ZIBELINE INTERNATIONAL™ PUBLISHING
ISSN: 2710-6012 (Online)
CODEN: JWBMAO

Journal of Wastes and Biomass Management (JWBM)

DOI: http://doi.org/10.26480/jwbm.01.2026.44.49

CrossMark

REVIEW ARTICLE

PHYSICAL WEED CONTROL METHODS

Alisha Adhikari, Bharat Adhikari, Abhishek Pokhrel*

Department of Agronomy, Agriculture and Forestry University, Rampur, Chitwan, Nepal
****Corresponding Author Email: Abhipokhrel777@gmail.com***

ARTICLE DETAILS

Article History:

Received 13 March 2026
Revised 21 April 2026
Accepted 15 May 2026
Available online 04 June 2026

ABSTRACT

Weeds are major biological constraints to agricultural productivity, causing significant yield losses by competing with crops for water, nutrients, light and space. Although chemical herbicides provide quick and effective control, their excessive use has resulted in environmental pollution, herbicide resistance, health risks and biodiversity loss. Consequently, physical weed control methods have gained importance, particularly within Integrated Weed Management (IWM) and organic farming systems. This paper reviews key physical methods, including burning, flaming, soil steaming, soil solarization and mulching and discusses their mechanisms, advantages, disadvantages and practical applications. Burning and flaming use heat to destroy weed plants and reduce the soil seed bank. Soil steaming and solarization increase soil temperature to levels lethal to weed seeds and soil-borne pathogens. Mulching suppresses weed growth by blocking light and modifying soil microclimatic conditions. These approaches reduce reliance on chemical herbicides and help minimize pesticide residues in soil and water. However, their broader adoption is constrained by high labor requirements, energy consumption, environmental concerns such as smoke emission and plastic waste and substantial initial investment costs. Despite these limitations, physical weed control methods contribute significantly to sustainable agriculture, especially in high-value and organic cropping systems and are most effective when integrated with cultural and biological practices.

KEYWORDS

Integrated Weed Management, burning, flaming, soil steaming, soil solarization, mulching

1. INTRODUCTION

Weeds, insect pests and pathogens are the three major biological factors affecting agriculture. Among these, weeds cause significant crop losses and yield reduction (Weerakkody and Hettiarachchi, 2025). The impact of weeds on productivity of food crops have been increasingly experienced worldwide. Weeds in agricultural fields cause significant crop yield losses by competing with crops for water, light, nutrients and space. Chemical control is currently the most widely used weed management method because it is easy to apply and provides rapid results. However, concerns over the negative impacts of pesticides on human health and the environment, the increasing development of herbicide-resistant weeds and the growing demand for organic products have highlighted the need for more environmentally friendly technologies in agriculture. Herbicide leaching into surface and groundwater, along with residues in drinking water and food, represents a serious public health concern (Rifai et al., 2002).

Weed management is one of the major challenges faced by organic farmers. In most organic farming systems, weeds are primarily controlled through mechanical methods. However, thermal weed control is becoming increasingly popular. It can be applied in different crops (Shrestha et al., 2013). In many countries, various thermal techniques such as flaming, combustion gases and hot water are used in organic farms. Studies have shown that thermal weed control can be more effective than mechanical methods (Ascard et al., 2007). Thermal weed control influences not only weeds but also insect pests, pathogenic microorganisms and other disease-causing agents in crops. However, limited information is available regarding its effects on fungal diseases. Previous studies reported that steam treatment reduced Verticillium and dark leaf and pod spot incidence in winter oilseed rape, while flaming decreased blossom end rot in tomato (Marcinkevičienė et al., 2018; Wszelaki et al., 2007). Physical weed control methods are widely used in organic and integrated weed management systems where reduction of chemical herbicide use is required (Bennett et al., 2005; Batlla and Arnold, 2007). Thermal weed control can be applied in different crops and has been reported to be effective in organic farming systems (Shrestha et al., 2013; Ascard et al., 2007). Burning is practiced in field crops, grazing lands and as a harvest weed seed management tool to reduce the weed seed bank (Walsh and Newman, 2007; Alexander et al., 2016). Seasonal burning is used to remove old biomass and stimulate new forage growth in grazing systems (Alexander et al., 2016). Flaming is applied before sowing, before crop emergence, before transplanting and post-emergence in heat-tolerant crops such as maize, soybean and sorghum (Peruzzi et al., 2010; Ulloa et al., 2011). It is particularly suitable in organic farming and in situations where soil moisture prevents mechanical weeding (Sivesind et al., 2009; Domingues et al., 2008). Soil steaming is mainly used as a pre-emergence technique in high-value and organic crops to destroy weed seeds and seedlings (Peruzzi et al., 2012). Band steaming is used to reduce energy consumption while maintaining weed suppression within crop rows (Melander and Jørgensen, 2005). Steam treatment has effectively suppressed weeds in onion fields and reduced weed biomass (Vasinauskienė et al., 2019).

