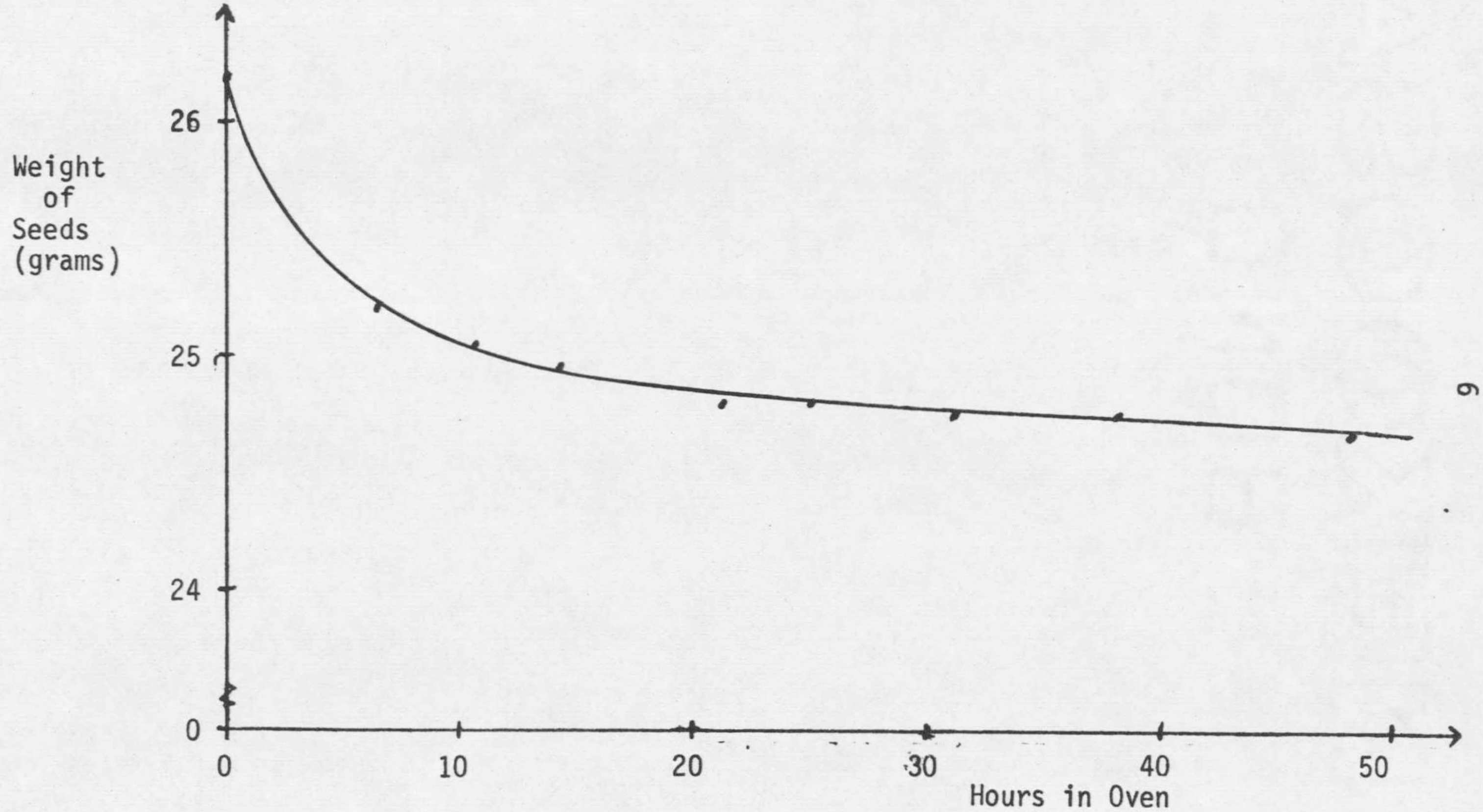

Figure 2 Drying Curve for Spring Wheat