

Ultraviolet-B Radiations Effects on Radishes and Sunflowers

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Editor's Note: The following article was submitted by Laurel Ashton as a high school sophomore. She conducted the experiment under the supervision of Dennis Stockdale.

Abstract

A study was performed to see what affect different levels of UV-B radiation have on sunflowers and radishes. It concluded that the more UV-B radiation the plants are exposed to the taller they will grow.

Introduction

The ozone layer is a thin layer of gas produced in the stratosphere. It is only a few millimeters thick but it protects the earth from certain wavelengths of ultraviolet radiation and is responsible for the heating of the middle atmosphere (Worrest & Caldwell, 1986). The ozone layer was first discovered in 1839 by German scientist Christian Friedrich Schonbein but wasn't accurately measured until 1918 by Robert Strutt (British Antarctic Study, NASA, Environment Canada, UNEP, & EPA, 2004).

In the early 1970's speculation of the possibility of ozone reduction surfaced. Scientists began to fear the consequences of the injection of large quantities of nitrogen oxides into the upper atmosphere by supersonic aircrafts traveling at high altitudes (Worrest & Caldwell, 1986). In 1984 the hole in the ozone layer over Antarctica was discovered and by October 1987 scientists found the hole had reached the size of the USA. The ozone layer became a large topic of discussion and controversy after this startling discovery.

Six sources cause the depletion of the ozone layer; solvent cleaning sources (36.1%), refrigeration and air conditioning (29.6%), Aerosols (5.0%), farm products (14.3%), sterilization (3.0%), and other products including Halons (12.0%). These chemicals contain chorine, bromine, and many others. Ozone depletion is primarily caused by man-made chemicals (British Antarctic Study, NASA, Environment Canada, UNEP, & EPA, 2004).

Cooperative measures are being done to stop ozone depletion. In 1978 the use of CFC propellants in spray cans, another factor in ozone reduction, was banned. In 1987, the Montreal Protocol was signed committing signatory nations to helping reduce CFC's and other ozone depleting substances. Eight years later the treaty was ratified by 180 other countries. The EPA (Environmental Protections Agency) has also been very active in helping stop ozone depletion by setting up many regulatory programs designed to stop ozone killing substances (EPA, 2004).

With the depletion of the ozone layer comes an increase in the amount of ultraviolet (UV) radiation that hits the planet. There are three main types of UV radiation. UV-A radiation has wavelengths of 320 to 400 nm. This kind of ultraviolet light is only slightly affected by the ozone layer which means it can easily reach the earth's surface. It contributes to skin tanning, skin aging, eye damage, and immune suppression. UV-B light has a wavelength of 280 to 320 nm. This is the ultraviolet radiation most heard about. It is partly absorbed by the ozone layer but it still reaches earth. It contributes to sunburn, snow blindness, skin cancer, immune suppression, and premature aging. UV-C radiation has a wavelength of 100 to 280 nm. It is strongly affected by the ozone layer and not much reaches earth's surface (British Antarctic Study, NASA, Environment Canada, UNEP, & EPA, 2004). A lesser known ultraviolet radiation is called Vacuum UV which cannot freely exist if there is oxygen. Oxygen absorbs all energies less then 200 nm and Vacuum UV falls under this category (Hart, 1988).

The four main areas affected by UV radiation are wildlife, environment, human health, and agriculture. After many studies agricultural scientists have stated that soybeans, tomatoes, tobacco, potatoes, corn, beans, and wheat are especially sensitive to UV light. Most of these plants are big cash crops all around the world (British Antarctic Study, NASA, Environment Canada, UNEP, & EPA, 2004). Although these are thought to be the main plants affected by UV radiation

they are not the only ones. Any seedling can get 'sun burnt' when suddenly planted in UV-enriched locations. Symptoms of plants in overly radiated areas include the development of very thick cuticles. Indirect effects on plants are things like smog and acid rain caused by ionizing and oxidizing actions on atmospheric pollutants (Hart, 1988).

Some plants are able to protect themselves from some UV radiation. Plants in habitats where the UV radiation is higher than normal obtain protective features like flavones, flavonols, and repair mechanisms. Flavones and Flavonols are ivory-colored pigments that occur in flower parts and leaves. They absorb in the UV-B radiation while still letting the visible, photo synthetically active wavelengths go through to the palisade layer of cells. Although they are helpful, less than 1% of the radiant energy that reaches the earth's surface is absorbed by the pigment (McDonald, 2003). Today about 4.6% of earth's surface is not covered by the ozone layer at all. If the ozone level isn't brought under control many scientists believe the ultraviolet radiation on plants could be disastrous for future generations.