Soil solarization is used in direct-seeded and closely spaced crops where mechanical cultivation may damage crops and it serves as an alternative to herbicides in integrated weed management systems (Shaw, 1982; Katan et al., 1976). Mulching is commonly used in organic and low-input cropping systems to reduce weed pressure, conserve soil moisture and improve crop establishment (Ramakrishna et al., 2006). Living mulches

Quick Response Code	Access this article online	
	Website: www.jwbm.com.my	**DOI:** 10.26480/jwbm.01.2026.44.49

are used where soil conservation and ecological sustainability are priorities, while plastic films are adopted in high-value crops requiring effective weed suppression and soil temperature regulation (Kitis et al., 2011; Parmar et al., 2013).

2. Physical Weed Control Method

Physical weed control refers to the use of mechanical or thermal techniques to remove, damage, or kill weeds, thereby reducing weed density and minimizing competition with crops for light, water, nutrients and space. The primary objective is to enhance crop yield and improve produce quality without relying solely on chemical herbicides.

It is considered one of the key components of Integrated Weed Management (IWM), where multiple control strategies are combined for sustainable weed suppression. Various physical weed control methods are practiced in different cropping systems, including burning, flaming, soil steaming, soil solarization and mulching, each applied according to crop type, growth stage and environmental conditions.

2.1 Burning

Burning is a traditional physical weed control method that uses fire to remove vegetation, recycle nutrients and suppress weeds or weed seeds (Walsh and Newman, 2007). Burning may be conducted as field burning, stubble burning, or windrow burning. In windrow burning, crop residues containing weed seeds are concentrated into rows and burned to reduce the weed seed bank.

Seasonal burning is also practiced in grazing systems to remove old biomass and stimulate new forage growth (Alexander et al., 2016). Burning produces ash that temporarily enhances soil fertility in the surface layer (0–5 cm) by increasing organic carbon and exchangeable bases.

The heat generated during burning can raise soil temperature, leading to short-term increases in soil pH, cation exchange capacity (CEC) and the availability of essential nutrients such as calcium (Ca), magnesium (Mg), potassium (K)and phosphorus (P). However, excessive temperatures may reduce CEC and cause nutrient losses, particularly Ca, Mg, K and P (Giovannini et al., 1990).

These fertility improvements are generally short-lived. After burning, soils become more vulnerable to rainfall-induced nutrient leaching and fertility levels often decline within about 90 days. Repeated burning can negatively affect soil physical, chemical, biological and mineralogical properties, including reductions in microbial populations such as microfungi (Santana et al., 2013).

Figure 1: Types of Burning

2.1.1 Advantages

Recycling nutrients bound in plant residues, burning helps return essential elements to the soil. It is also effective in controlling woody plants and herbaceous weeds, thereby reducing competition. Additionally, it improves forage quality and stimulates plant growth in grazing systems (Howenstine et al., 2012). Furthermore, it can be utilized as a harvest weed seed management tool, contributing to the reduction of weed seed banks (Walsh and Newman, 2007).

2.1.2 Disadvantages

There is limited documented evidence on its overall efficiency in destroying weed seeds (Walsh and Newman, 2007). Smoke emissions can negatively affect air quality and public health, requiring careful management (Howenstine et al., 2012). Long-term or repeated burning can reduce soil fertility, increase nutrient leaching and decrease beneficial microbial activity (Giovannini et al., 1990; Santana et al., 2013).

2.2 Flaming

Flaming is a thermal weed control method that suppresses or kills weeds by exposing plant tissues to intense heat (≥100 °C) for a very short duration (usually less than 1 second), resulting in protein coagulation and disruption of respiration and other vital plant functions (Hewitt et al.,1998). Unlike direct burning, flaming heats plant tissues without completely incinerating them (Leroux et al., 2001). Historically, it was widely used from the late 1930s to the mid-1960s, particularly under humid tropical conditions (Raffaelli et al., 2010). Flaming is carried out using liquefied petroleum gas (LPG) or propane burners that produce a controlled and directed flame passed briefly over weeds. Its effectiveness depends on operational factors such as nozzle size, number of nozzles, burner type, flame temperature and gas–air ratio (Vanhala et al., 2004). It can be applied before sowing, before crop emergence, or before transplanting and also post-emergence in heat-tolerant crops such as maize, soybean and sorghum (Peruzzi et al., 2010; Ulloa et al., 2011).

