Electrical weed control in the UK – the current situation.

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Abstract

Electrical weed control involves the application of very high voltage, short duration pulses or high voltage ac or dc current directly to the unwanted plants or the use of microwaves or radio frequency waves to destroy unwanted plants and seeds or to sterilise soil. The paper describes the techniques and briefly reviews some of the applications to which the techniques have been used, with particular emphasis on the United Kingdom. Equipment to remove weed beet from sugar beet crops and a general agricultural weed control machine are described, as well as a system for treating Japanese Knotweed. The rise in organic produce and the increasingly severe restrictions on the use of chemicals throughout the EU should have offered an opportunity for electrical weed control methods, as they are very environmentally friendly, but the authors do not know of any equipment being built or tested in the UK at the time of writing – in spite of several attempts to apply for funding.

Keywords

Electrical; high voltage; microwave; radio frequency; non-chemical; environmentally friendly; weed control; soil sterilisation; Japanese Knotweed

Introduction

Electrical weed control is an environmentally friendly method of killing weeds for horticulture and agriculture. It is not well used, however, although it has been practised for over 100 years, due to the well established (and effective) methods of controlling weeds by chemicals.

There are three main types of electrical methods. The first consists of applying high voltage (5 kV – 80 kV), short duration (µs) pulses to plants, either directly or by discharging to the plant via. an arc. Power levels are generally low, usually a few tens of Watts, depending on the pulse repetition frequency [1, 2]. The second system uses high voltages (5 kV – 15 kV), ac or dc, continuously generated, which are applied to the plants via. an electrode or electrodes [3, 4]. The third type uses high power (5 kW – 100 kW) microwaves (915 MHz or 2450 MHz) or radio frequency waves (13.5 MHz – 80 MHz) to kill the plants by heating them or to kill seeds, either on the surface or buried, or to sterilise soils [5, 6].

The techniques are rapid, versatile and effective, as the electric currents heat the plant tissue and destroy cellular integrity. In addition, high voltage pulses subject the plant stem to sudden shock waves and very high temperature plasmas – albeit for a few µs. Plants cannot adapt to them, so their effectiveness stays constant over time. A very wide variety of plants are treatable, ranging from grasses and cereals to plants such as nettles (*Urtica dioica*) and weed beet (*Beta maritima*). Plants can be a few cm high or a couple of metres tall. As the electrodes pass over the plants, they do not disturb the soil or leave any residues. They can be used on soils normally unworkable, e.g. too wet, for mechanical hoeing, so offering increased versatility of timing the weeding to farmers – an important factor in the UK with its wet springs and summers.

They are environmentally friendly, leaving no chemicals or residues to leach into the soil and so are ideal for the growing areas of organically farmed produce. Wildlife is not harmed. The authors have seen wildlife, disturbed from feeding, fly up and over or away from and round the equipment and go behind and continue feeding straightaway. The same equipment can be used on organic or non-organic farms, so increasing its usefulness both to farmers and contractors.

Development time for equipment is short, as the main generating systems are made from standard components and most development is in the applicators.

In spite of all these advantages, however, the methods are little used. The authors believe this is primarily not because they are unfamiliar to farmers, but they are familiar with chemical methods and the dosing requirements. Recent changes to EU legislation, however, mean that many chemicals will disappear or face severe restrictions, so alternative methods will have to be identified and used.

Presentation

The earliest electrical weed system that the authors are aware of is dated 1893 – a steam operated 'Vegetation Exterminator' [7]. Various designs and patents followed, but it was not until the Lasco Corporation of the USA stared to manufacture and sell electrical weed control equipment in the 1970s and 1980s, that high power, effective machines became available [8].

There had been interest in the UK in the effect of electricity on plants, but the emphasis was on helping them grow. There was a 'Committee for Electroculture' established in 1917, which delivered its final report in 1937 [9]. It systematically studied the effects of high voltage, electric fields on the growth of plants. Although it found some interesting effects, in that applying 30/60 kV to arrays of wires placed above growing crops in fields sometimes produced increases in yield, the disadvantages outweighed the advantages. In addition the advent of mechanisation and the use of artificial fertilisers made farming far more productive than the electrical systems studied.