The purpose of the experiment was to try and see what affect UV-B radiation has on plants and if in fact these accusations of ultraviolet radiation being disastrous for plant life had any truth to them. This study uses radishes and sunflowers because they are fast growing plants. The hypothesis was that there would be a small difference in growth rate between the plants blocked from 98%, 20%, and 0% of UV-B radiation. Sunflowers and radishes are not known to be highly affected by UV radiation and it seems unlikely that the study area would be an overly radiated area. It is felt, however, that the plants protected from 98% UV-B radiation would look healthier even if the height of the plants were relatively the same. This conclusion was reached because even though sunflowers and radishes are not overly affected by radiation, they are affected.

Methods and Materials

The experiment began March 7, 2005, and ended on April 8, 2005. Each of the sunflowers and radishes were planted in six inch pots, and a commercially available potting soil purchased from Reems Creek Nursery (70 Monticello Rd., P.O. Box 87, Weaverville, N.C. 28787, Phone number 828-645-3937). Two radishes were placed in each of fifteen pots to assure growth in each container. The same was done for the sunflowers. A mixture of five pots for the radishes and five pots for the sunflowers was placed randomly in each of three seedling flats. The three seedling flats were either covered by Plexiglas that blocked out 98% of UV-B radiation, 20% of UV-B radiation, or it was not covered by Plexiglas at all (the control).

Plants were kept inside because of the frost. They were placed on a table in front of a large window facing a southerly direction. The window was covered with white paper to diffuse the sunlight. The seedling flats were rotated every other day so that no plant received more sunlight than the others.

At the beginning the plants were watered every four or five days but towards the end they were watered less often. Each seedling flat received approximately 1.5 liters of water at each watering.

Data collection began on March 10. Data were collected every Monday, Wednesday, and Friday. There was a period of ten days in the middle of the experiment when no data were collected due to spring break. The height of both the sunflowers and the radishes was recorded in centimeters. Data and graphical presentation are below.

Results

Radish with 98% Block

Day	3/10	3/14	3/16	3/18	3/28	3/30	4/1	4/4	4/6	4/8
Average Height (cm)	3.26	7.7	8.4	9.8	10.56	10.5	10.6	11.2	10.6	10.6
Number of Plants	9	9	9	7	5	4	4	3	3	3