Figure 2: Flaming

2.2.1 Advantages

Highly effective against tender, herbaceous weeds with high water content, especially small annual broadleaf weeds at the seedling stage (Cisneros and Zandstra, 2008). It is suitable for organic farming systems where herbicides are prohibited (Sivesind et al., 2009). It can be used when the soil is too moist for mechanical weeding (Domingues et al., 2008). It is less costly than hand weeding and has minimal impact on deeper soil microbial biomass (Rahkonen et al., 1999).

2.2.2 Disadvantages

It is less effective on mature weeds and grassy species (Cisneros and Zandstra, 2008; Holekamp, 1954). Open-flame systems may cause heat loss and potential crop injury, while shielded burners may increase fuel consumption (Vanhala et al., 2004). It may negatively affect beneficial flora and fauna and contribute to greenhouse gas emissions such as CO_2, CH_4 and N_2O (Abou et al., 2018).

2.3 Steaming

Soil steaming is a thermal weed control method in which high-temperature steam is applied to the soil to kill weed seeds and young seedlings before crop emergence. It is mainly used as a pre-emergence technique because it does not differentiate between crop and weed species. Due to concerns over environmental pollution and health risks from chemical fumigants, soil steaming has re-emerged as an important non-chemical alternative, particularly in organic farming systems. The primary mechanism of soil steaming isheattransfer into the soil, which raises soil temperature to levels that denature proteins, disrupt cell membranes and inactivate enzymes in weed seeds and seedlings. Exposure to temperatures between 50–100°C for a sufficient duration can kill both germinated weeds and ungerminated seeds, including dormant seeds (Peruzzi et al., 2012). The effectiveness of steaming depends on peak temperature reached, duration of heat exposure, soil moisture and soil texture. Some researchers emphasize that achieving a high peak temperature is critical, while others suggest that maintaining moderate temperatures (50–60°C) for a longer period can also ensure seed mortality (Melander and Kristensen, 2011; Dahlquist et al., 2007). Steam can be applied either as broadcast steaming (treating the entire soil surface) or band steaming (treating only crop rows). Band steaming reduces energy consumption while maintaining weed suppression in the crop zone (Melander and Jørgensen, 2005). The addition of exothermic materials such as calcium oxide (CaO) can prolong high soil temperatures and enhance weed seed devitalization (Barberi et al., 2009). Soil characteristics also influence performance; sandy soils allow better steam diffusion but may require more time to reach target temperatures (Melander and Kristensen, 2011).

2.3.1 Advantages of soil steaming

It is effective control of a wide range of weed species, including dormant seeds. It provides long-term reduction of the weed seed bank. It is suitable for organic farming systems. It leaves no chemical residues in soil or crop. It can also suppress certain soil-borne pests and pathogens (Luvisi et al., 2015). Band steaming reduces hand weeding time and can significantly increase crop yield, especially in weakly competitive crops like carrot (Raffaelli et al., 2016).

2.3.2 Disadvantages of soil steaming

It needs high initial investment and operational cost, high fuel or energy consumption. Limited field capacity compared to mechanical methods.Temporary negative effects on soil microorganisms, including nitrifying bacteria and enzyme activities (Roux-Michollet et al., 2008; Elsgaard et al., 2010). Possibility of selecting heat-tolerant weed species or pathogens (Altenburger et al., 2014). Sub-lethal temperatures may stimulate germination in some species by breaking dormancy (Vidotto et al., 2013). So, soil steaming is a promising non-chemical weed management technique, particularly for high-value crops and organic production systems. However, its economic feasibility and energy requirements remain major limitations and its integration with other weed management practices is recommended for sustainable long-term control.

