Chemical control with herbicides: This offers certain advantages over manual weeding in speed and effectiveness. However, over reliance on chemical control has provoked irrational use and unwanted negative effects, including build up of herbicide residues in soil, phytotoxic damage to coffee bushes, and most commonly, soil erosion problems when inappropriate use removes too much vegetation, leaving soil bare and unprotected. Farmers may not be aware of the side effects of inappropriate herbicide use or careless application onto coffee foliage may often go unnoticed, as the damage symptoms can easily be confused with pest or disease attack or certain nutrient deficiencies.

Herbicides should be applied when target weeds are small (2-3 true leaf stage) and spraying should be targeted and selective, not blanket coverage. It is best to use low discharge nozzles in fan shape and, if possible, a shield or screen at the sprayer lance tip to avoid herbicide drift onto the bushes. Spraying herbicides by knapsack sprayer on vegetation higher than 25cm increases the likelihood that the product will come into contact with the coffee foliage, as the operator will tend to raise the lance, and it ends up taking longer, using more herbicide and increasing costs. It is better to control tall vegetation with manual methods instead. Herbicide use should always be combined with other weed management methods and not relied on as the main form of control.

Farmer training and advice on selective weed management

The CATIE Coffee IPM and Agroforestry programme in Nicaragua during the 1990s trained farmers on how to distinguish harmful from beneficial weed species and to develop farm plans for reducing the most problematic weeds and conserving ground-covering and shallow rooting species, which do not harm the coffee bushes. The project developed a simple 'shoe tip' vegetation sampling method for farmers to assess levels of harmful and beneficial weeds in their groves and to use this monitoring for decision making. Field monitoring note books enable farmers to record: harmful weeds; climbers and vines; beneficial or 'soft' weeds; bare soil; leaf litter; or cut harmful weeds, sampling 150-300 shoe tip points, at every 5 to 10 paces, along every 6 to 10 coffee rows, according to field size. This sampling takes 30-60 minutes and is best done when weeds are not too high (2-3 weeks after the start of the rainy season and 2-4 weeks after the main weeding session).

Guides to useful and harmful weeds are now available, for example, the Illustrated Guide to Integrated Weed Management in Coffee Groves (Utz, CATIE & Aceres, 2013). This booklet (in Spanish) provides annotated photos of commonly found weed species in Central American coffee groves, divided into four plant groups: Good Cover; Medium; Competitive and Very Competitive. Guidance is given on suitable control or management strategies for each species, selective weeding methods, beneficial uses, and notes on appropriate and reduced rate herbicide use where required.

Sources of information used

Cómo tener más hierbas de cobertura y menos malezas en nuestros cafetales. Staver, C. (2001) *Agroforestería en las Américas* (Costa Rica) 8 (29):30-32.

Manual of Weed Management in Organic Coffee Groves. Ramos et al. (2014) University of Puerto Rico (Utuado) (in Spanish) Via: https://drive.google.com/a/upr.edu/file/d/0ByBoB4oi017eNVBSTHY5NmpPTXc/view?pref=2&pli=1

Manejo Integral de Hierbas en Cafetales, Guia ilustrativa. Utz, CATIE & Aceres, 2013. Via: https://issuu.com/abejassilvestres2013/docs/manejo_integral_de_hierbas_en_cafet

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Integrated weed management with reduced or zero herbicide use in coffee groves

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Background

Pesticide use surveys of coffee farmers in Costa Rica conducted under this SAICM-funded project have identified several herbicides in use which qualify as HHPs, including diquat, glyphosate, oxyfluorfen and paraquat. The IRET project team has identified a considerable shift away from glyphosate use in smallholder coffee groves, due to grower concerns about phytotoxicity from possible drift onto coffee foliage during poor application by casual hired labourers. Instead, more growers are using paraquat, raising a 'red light' warning as IRET researchers consider this is likely to hugely increase acute toxicity risk, especially if casual workers are engaged in poor practices. Paraquat is reported in use by 25% of the 85 coffee farmers surveyed during 2015-2016. It is applied for weed control between one and three times a year.

One of the project activities is to explore safer alternatives to HHP herbicides used in coffee groves. This briefing describes some alternative methods for controlling weeds, compiled from relevant research and practical experiences in the Central American region.

Integrated Weed Management: using a variety of control tools

The key to reducing or eliminating herbicide use in coffee groves is to integrate a variety of physical, cultural and ecological methods, to achieve short term control of the most harmful weeds where needed and over time to alter the vegetation balance to favour more beneficial and neutral plants. Understanding which weedy plants are most harmful and which pose no problem for the coffee bushes is essential, along with regular field monitoring and knowing when and how to manage the different weed types most effectively.

There are no blanket recommendations and the effectiveness of different methods, their costs and benefits will vary widely, according to farm location, agroclimatic conditions, soil types, coffee cultivars and production systems used and the costs of labour and other inputs. Working out the best combinations of methods to develop a flexible but effective strategy for a particular farm is needed, drawing on lessons from local research and making use of farmer group learning and experience sharing.

