NEW TECHNIQUES IN WEED CONTROL VIA MICROWAVES

Frank Davis
Phytox Corporation - College Station, Texas

Phytox Corporation, a subsidiary of Oceanography International Corporation, was formed in 1971 after proprietary rights to a concept employing the use of ultra-high frequency electromagnetic energy of "microwaves" as an agricultural herbicide was purchased from Texas A&M University and its three co-inventors.

The development of this concept from scientific theory to engineered prototypes was a principal activity of the Company from 1971 to the present. The prototypes developed, called "Zappers," have been tested in the field by both the Company and federal and state researchers. The most recent prototype, designated Zapper III, underwent tests at the State-Federal Research Station at Weslaco, Texas. These tests have provided refined data necessary for the construction of the first semi-commercial prototype (Z-V-a).

In October, 1971, the Company purchased all proprietary rights to a discovery made at Texas A&M University concerning the toxic effects of microwaves on plants. The discovery was the result of the efforts of Drs. M. G. Merkle, J. R. Wayland, and F. S. Davis, then professors in the Soil and Crop Sciences, Physics, and Range Science Departments, respectively, of Texas A&M University.

The Company's first prototype to field test the discovery was named Zapper I. Zapper I has been used in a cooperative testing program with federal and state agricultural research agencies and with growers in Texas, California, Florida, New Mexico, Washington, Idaho, Nebraska, Arkansas, North Carolina, Georgia and Michigan.

The Zapper I test program proved that microwaves can be safely injected into soil in sufficient quantities to be an effective herbicide. In addition, microwaves also proved to be toxic to nematodes, certain fungi, and to soil-borne insect pests. Further, the phenomenon of growth stimulation was first observed in plants which germinated in "zapped" soil.

Following the initial Zapper I program, the Company built a second prototype, Zapper III, which was used to determine the cost of Zapper treatments required to destroy various types of weed seeds assuming different soil conditions, particularly moisture content. The Zapper III program also experimented with different equipment configurations in order to determine the most efficient system design for commercial use.

Based on its testing program and marketing research to date, the Company believes that the Zapper has three basic advantages over chemical herbicides and hand weeding.

First, its testing program has proven that Zapper applications are toxic to all weed seeds, not just those that become active (controllable by chemical herbicides) or those that emerge (controllable by hand weeding).

The second competitive advantage is that Zapper has no known negative implications for the environment. Besides the social implications, this advantage is economically important to the grower because the fact that Zapper does not result in a residue in the soil means that no arduous chemical analysis is needed to insure the safety of the crop, and the grower need not be concerned with chemical effects of the residue.

Thirdly, the Company believes that the Zapper can effectively compete on a cost-per-acre basis with other methods of weed control.

There are four basic components in a commercial Zapper unit: electrical generators, microwave transmitters, applicators, and the equipment chassis. All of these components, with the exception of the applicators, are available from a large number of vendors. The applicators will be manufactured under close supervision by the Company.

Cost of the first machines will prevent their purchase by all but a few very large growers. For the most part, Zapper service will be sold on a per-acre basis. The cost of application per acre will depend upon the width and depth of the treated band. We believe that offering a service is the most advantageous situation for the grower.

Following is a synopsis of some research results:

Crops tested include: cotton, soybeans, alfalfa, sugarbeets, watermelon, cantaloupe, strawberries, radishes, onions, lettuce, and others.

Pests controlled: (weeds) dodder, morning glory, cocklebur, ragweed, London rocket, annual sunflower, pigweed, lambsquarter, nutsedge, sow thistle, crabgrass, goosegrass, junglerice, nightshade and others. Field bindweed, Johnsongrass, nutgrass, and other perennial weeds are controlled but costs per acre are higher.

Nematodes: Cyst, lesion, spiral, reniform, root-knot, stunt, and others.

Fungus diseases: downy mildew, damping off and others.

Soil borne insects: wireworms, sugarbeet maggot, bollworm (cotton)

Duration of Control: With deep treatments, up to 12 months (no data have been taken for a longer period).

Microwaves are a form of radio waves. Thus they can be generated, sent through space and absorbed at a distance. Most materials have some degree of absorption so that microwave energy is used up in going through the material. This can cause the material to heat up or it can produce effects that are not a direct result of the heat produced. One can think of microwave fields as having many of the characteristics of the flow of air or just plain wind. It has direction and strength (e.g. with wind

20 mph from the southwest); it has energy (e.g. with wind it can turn a windmill or sail a ship). The wind can transport loose objects such as debris from trash pile to trash pile, and it can rotate and line up tied-down objects such as weather vanes. If the gusts come close enough together, our ears hear them as sound. When one deals with microwaves the miles per hour become volts per inch; debris becomes electrons and ions; weather vanes become molecular dipoles; gusts per minute become gigahertz; and horsepower becomes kilowatts. A comment on gigahertz: gip comes from the root for gigantic and means a thousand million or EP, a hertz is a cycle or gust per second.

Another aspect of microwaves is power and is practicably measured in kilowatts. Power is an expression of how much work microwaves can accomplish in a given time. A kilowatt is about one third more power than a horsepower.

When microwaves interact with weeds, nematodes, etc., they cause the molecules from which the weed, et al, are constructed to rotate, twist and bend (or if you wish to shake, rattle and roll). This causes damage to the internal structure of the seed or plant resulting in death. Experiments have shown that it is more than simple whole body heating and probably involves cell membrane disruption. The killing is physical in nature, not chemical.

Because microwaves can be turned on and off like the electric lights in your home, there is not a problem as with chemical residues to cause harm later. They can not penetrate metals, and it is possible to make them go just where you want them regardless of how hard the wind is blowing.

The deeper the treatment, the longer control lasts. Depth of soil treatment with Zapper I depends on the amount of energy used, and producing such energy is costly. For that reason, only the minimum depth needed should be treated.

On the current prototype, the microwave "horn" applicator, located under the machine, skims over the soil surface. For preparation of forest tree nurseries, several applicators will be located side by side, and close enough together so that the microwave bands overlap.

In a nursery situation, with near-broadcast conditions, the first commercial machines equipped with horn applicators should be able to treat 1-5 acres daily. If acreage must be covered quickly, several machines can be used. When using the horn, applications are not limited by soil temperature or moisture (except extremely wet conditions). The microwave treatment eliminates weed seeds, most pathogenic fungi, and nematodes in the treated zone. The rate of reinfestation is not known but if soil below the treated zone is not brought to the surface by plowing, it seems reasonable to assume that control would last for at least one full growing season.

A note on mycorrhizal fungi: There are no data available on the effect of microwaves on these desirable species. Presumable populations would be reduced by microwave treatment. In this event the recently developed practice of adding mycorrhizal fungi to the soil may be applicable.

Although cost figures are not final, the Company believes that the service can be offered to seedling nurseries for no more than the present cost of weed control.