2.4 Soil solarization

Soil solarization is a physical weed control method that utilizes solar energy to suppress weeds without the use of chemical herbicides. In this technique, moist soil is covered with transparent polyethylene (PE) film during periods of high solar radiation. The plastic cover traps heat, creating a greenhouse effect that significantly increases soil temperature (Katan et al., 1976). The elevated temperature damages or kills weed seeds and young seedlings by denaturing proteins, disrupting cell membranes and inhibiting essential metabolic processes. Prolonged exposure to high temperatures reduces weed seed viability and weakens the soil weed seed bank, resulting in lower weed emergence in subsequent crop growth stages. As a component of Integrated Weed Management (IWM), soil solarization offers an environmentally friendly approach to weed suppression. It is particularly suitable for high-value, direct-seeded, or closely spaced crops where mechanical cultivation is difficult and excessive herbicide use is undesirable. By reducing weed pressure before crop establishment, soil solarization improves crop growth conditions and contributes to sustainable agricultural production (Shaw, 1982; Katan et al., 1976).

Figure 3: Soil Solarization

3. The Mechanism of Soil Solarization is Based on The Greenhouse Effect

Transparent polyethylene allows short-wave solar radiation (0.3–3 μm) to pass through into the soil.The heated soil emits long-wave radiation (4–40 μm), which is trapped beneath the plastic film.Soil temperature increases significantly over several weeks.High temperature damages cellular proteins, enzymes and membranes of weed seeds and soil organisms (Singla et al., 1997). Moist soil enhances heat conduction and increases the lethal effect on weed seeds. Weed seed mortality depends on both temperature and duration of exposure. In addition to direct heat injury, indirect effects such as increased nutrient availability may also influence weed emergence and soil microbial activity (Stapleton et al., 1985). Solarization is particularly effective against weeds not easily controlled by selective herbicides, such as Malvaparviflora, Convolvulus arvensis and Abutilon theophrasti. Winter annual weeds like Lactucaserriola, Poaannua and Senecio vulgaris are effectively controlled under solarization conditions. However, some warm-season weeds may tolerate high temperatures and certain species such as Melilotussulcatus show resistance (Elmore, 1991). In some cases, solarization has been ineffective against Indigofera species and emergence of Cyperus rotundus from tubers has even increased under polyethylene mulching (Kumar et al., 1993).

3.1 Mulching

Mulching is a physical weed control method in which a material is placed on the soil surface to block light and physically suppress weed emergence and growth (Bond and Grundy, 2001). It is widely accepted in integrated non-chemical weed management and organic farming systems because it reduces reliance on synthetic herbicides (Massucati and Kopke 2014). The principal mechanism of mulching is the interruption of light penetration to the soil surface, thereby inhibiting weed seed germination and seedling development. Mulches also modify soil temperature and moisture, indirectly influencing weed suppression and crop growth (Parmar et al., 2013). Mulches are broadly classified into living mulches (cover crops grown alongside the main crop) and non-living mulches (organic residues, compost, straw etc.). Living mulches suppress weeds through competition for light, nutrients and space, while non-living mulches act mainly through physical soil coverage and light exclusion.

3.1.1 Uses of mulching in different situations

Mulching is commonly used in organic and low-input cropping systems where chemical weed control is restricted or avoided. It is applied in row crops and vegetable production to reduce weed pressure, conserve soil moisture and improve crop establishment (Ramakrishna et al., 2016). Living mulches such as white clover (Trifolium repens) and other legumes are used in crops like maize, soybean, cabbage and strawberry to suppress weeds and reduce soil erosion while improving soil fertility. Their use is recommended when ecological sustainability and soil conservation are primary objectives (Kitis et al., 2011). Biodegradable mulches such as straw, sawdust, compost and paper are used where seasonal soil coverage and easier incorporation into soil are desired. Straw mulch is particularly used in vegetable systems to reduce weed density and biomass (Grassbaugh et al., 2002). Non-biodegradable polyethylene (PE) and polypropylene (PP) films are used in high-value crops and perennial systems where maximum weed suppression and soil temperature regulation are required. These films are commonly adopted in crops requiring warmer soil conditions and improved moisture conservation (Parmar et al., 2013). Gravel and inorganic mulches are used in long-term plantations or landscaping systems where durable weed suppression is required (Qiu et al, 2014).

Figure 4: Mulching

3.1.2 Advantages of mulching

Mulching significantly reduces weed germination and biomass by preventing light from reaching the soil surface (Monks et al., 1997). It improves soil moisture retention and regulates soil temperature, thereby enhancing crop growth and yield. Organic mulches contribute to improved soil structure, increased microbial activity and humus formation through decomposition (Kosterna, 2014).

Living mulches help reduce soil erosion and nitrate leaching and enhance ecological balance within cropping systems (Gibson et al., 2011). Film mulches effectively prevent weed emergence and reduce runoff, erosion and pest incidence. Biodegradable mulches can be incorporated into the soil after use, reducing labour required for removal.