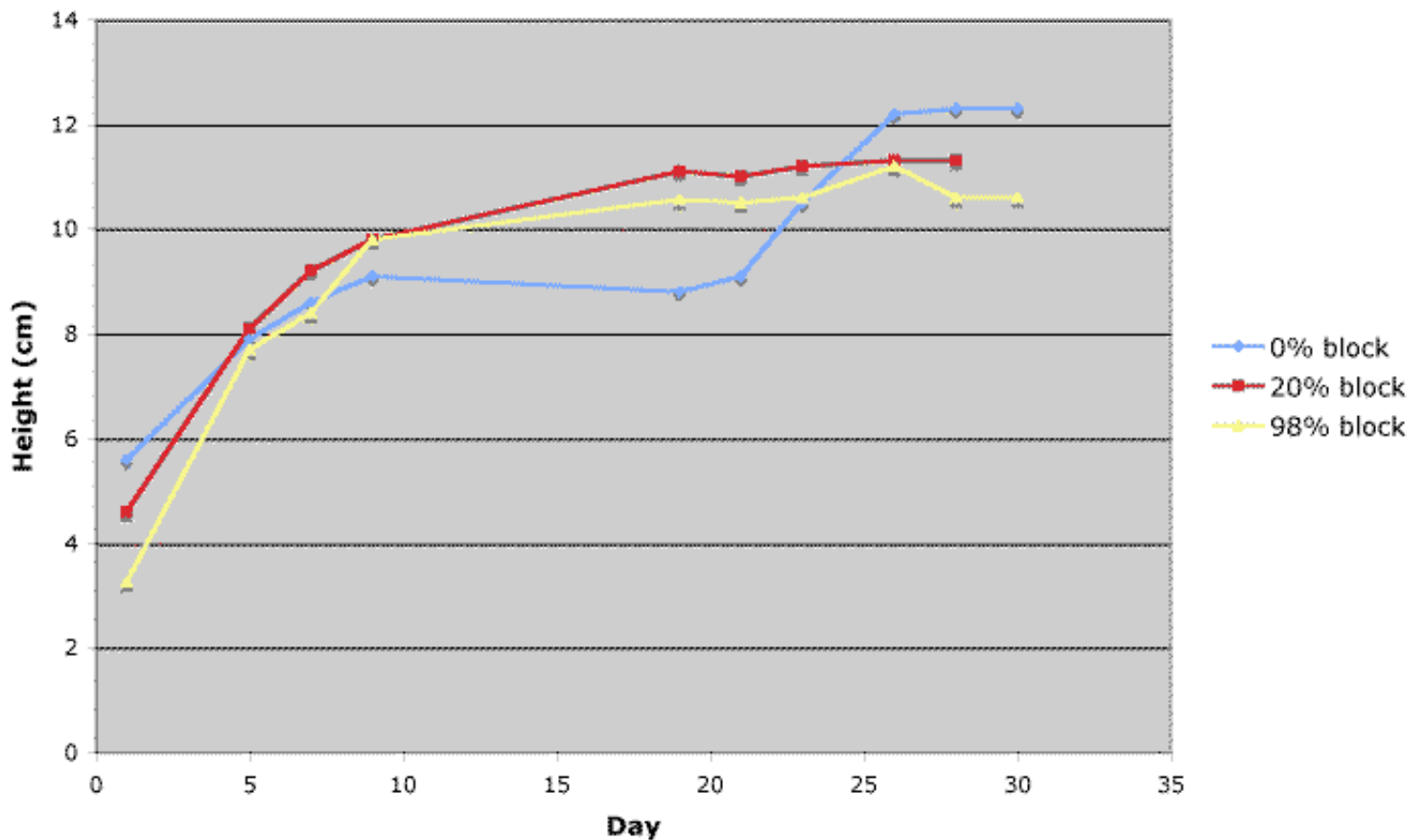
Radish with 20% Block

Average Height (cm)	4.6	8.1	9.2	9.8	11.1	11.0	11.2	11.3	11.3	
Number of Plants	6	9	9	9	5	3	2	2	2	0

