Flame Weeding in Corn, Soybean and Sunflower

Stevan Z. Knezevic

Professor of Integrated Weed Management Northeast Research and Extension Center, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Concord, Nebraska 68728, USA Email: sknezevic2@unl.edu
1-402-584-3808/1-402-584-3859 (fax)

Abstract. Flaming as a vegetation control method based on utilizing heat to increase temperatures high enough to boil water inside the plant tissue, which is then resulting in plant death from the loss of membrane and cuticle breakdown (plant desiccation), denaturation of proteins, and water boiling. Machines are available to deliver the heat utilized during the flame weeding, and they are commonly referred as “weed flamers”. A propane-fueled weed flamers utilize a propane-fueled burners to expose plant tissues to rapid heat. Several flame weeding systems are commercially available, ranging from small, handheld flamers that can be used to control weeds in residential home gardens to multi-row (tractor-pulled) flamers for use over larger acres of land. Flame weeding has a potential to be used effectively in at least 6 agronomic crops (field corn, sweet corn, popcorn, sorghum, soybean, sunflower) when conducted properly at the most tolerant growth stage.

Keywords: Flaming, flame weeding, propane, weed, crop, heat.

1 Introduction

The interest for organic crop production in the United States is increasing due to strong demand for organic food from consumers and an attractive income potential for organic farmers. Organic crops can be used for human consumption (food grade crops) or making organic feed rations and different food products. Weeds are one of the major pests and are responsible for significant reductions in crop yields. Organic production systems do lack an effective weed management practice, as weeds are a major production-related problem because the use of synthetic herbicides is not allowed. Therefore, organic producers rely extensively on mechanical cultivation and hand weeding. Mechanical cultivation is one of the most commonly utilized weed control practices in row crops. Cultivation, however, leaves a strip of uncontrolled weeds within 10-15 cm on either side of the crop row, directly influencing crop yield. Also, repeated cultivation causes loss of soil organic matter, destroys soil aggregate, increases the chance for soil erosion and promotes emergence of new weed flushes. The labor required for hand weeding is expensive in USA (ranging from \$300 to \$800 ha^{-1}), time consuming and difficult to organize

Proceedings of the 8th International Conference on Information and Communication Technologies in Agriculture, Food and Environment (HAICTA 2017), Chania, Greece, 21-24 September, 2017.

(Kruidhof et al., 2008). Hence, systems-oriented approaches to weed management that make better use of alternative weed management tactics need to be developed (Kruidhof et al., 2008). Propane flaming is one of the most promising alternatives for weed control in organic cropping systems (Knezevic, 2009). Therefore, the objective of this brief article is to provide some insights of this innovative method of weed control and promote our manual for propane fueled flame weeding. Since this conference is about Information and Communication Technology, the hope is that the topic of flame weeding will contribute “a new type of information” and make colleagues who work in the area of information technology aware of this new technology for weed control.

2 Propane flaming (Flame weeding)

Propane flaming (or flame weeding), is a process of exposing plant tissues to flames coming from a propane burner, which can generate combustion temperatures of up to 1,900 ^{o}C. Direct heat injury results in denaturation of membrane proteins, which further results in loss of cell function (Lague et al., 2001). Direct heat injury also causes cell proteins to denature (starting at 113 degrees Fahrenheit or 45 degrees Celsius). Temperatures in the range of 203–212 degrees Fahrenheit (95–100 degrees Celsius) have been lethal to weed leaves and stems when applied for at least 0.1 seconds, which further results in cell desiccation and ultimately the loss of cell function (Lague et al., 2001). The loss of water and denaturing of proteins drastically reduces the weed’s competitive ability to survive. In general, plants die from loss of membrane semi-permeability and cuticle breakdown (resulting in plant desiccation), denaturation of proteins, and other chemical decomposition. Morphological differences of plant species are important in determining sensitivity to heat, including factors such as: leaf type, leaf thickness, leaf cuticle type, location of growing point, nature of storage organs. Leaf orientation (upright or flat) and shape, cuticle characteristics, presence of hair, growth stage, and degree of stress (both moisture and nutrient) will affect sensitivity or interfere with a passing of the heat.