Apart from some laboratory trials by Sidaway [10] and others in the UK, described in an extensive review of electrical methods [11] the next major study of the electrical methods was by the British Sugar Corporation and the University of Sheffield in the 1980s to combat weed beet in sugar beet crops. They used the direct contact, high voltage method and various machines were built over a period of 5 years. The final version [Figure 1] produced 15 kV at 50 kW and could treat 12 rows of crop whilst moving at 5 km hr^{-1}.

Figure 1: the British Sugar Corporation weed beet control machine developed in the 1980s

Trials showed it was effective [12], but the size and weight of the equipment, the introduction of the 'Weed Wiper' using a rope wick applicator to wipe herbicides onto the weed beet and the lack of any environmental pressures thirty years ago, meant that the technique was not commercialised and no further machines were produced at that time.

The next development in the UK came in the year 1999 with a machine built by Balls and Diprose for Wadhurst Park Farm Ltd. After some initial trials, a full size machine was built [Figure 2] in the year 2000 and its initial results were very promising. The builders were asked to submit plans for a three year development and trials programme, but before it was confirmed, the owner of the farm decided to withdraw from all his farming interests, apart from deer farming. All his farms and projects were closed apart from those changed to deer parks. This machine, like the previous one was dismantled.

Figure 2: The Wadhurst Park Farm machine; 2000

Since then, during 2006 and 2007 Balls and Diprose applied for various grants to build machines without success. The ideas were well received, but no funds were forthcoming. In 2008 the authors spent the summer taking a small, trailer based system, producing up to 5 kV at 5 kW [Figure 3], to various locations in the UK demonstrating the techniques. Demonstrations were given for the following:

Seedling thinning
Volunteer potatoes and haulm removal

Chrysanthemum weed (*Artemisia vulgaris*)
Between row weeds in carrots and parsnips

Figure 3: The portable apparatus of Balls and Diprose; summer 2008

Some experiments on treating carrots and weeds together.
Docks (*Rumex obtusifolius*) and thistles (*Cirsium arvense*) in rhubarb
Nettles (*Urtica dioica*)
Stale seedbed clearance
Windbreak crops

None of these were scientifically based trials, merely demonstrations as to the capability of the equipment and its potential for agricultural weed control. As a result, a contract was promised to the authors for building and trialling a machine for the 2009 season and also for a literature review of work done since the early 1980s, when Diprose, Benson and Willis [11] finished reviewing papers. Both of these were cancelled; one after the economic crisis of autumn 2008 and for contractual differences for the review. The net result of the work has been considerable interest – especially by organic growers – but no funding for equipment.

Diprose and Holland have developed an electrical technique for treating Japanese Knotweed (*Fallopia japonica*) with direct contact equipment. It is subject to patent applications in the UK and EU, so there are no publishable results available [13]. The electrical methods do not eradicate the weed, which is causing major problems in the UK, but does significantly reduce an infestation after a mechanical removal of ‘crowns’ (large, woody, spherical growths of rhyzome material, sometimes over 30 cm in diameter). After crown removal, the plants are treated electrically two or three times in a year and the treatment kills off the new growth and also damages the rhizome system – weakening the infestation considerably. It is the damage to the rhizomes, which is a particular aspect of the method, as normally, it is difficult to damage them. Generally, after electrical treatment, the remaining growth can easily be treated by hand pulling or by the new government proposal to use insects bred to eat only Knotweed.

In June of this year, a meeting was held to investigate alternative methods of weed control as a response to the EU directives that are appearing. One speaker outlined the losses

of herbicide types due to the Water Framework Directive and also the potential loss of herbicides under the new way of assessing dangers described in the 91/414/EEC Directive. This alters the assessment of herbicides to a hazard basis rather than the present system of risk of hazard assessment (a 'hazard' is the danger posed by a chemical and the 'risk' is the likelihood of the danger occurring). A presentation was given on electrical methods and created considerable interest. There were other systems described including the work on autonomous, robotic weeders, which scan crop rows, identify weeds and crops and remove the weeds. These use advanced recognition programmes and GPS for guidance. Following this meeting the authors have been invited to meet with a major grower in late August.