Radish with 0% Block

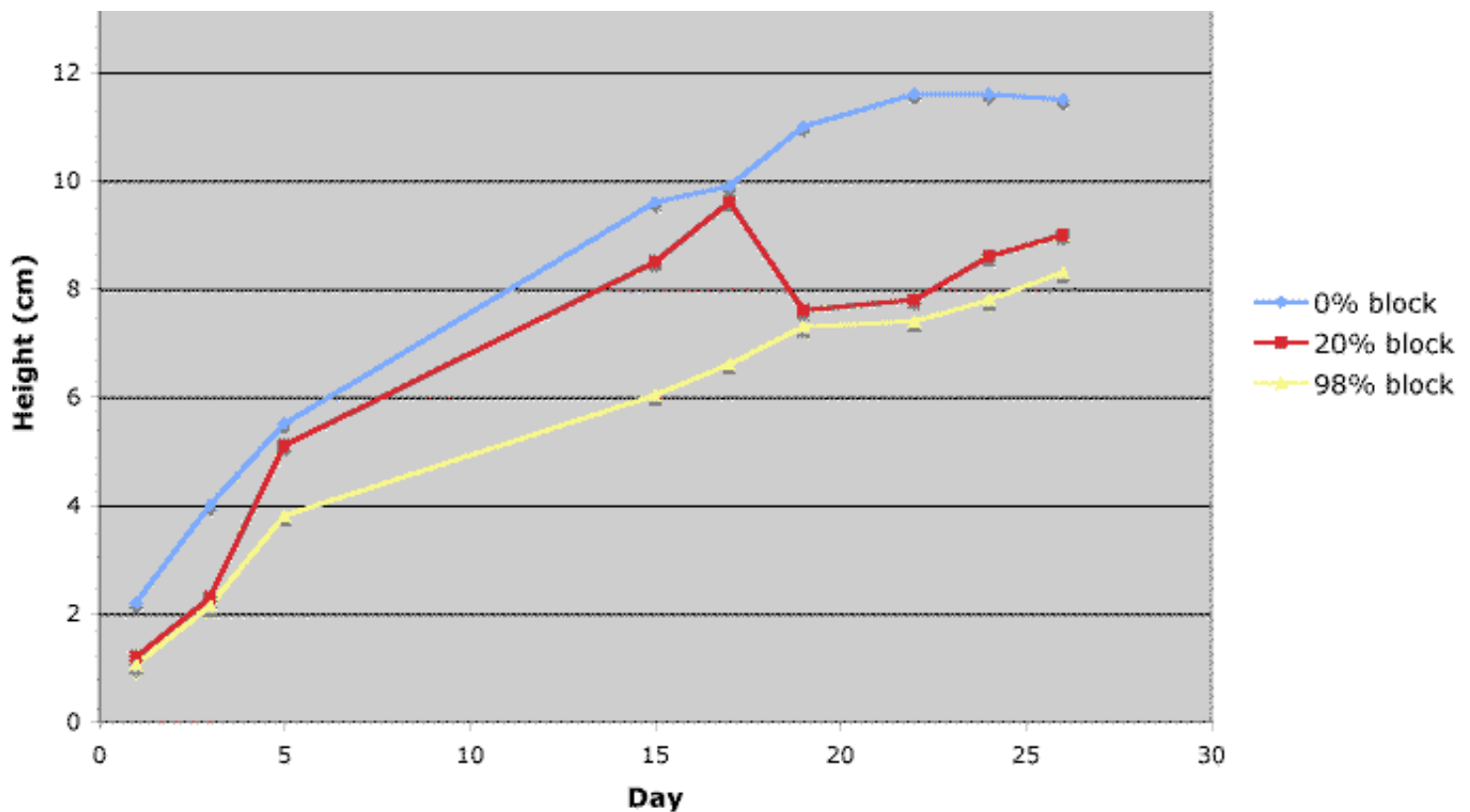
Average Height (cm)	5.6	7.9	8.6	9.1	8.8	9.1	10.5	12.2	12.3	12.3
Number of Plants	3	5	5	5	4	3	2	1	1	1
Sunflower with 98% Block										
Average Height (cm)		1.06	2.14	3.8	6.04	6.6	7.3	7.4	7.8	8.3
Number of Plants		5	5	5	5	5	5	5	5	4
Sunflower with 20% Block										
Average Height (cm)		1.2	2.3	5.1	8.5	9.6	7.6	7.8	8.6	9.0
Number of Plants		2	2	2	2	2	3	3	3	3
Sunflower with 0% Block										
Average Height		2.2	4.0	5.5	9.6	9.9	11.0	11.6	11.6	11.5
Number of Plants		3	3	3	2	2	2	2	2	2

Radish Plant Height



Sunflower Plant Height





Discussion

When looking at the graphs above, it would appear that in both the sunflowers and the radishes, the 0% UV-B radiation block (100% exposure to UV-B radiation) did the best and the 98% block (2% exposure to UV-B radiation) did the worst. But a factor that must be taken into consideration is how many plants remained on each day. You can find this information in the data tables. The averages are larger when there are fewer plants. Knowing this, you can see that the 98% block (2% exposure) has more than double the amount of plants on almost every day that the data was collected.

You may notice that the number of plants begin to grow smaller in most cases. The majority of the plants began to die after the 10-day period when no data was taken because of spring break. The most common cause of death was the base of the plant withering up. This was happening because of a fungal disease most commonly known as “damping off” (Jeff Ashton, professional gardener). This occurs when there is too much moisture and not enough air movement. This was certainly the case for the experiment since the plants were kept inside. The radishes were much more affected by the disease than the sunflowers. In the end six radishes from the 98% block (2% exposure) group died, nine from the 20% block (80% exposure) group, and four from the 0% block (100% exposure) group. The deaths affected the 20% blocked (80% exposure) radishes and the 0% blocked (100% exposure) radishes the most since they started out with a lesser amount of plants than the 98% block (2% exposure).

In conclusion, in both cases of the radishes and sunflowers, the plants with 0% UV-B radiation block (100% exposure) grew the most, 98% UV-B radiation block (2% exposure) grew the least, and 20% UV-B radiation block (80% exposure) in between. This conclusion is the opposite of the hypothesis and leaves many unanswered questions that will hopefully, in a later time, be explored and answered.

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