2.1 Flame Weeding Equipment

Propane-fueled flaming equipment must have several major components to carry out a successful and safe flaming treatment. The following are basic equipment components: propane supply tank, supply network and plumbing, torches (burner) (Knezevic et al, 2014b).

2.2 Weed response to propane flaming

Ascard (1995) classified weed species to four groups according to their susceptibility to propane flaming. The first group consisted of species with unprotected growing points and thin leaves [e.g., common lambsquarters (*Chenopodium album* L.)]: these species can be easily controlled using propane doses of 20 to 50 kg/ha. The second group consisted of species with relatively protected growing points and leaves that were moderately heat-tolerant [e.g., common knotgrass (*Polygonum aviculare*)]: these species can be completely controlled, but required propane doses higher than 50 kg/ha. The third group contained species with more protected growing points [e.g., shepherd's purse (*Capsella bursa-pastoris*)]: these species can be completely controlled at early stages (up to 4-leaf stage), but complete control is difficult to achieve at later growth stages. The fourth group consisted of plants with creeping growth habit and well protected growing points (e.g., perennial broadleaf and grasses): these plants regrow from their below ground meristems. To control species belonging from the third and the fourth group, flaming treatments should be conducted more than once.

Knezevic et al., (2009c; 2014a, b) determined that the propane doses of 60-80 kg/ha were highly effective in controlling many broadleaf weeds at early growth stages (up to 25 cm tall). Such doses provided over 90% control of major broadleaf species (velvetleaf, ivyleaf morningglory (*Ipomoea hederacea* Jacq. (=*I. barbigera* Sweet, *I. desertorum* House), redroot pigweed (*Amaranthus retroflexus* L.), common waterhemp, lambsquarters, field bindweed (*Convolvulus arvensis* L. (=*C. ambigens* House, *c. incanus auct. Non* Vahl), kochia (*Kochia scoparia* (L.) Schrad. [=*K. alta* Bates, *K. sieversiana* (Pallas) C.E. Mey.]), and Venice mallow (*Hibiscus trionum* L. [=*Trionum t.* (L.) [= *Trionum t.* (L.) Woot. & Standl.])) and 80% control of several grass species (barnyardgrass (*Echinochloa crus-galli* (L.) Beauv. [= *E. pungens* (Poir.), Rydb., *Panicum c.* L.]), green foxtail, and yellow foxtail (*Setaria glauca* (L.) Beauv. [=*S. lutescens* (Wreigle), F.T. Hubbard,*S. pumila* (Poir.) Roemer and J.A. Schultes])). The annual broadleaf and grass weed species responded differently to the flame and heat (Ulloa et al., 2010a, b). Leaves of annual broadleaf species were completely desiccated within a few days after flaming, and there was no plant regrowth especially when flamed with doses above 60 kg propane ha^{-1}.

2.3 Flame Weeding in Agronomic Crops

Crop susceptibility to propane flaming varies with species and growth stages (Knezevic and Ulloa, 2007). Grass type crops (e.g., field corn, popcorn, sweet corn and sorghum) are more tolerant to propane flaming than the broadleaf crop (e.g., soybean). Post-emergent flaming is not recommended in winter wheat due to high injury level and unacceptable yield reduction. Corn and sorghum can be safely flamed at their growth stages between VE (emergence) to V10 (10-leaf) stage. Soybean is tolerant to flaming only at the VE-VC stage (emergence-unfolded cotyledon) and at the V4-V5 stage (4-5 trifoliate). It is not recommended to flame soybean at the VU, V1 (first trifoliate), V2 and V3 (third trifoliate), as these stages are very sensitive to heat and will result in very high crop injury and yield reduction (Knezevic et al. 2014b).

2.4 Economics of flame weeding

From an economic stand point, the costs of a single flaming operation applied broadcast below crop canopy could be \$30–\$40/ha, without taking into account the costs of the equipment and labor [current price of propane (\$0.5/kg × 60–80 kg). Banded application (over the crop row) of flaming can cost \$12–\$20/ha due to lower propane use rates (30–40 kg/ha).