Conclusions

There are many benefits to using electrical methods of weed control in agriculture and horticulture. At present, however, to the best of the authors knowledge, there are no operational systems in the UK nor any scientific studies of the techniques. There are a few far-sighted farmers and growers who have been supporting the adoption of new approaches, but they are few and have not yet been heeded. Due to the growth in organic farming and the increase in restrictions on chemicals that can be used and reductions in doses for those that are still licensed, it is likely, however, that the industry will be forced to look at alternatives in the near future.

References

[1] V. I. Bayev, V. N. Savchuk. 1974. The effective factors of electric spark discharge in treatment of plants. Electrochemistry in Industrial Processing and Biology 1: 73–75

[2] N. Armyanov, V. Bayev, V. Savchuk, M. Diprose, S. Stefanova, T. Stoyanova and N. Nedlyakov: 1999. Basic treatment parameters in electric spark processing of plants and their impact upon its effectiveness. Agricultural Engineering Research Papers, Lithuanian Institute of Agricultural Engineering, Lithuanian University of Agriculture 31(3): 67-82

[3] M.F. Diprose, F.A. Benson and R. Hackam. 1980. Electrothermal control of weed beet and bolting sugar beet. Weed Research 20: 311-322

[4] A. Dexter, J.J. Freight. 1979. Zap weeds with Lightning Weeder. Weeds Today 10(3): 9-10

[5] K. F. Baker, W. H. Fuller. 1969. Soil treatment by microwave energy to destroy plant pathogens. Phytopathology 59: 193-197

[6] J. R. Wayland, F. S. Davis, R. M. Menges, R. Robinson. 1975. Control of weeds with UHF electromagnetic fields. Weed Research 15: 1-5

[7] A. A. Sharp. 1893. Vegetation Exterminator. USA Patent no. 402 635 (Feb. 28th 1893)

[8] W. G. Dykes. 1977. E. D. S. for control of broadleaf weeds in sycamore trees. Lasco Inc., Vicksburg, Mississippi, USA. Copy available from the authors.

[9] Board of Agriculture and Fisheries. 1918 – 1937. Reports 1–18 of the Electro-Culture Committee (Chairman: Sir J. Snell). Microfilm copy available from: Ministry of Agriculture, Food and Fisheries, Great Westminster House, Horseferry Road, London, SW1P 2AE.

[10] G. H. Sidaway, G. F. Asprey. 1968. Influence of electrostatic fields on plant respiration. International Journal of Biometeorology 12 (4): 321-329

[11] M.F. Diprose, A.J. Willis and F.A. Benson. 1984. The effects of externally applied electrostatic fields, microwave radiation and electric currents on plants and other organisms, with special reference to weed control. Botanical Review 50(2): 171-223

[12] M.F. Diprose, R. Fletcher, P.C. Longden and M.J. Champion. 1985. The use of electricity to control bolters in sugar beet (*Beta vulgaris L*.) crops; a comparison of the electro-thermal with chemical and mechanical methods. Weed Research 25: 53-60

[13] R. E. B. Holland, M. F. Diprose. U. K. Patent Application no. 05 22 275.7 Japanese Knotweed Control (in process).

[14] M.F. Diprose. 2001. Some considerations when using a microwave oven as a laboratory research tool. Plant and Soil 229: 271-280.

About the authors

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A chartered Engineer with 30 years experience in academic research and teaching at the University of Sheffield. A specialist in inter-disciplinary work he has been involved in projects ranging from electrical weed killing to developing systems for preventing marine bio-fouling in ships seawater piping systems. Introduced innovative methods into his teaching. He took early retirement in 2006 to start a company – Spectrum-tec – specializing in science communication and electrical weed control.

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Mr. Roger Balls

A professionally qualified engineer, specialising in the design and use of machinery in the agricultural and horticultural sectors; for many years specialising in the machinery associated with intensive production of high value horticultural crops and potatoes. This included the engineering input into equipment development projects on onions, daffodil bulbs, brassica and rapid seed germination. This work has been done both in the UK and overseas.
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