3.1.3 Disadvantages of mulching

Living mulches may compete with the main crop for water, nutrients and light, potentially reducing crop yield if not properly managed. Straw mulch may harbor rodents and pests and can introduce weed seeds if contaminated. Compost mulches may contain viable weed seeds, reducing their effectiveness for weed suppression (Bozic et al., 2015). Non-biodegradable PE and PP films pose environmental disposal problems and require removal after use.

Improper disposal, including burning, leads to environmental pollution. These films are costly for small farmers and often require irrigation systems, thereby increasing production costs (Briassoulis, 2006). Gravel mulch is difficult to remove and is therefore unsuitable for short-term cropping systems (Fairbourn, 1973).

4. Advantages of Physical Weed Control

Physical weed control reduces dependence on chemical herbicides and minimizes the risks of pesticide residues in soil, water and food (Rifai et al., 2002). Thermal methods can effectively control weeds and may also suppress certain insect pests and soil-borne pathogens (Ascard et al., 2007; Luvisi et al., 2015). Burning recycles nutrients tied up in plant residues and can control woody and herbaceous weeds (Howenstine et al., 2012). Flaming is effective against young broadleaf weeds and has minimal impact on deeper soil microbial biomass (Cisneros and Zandstra, 2008; Rahkonen et al., 1999). Soil steaming provides effective control of a wide range of weed species, including dormant seedsand offers long-term reduction of the weed seed bank without chemical residues (Peruzzi et al., 2012). Soil solarization suppresses weed seeds and soil-borne pathogens through heat accumulation without chemical inputs (Katan et al., 1976). Mulching reduces weed germination by blocking light, improves soil moisture retention and enhances soil structure and microbial activity (Monks et al., 1997; Kosterna, 2014).

5. Disadvantages of Physical Weed Control

Physical methods such as hand weeding are labor-intensive and expensive in vegetable crops. Burning may reduce soil fertility in the long term, increase nutrient leaching, decrease beneficial microbial populations and cause air pollution through smoke emissions (Giovannini et al., 1990; Santana et al., 2013; Howenstine et al., 2012). Flaming is less effective on mature weeds and grassy species and may increase fuel consumption or cause crop injury (Cisneros and Zandstra, 2008; Vanhala et al., 2004). Soil steaming requires high initial investment and energy consumption and may temporarily reduce beneficial soil microorganisms (Roux-Michollet et al., 2008; Elsgaard et al., 2010). Soil solarization may be ineffective against certain tolerant weed species and depends on climatic conditions (Elmore, 1991; Kumar et al., 1993). Mulching materials such as plastic films create disposal and environmental problems and increase production costs (Briassoulis, 2006). Living mulches may compete with the main crop for resources if not properly managed.

Table 1: Comparison of different physical weed control methods based on mechanism, cost, effectiveness and limitations

Method	Mechanism	Cost	Effectiveness	Limitation
Burning	Heat destruction	Low	Moderate	Environmental pollution
Flaming	Thermal shock	Medium	High (young weeds)	Fuel cost
Steaming	Soil heating	High	Very high	Energy intensive
Solarization	Solar heat trapping	Medium	High	Climate dependent
Mulching	Light blocking	Low–Medium	High	Material cost

6. Economics of Physical Weed Control

Hand weeding, although effective, is costly due to high labor requirements in vegetable production systems. Flaming is reported to be less costly than hand weeding under certain conditions (Shrestha et al., 2013). Band steaming reduces hand weeding time and can significantly increase crop yield but soil steaming requires high initial investment and operational costs due to energy consumption (Raffaelli et al., 2016). Biodegradable mulches can reduce labor costs since they suppress weeds effectively and can be incorporated into the soil after use (Jodaugiene et al., 2006). Non-biodegradable film mulches may be cost-effective in high-value or perennial crops; however, their high initial cost and additional disposal expenses limit their suitability for small-scale farmers (Briassoulis, 2006).