2.5 Practical implications of flame weeding

Flame weeding is an acceptable weed control option in organic production and has received renewed interest for conventional cropping systems. It can be used as part of an integrated pest management program not only for weeds but also for insect control in agronomic crops. Flaming has a potential to be used effectively in organic crop production systems of three corn types, sorghum, soybean and sunflower when conducted properly at the most tolerant growth stage. It is important to emphasise that propane flaming should not be the only method for non-chemical weed control; however, it could be part of an IWM program. Other measures are still needed to control weeds that emerge later during the growing season. More research is needed to perhaps develop new flaming equipment and methods of flaming. Information from such research would expand flaming options as part of an IWM program for both organic and conventional crop production systems.

2.6 Manual for Propane-Fueled Flame Weeding in corn, soybean and sunflower

From 2006-2012 we have conducted a series of over 40 studies, which were funded by PERC and other sources (e.g. USDA). This extensive work resulted in over 20 journal and proceeding articles about crop tolerance to heat and weed control with flame weeding in field corn, popcorn, sweet corn, sunflower, soybean, sorghum and winter wheat. We compiled the above research information into a training manual that describes the proper use of propane fueled flaming as a weed control tool in six agronomic crops (field corn, popcorn, sweet corn, soybean, sorghum, and sunflower). The flame weeding manual contains 32 pages of text and color pictures. The pictures provide visuals of crop growth stages when flaming can be conducted safely without having side-effects on crop yield. Pictures of weeds provide visuals of appropriate growth stages when weeds need to be flamed to achieve good weed control. There are six chapters in the manual: (1) The need for alternative weed control methods; (2) Propane fueled-flame weeding; (3) How flame weeding works; (4) Equipment and configurations; (5) Propane dosage at different weed growth stages, and (6) Crop Tolerance to post-emergent flame weeding. We believe that our manual provides a recipe on how to use flaming procedures and it is written in a user friendly manner that can be understood by the general public. The manual is free, it can be downloaded in a pdf format from the following website: http://www.agpropane.com/ContentPageWithLeftNav.aspx?id=1916

References

1. Ascard, J. (1995). Effects of flame weeding on weed species at different developmental stages. Weed Res. 35, 397–411.
2. Knezevic, S. Z., and Ulloa, S. M. (2007). Flaming: potential new tool for weed control in organically grown agronomic crops. J. Agric. Sci. 52, 95–104.
3. Knezevic, S. Z. (2009). Flaming: A New Weed Control Tool in Organic Crops. Crop Watch, University of Nebraska-Lincoln Extension. Web page: http://cropwatch.unl.edu/archives/2009/crop17/organic_flaming.htm (accessed March 12, 2012).
4. Knezevic, S. Z., Datta, A., and Ulloa, S. M. (2009c). Tolerance of selected weed species to broadcast flaming at different growth stages. In "Proceedings of the 8th European Weed Research Society Workshop on Physical and Cultural Weed Control" (D. C. Cloutier, Ed.), pp. 98–103, Zaragoza, Spain.
5. Knezevic S., Stepanovic S, and Datta A. 2014a. Growth Stage Affects Response of Selected Weed Species to Flaming Propane. Weed Technology, 28(1):233-242.
6. Knezevic, S., A. Datta, C. Bruening and G. Gogos, 2014b. Propane Fueled Flame Weeding in Corn, Soybean and Sunflower. A 38 page manual, free downloads from http://www.agpropane.com/ContentPageWithLeftNav.aspx?id=1916
7. Kruidhof, H. M., Bastiaans, L., and Kropff, M. J. (2008). Ecological weed management by cover cropping: effects on weed growth in autumn and weed establishment in spring. Weed Res. 48, 492–502.
8. Lague, C., Gill, J., and Peloquin, G. (2001). Thermal control in plant protection. In "Physical Control Methods in Plant Protection" (C. Vincent, B. Panneton, and F. Fleurat-Lessard, Eds.), pp. 35–46, Springer-Verlag, Berlin, Germany.
9. Ulloa, S. M., Datta, A., and Knezevic, S. Z. (2010a). Growth stage influenced differential response of foxtail and pigweed species to broadcast flaming. Weed Technol. 24, 319–325.
10. Ulloa, S. M., Datta, A., and Knezevic, S. Z. (2010b). Tolerance of selected weed species to broadcast flaming at different growth stages. Crop Prot. 29, 1381–1388.