Table 2: Summary of physical weed control methods with applications, advantages and limitations

Method	Application stage	Target weeds	Advantages	Limitations
Burning	Pre- or post-harvest	Broadleaf, woody weeds	Nutrient recycling, reduces seed bank	Air pollution, nutrient loss
Flaming	Pre- & post-emergence	Young annual weeds	Fast, effective, organic-compatible	Ineffective on mature weeds
Soil steaming	Pre-emergence	Seeds & seedlings	Highly effective, no chemicals	High cost, energy intensive
Solarization	Pre-sowing	Soil-borne weeds	Eco-friendly, improves soil health	Climate dependent
Mulching	Throughout crop cycle	Light-sensitive weeds	Moisture conservation, weed suppression	Cost, disposal issues (plastic mulch)

7. Conclusion

Physical weed control methods offer environmentally friendly alternatives to chemical herbicides and contribute significantly to sustainable crop production systems. Techniques such as burning, flaming, soil steaming, soil solarization and mulching effectively reduce weed pressure, lower the weed seed bank and in some cases suppress soil-borne pests and pathogens. These methods are particularly suitable for organic farming and high-value crops where chemical use is restricted or undesirable. However, each method has specific limitations related to cost, labor requirement, energy consumption, climatic dependence and potential environmental impacts. Therefore, no single physical method can provide complete and long-term weed control under all conditions. The successful adoption of physical weed control requires proper selection based on crop type, soil condition, climate and economic feasibility. Integrating these methods with cultural, mechanical and biological practices under Integrated Weed Management (IWM) systems is essential to ensure sustainable, cost-effective and ecologically sound weed management in modern agriculture.

Authors Contribution

Allauthors Contributed equally.

References

Abou Chehade, L., Fontanelli, M., Martelloni, L., Frasconi, C., Raffaelli, M., Peruzzi, A. 2018. Effects of flame weeding on organic garlic production. HortTechnology, 28(4), 502-508.

Alexander, J. A., Fick, W. H., Lemmon, J., Gurule, C. A., Preedy, G. W., Olson, K. C. 2016. Effects of growing-season prescribed burning on vigor of the noxious weed Sericea lespedeza (Lespedeza cuneata) in the Kansas Flint Hills. Kansas Agricultural Experiment Station Research Reports, 2(1), 14.

Altenburger, A., Bender, M., Ekelund, F., Elmholt, S., Jacobsen, C. S. 2014. Steam-treatment-based soil remediation promotes heat-tolerant, potentially pathogenic microbiota. Environmental technology, 35(6), 773-780.

Ascard, J., Hatcher, P. E., Melander, B., Upadhyaya, M. K. 2007. Thermal weed control. In CABI eBooks (pp. 155–175). https://doi.org/10.1079/9781845932909.0155

Barberi, P., Moonen, A. C., Peruzzi, A., Fontanelli, M., Raffaelli, M. 2009. Weed suppression by soil steaming in combination with activating compounds. Weed Research, 49(1), 55-66.

Bennett, A. J., Leifert, C., Whipps, J. M. 2005. Effect of combined treatment of pasteurisation and Coniothyriumminitans on sclerotia of Sclerotiniasclerotiorum in soil. European journal of plant pathology, 113(2), 197-209.

Bond, W., Grundy, A. C. 2001. Non-chemical weed management in organic farming systems. Weed research, 41(5), 383-405.

Bozic, D., Filipovic, V., Matkovic, A., Markovic, T., Vrbnicanin, S. 2015. Effect of composting on weed seeds survival.

Briassoulis, D. 2006. Mechanical behaviour of biodegradable agricultural films under real field conditions. Polymer Degradation and Stability, 91(6), 1256-1272.

Capogna, F., Persiani, A. M., Maggi, O., Dowgiallo, G., Puppi, G., Manes, F. 2009. Effects of different fire intensities on chemical and biological soil components and related feedbacks on a Mediterranean shrub (Phillyreaangustifolia L.). Plant Ecology, 204(2), 155–171. https://doi.org/10.1007/s11258-009-9579-2

Cisneros, J. J., Zandstra, B. H. 2008. Flame weeding effects on several weed species. Weed Technology, 22(2), 290-295.

Dahlquist, R. M., Prather, T. S., Stapleton, J. J. 2007. Time and temperature requirements for weed seed thermal death. Weed Science, 55(6), 619-625.

Domingues, A. C., Ulloa, S. M., Datta, A., Knezevic, S. Z. 2008. Weed response to broadcast flaming. RURALS: Review of Undergraduate Research in Agricultural and Life Sciences, 3(1), 2.

Elmore, C. L. 1991. Weed control by solarization. Soil Solarization, 61.

Elsgaard, L., Jørgensen, M. H., Elmholt, S. 2010. Effects of band-steaming on microbial activity and abundance in organic farming soil. Agriculture, ecosystems and environment, 137(3-4), 223-230.

Fairbourn, M. L. 1973. Effect of Gravel Mulch on Crop Yield 1. Agronomy Journal, 65(6), 925-928.

Gibson, K. D., McMillan, J., Hallett, S. G., Jordan, T., and Weller, S. C. 2011. Effect of a living mulch on weed seed banks in tomato. Weed Technology, 25(2), 245-251.

Giovannini, C., Lucchesi, S., and Giachetti, M. 1990. Effects of heating on some chemical parameters related to soil fertility and plant growth. Soil Science, 149(6), 344-350.

Grassbaugh, E. M., Regnier, E. E., and Bennett, M. A. 2002. Comparison of organic and inorganic mulches for heirloom tomato production. In XXVI International Horticultural Congress: Sustainability of Horticultural Systems in the 21st Century 638 (pp. 171-176).

Hewitt, M., Bullen, K., and George, D. 1988. Comparison of three weed control methods: chemical, flame and hot water. In Proceedings of the 9th Australian Agronomy Conference" Agronomy-Growing a Greener Future". Australian Society of Agronomy, Charles Sturt University, Wagga Wagga (pp. 607-608).

Jodaugiene, D., Pupaliene, R., Urboniene, M., Pranckietis, V., Pranckietiene, I. 2006. The impact of different types of organic mulches on weed emergence. Agronomy Research, 4, 197-201.

Katan, J., Greenberger, A., Alon, H., Grinstein, A. 1976. Solar heating by polyethylene mulching for the control of diseases caused by soil-borne pathogens. Phytopathology, 115(8V), 683-688.

Kitis, Y., Koloren, O., Uygur, F. 2011. Evaluation of common vetch (Vicia sativa L.) as living mulch for ecological weed control in citrus orchards. African Journal of Agricultural Research, 6(5).

Kosterna, E. 2014. The effect of soil mulching with organic mulches, on weed infestation in broccoli and tomato cultivated under polypropylene fibreand without a cover. Journal of Plant Protection Research, 54(2).

Kumar, B., Yaduraju, N. T., Ahuja, K. N., Prasad, D. 1993. Effect of soil solarization on weeds and nematodes under tropical Indian conditions. Weed research, 33(5), 423-429.

Leroux, G. D., Douhéret, J., Lanouette, M. 2001. Flame weeding in corn. In Physical control methods in plant protection (pp. 47-60). Berlin, Heidelberg: Springer Berlin Heidelberg.

Luvisi, A., Panattoni, A., Materazzi, A. 2015. Heat treatments for sustainable control of soil viruses: A. Luvisi et al. Agronomy for Sustainable Development, 35(2), 657-666.

Marcinkevičienė, A., Velička, R., Butkevičienė, L. M., Keidan, M., Pupalienė, R., Kriaučiūnienė, Z., Kosteckas, R., Čekanauskas, S., Raudonius, S. 2018. The impact of non-chemical weed control methods on the disease occurrence in the organically grown winter oilseed rape crop. Zemdirbyste-Agriculture, 105(4), 331–338. https://doi.org/10.13080/z-a.2018.105.042

Massucati, L. F. P., and Kopke, U. 2014. Effect of straw mulch residues of previous crop oats on the weed population in direct seeded faba bean in Organic Farming.

Melander, B., and Kristensen, J. K. 2011. Soil steaming effects on weed seedling emergence under the influence of soil type, soil moisture, soil structure and heat duration. Annals of Applied Biology, 158(2), 194-203.

Monks, C. D., Monks, D. W., Basden, T. O. M., Selders, A., Poland S., and Rayburn, E. 1997. Soil temperature, soil moisture, weed controland tomato (Lycopersicon esculentum) response to mulching. Weed technology, 11(3), 561-566.

Parmar, H. N., Polara, N. D., Viradiya, R. R. 2013. Effect of mulching material on growth, yield and quality of watermelon (Citrullus lanatus Thunb) Cv. Kiran. Universal Journal of Agricultural Research, 1(2), 30-37.

Peruzzi, A., Lulli, L., Fontanelli, M., Frasconi, C., Ginanni, M., Raffaelli, M., Sorelli, F. 2010. Innovative strategies for physical weed control on hard surfaces in urban area in central Italy: development of new flaming operative machines. In Book of Abstracts of the XVIIth World Congress of the International Commission of Agricultural and Biosystems Engineering, Québec City, Canada (p. 263).

Peruzzi, A., Raffaelli, M., Frasconi, C., Fontanelli, M., Barberi, P. 2012. Influence of an injection system on the effect of activated soil steaming on Brassica juncea and the natural weed seedbank. Weed Research, 52(2), 140-152.

Qiu, Y., Xie, Z., Wang, Y., Ren, J., Malhi, S. S. 2014. Influence of gravel mulch stratum thickness and gravel grain size on evaporation resistance. Journal of Hydrology, 519, 1908-1913.

Raffaelli, M., Fontanelli, M., Frasconi, C., Ginanni, M., Peruzzi, A. 2010. Physical weed control in protected leaf-beet in central Italy. Renewable Agriculture and Food Systems, 25(1), 8-15.

Raffaelli, M., Martelloni, L., Frasconi, C., Fontanelli, M., Carlesi, S., Peruzzi, A. 2016. A prototype band-steaming machine: Design and field application. Biosystems Engineering, 144, 61-71.

Rahkonen, J., Pietikäinen, J., Jokela, H. 1999. The effects of flame weeding on soil microbial biomass. Biological agriculture & horticulture, 16(4), 363-368.

Ramakrishna, A., Tam, H. M., Wani, S. P., Long, T. D. 2006. Effect of mulch on soil temperature, moisture, weed infestation and yield of groundnut in northern Vietnam. Field crops research, 95(2-3), 115-125.

Rifai, M. N., Astatkie, T., Lacko-Bartosova, M., Gadus, J. 2002. Effect of two different thermal units and three types of mulch on weeds in apple orchards. Journal of Environmental Engineering and Science, 1(5), 331-338.

Santana, G. S., Dick, D. P., Tomazi, M., Bayer, C., Jacques, A. V. 2013. Chemical composition and stocks of soil organic matter in a south Brazilian Oxisol under pasture. Journal of the Brazilian Chemical Society, 24, 821-829.

Shaw, W. C. 1982. Integrated weed management systems technology for pest management. Weed science, 30(S1), 2-12.

Shrestha, A., Kurtural, S. K., Fidelibus, M. W., Dervishian, G., Konduru, S. 2013. Efficacy and cost of cultivators, steam, or an organic herbicide for weed control in organic vineyards in the San Joaquin Valley of California. HortTechnology, 23(1), 99-108.

Singla, S. L., Pareek, A., Grover, A. 1997. Short-term Salinity and High Temperature Stress-associated Ultrastructural Alterations in Young Leaf Cells of Oryza sativa L. Annals of Botany, 80(5), 629-639.

Sivesind, E. C., Leblanc, M. L., Cloutier, D. C., Seguin, P., Stewart, K. A. 2009. Weed response to flame weeding at different developmental stages. Weed technology, 23(3), 438-443.

Stapleton, J. J., Quick, J., DeVay, J. E. 1985. Soil solarization: effects on soil properties, crop fertilization and plant growth. Soil biology and biochemistry, 17(3), 369-373.

Ulloa, S. M., Datta, A., Knezevic, S. Z. 2011. Growth stage influenced sorghum response to broadcast flaming: Effects on yield and its components. Agronomy journal, 103(1), 7-12.

Vanhala, P., Kurstjens, D., Ascard, J., Bertram, A., Cloutier, D., Mead, A., Rasmussen, J. 2004. Guidelines for physical weed control research: flame weeding, weed harrowing and intra-row cultivation. In 6th EWRS Workshop on Physical and Cultural Weed Control Lillehammer, Norway, 8-10 March 2004 (pp. 194-225). European Weed Research Society.

Vasinauskienė, R., Brazienė, Z., Avižienytė, D. 2019. The effects of water steam on weeds and fungal diseases in the stands of onion. Zemdirbyste-Agriculture, 106(1), 53–58. https://doi.org/10.13080/z-a.2019.106.007

Vidotto, F., De Palo, F., Ferrero, A. 2013. Effect of short-duration high temperatures on weed seed germination. Annals of Applied Biology, 163(3), 454-465.

Walsh, M., and Newman, P. 2007. Burning narrow windrows for weed seed destruction. Field Crops Research, 104(1-3), 24-30.

Weerakkody, P., and Hettiarachchi, M. H. S. M. 2025. Efficacy and environmental safety of flame weeding in the humid tropical region. Efficacy and Environmental Safety of Flame Weeding in the Humid Tropical Region. https://doi.org/10.5958/0974-8164.2025.00017.4

Wszelaki, A. L., Doohan, D. J., and Alexandrou, A. 2006. Weed control and crop quality in cabbage (Brassica oleracea (capitata group)) and tomato (Lycopersiconlycopersicum) using a propane flamer. Crop Protection, 26(2), 134–144. https://doi.org/10.1016/j.cropro.2006.04.012