Good cultural controls: Growing healthy coffee plants, with well balanced fertilisation, helps vigorous growth in the early years, enabling the young bushes to compete better with weeds for space, light, nutrients and water. Planting at high density with improved varieties is also beneficial, aiming for the coffee bush canopy to close as early as

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possible and limit aggressive weed growth.

Use of shade trees: Shade trees help to reduce weed growth. In addition the organic matter generated by shade tree leaf fall and pruning forms a natural mulch cover which is very effective in inhibiting weed growth. While coffee grown under full sun will need weeding 4-6 times per year, groves with shade trees need only 2-3 sessions. Quick growing shade trees, such as bananas or plantains, will provide temporary shade for young coffee groves.

Dead mulches: Dead mulches, composed of crop waste (maize, beans, etc), grass cuttings and most herbaceous plant material, can be scattered over the soil and helps to inhibit weed development.

Living mulches or cover crops: This is another method, in which selected cover plants (sometimes known as 'smother crops' because they will cover the soil) are deliberately sown in the grove for multiple benefits: soil protection, conservation of nutrients and water, biodiversity and for natural control of pests and weeds. Many different species can be sown as cover plants. These should be low-growing plants with shallow rooting, which will not compete with the coffee bushes. With their ground-covering habit they can form mats of green material which protect the soil and reduce weed growth.

Most cover plants sown in coffee groves are leguminous, including forage groundnut (*Arachis pintoi*), kudzú (*Pueraria phaseoloides*), canavalia (*Canavalia ensiformis*), dólicos (*Dolichus lablab*) and 'soft weeds', e.g. chicken herb (*Commelina elegans*), rabbit grass (*Oplismenus burmannii*), drimaria (*Drymaria cordata*).These cover plants are managed by sowing between the coffee bush rows in newly planted groves and in any spaces in older groves where there is sufficient light penetration, but leaving clear the root feeding zone (drip circle) around each bush. This method does more require labour at first than manual removal, especially in the first few months of establishment, but can deliver longer-term economic gains from improved weed management plus soil health benefits.

Polycropping: Companion crops (beans, soya, amongst others) also contribute to inhibiting weed growth when established between coffee rows during the first 2-3 years of the grove. They can also be sown when mature bushes are coppiced, as long as there is sufficient light for the crops to develop.

Controlled grazing: livestock (mainly sheep) are used by some coffee growers as a weed control method. Care needs to be taken to rotate their grazing around the different plots.

Manual or mechanical control (by hand tools or motorised equipment): Coffee bushes are least able to compete with weeds in recently planted groves and in the period before harvesting. Manual weeding operations need to focus on (a) complete removal of weeds in the coffee bush 'drip zone' or base circle and (b) selective weeding (hand pulling or slashing by machete) between rows.

Weed removal in the drip zone involves clearing by hand or with a machete, all the weeds growing within a circle of 75cm diameter around the stem of each bush. This practice is very important in the first two years of the grove growth. It also makes compost/fertiliser application easier and reduces the number of weeding sessions needed throughout the year. Weed material removed can be left on the ground as a protective cover for the soil.

It is important to achieve a good control over weed growth, especially of damaging weeds, which need to be cut back within and between rows. This can be done by machete or with motorised weeders or strimmers, cutting weeds at a height of 10cm, and taking good care not to damage the coffee bushes. Timely control is also very important - if weeding operations are carried out when vegetation is already thick and high, it becomes more difficult, takes longer and incurs more expense, whether this is done manually, mechanically or using herbicides.

Modifying the weed community: This longer term method involves changing the composition of the weed communities, also known as '**selective weeding'**. It can be used in organic and conventional groves. It consists of leaving those naturally occurring plant species which provide more benefit than harm and eliminating those that are more harmful than good. It aims to encourage more of what are known (in Spanish) as 'noble cover' plants or 'soft' weeds- those with a creeping or ground-hugging growth habit, which don't have deep roots and which can quickly cover the soil. The success of this method has been documented in conventional coffee groves, for example, in Nicaragua, where the make-up of the weed community shifted to mainly good cover plants after three years of selective weeding. Table 1 contrasts characteristics of good and bad weeds and their benefits and damage, respectively.

Table 1. Comparison of bad versus good weeds

Harmful weeds	**Good or 'soft' weeds**
Characteristics of harmful weed species	***Characteristics of beneficial or neutral weed species***
Annual and perennial vines/climbers.	Low growing species, with shallow rooting.
Rapid growth species, reaching >25cm high	Low growing, creeping species which form ground-covering mats.
Creeping or tussocky grass species, which absorb lots of water and nutrients.	Species which reduce growth of harmful weeds.
Species which continue to develop during the dry season.	
Types of damage	***Types of benefits***
Physical damage, e.g. breakage of branches or buds	Protects soil from rain impact
Restrict photosynthetic ability, by smothering branches and leaves	Protects soil from water run-off
May encourage pests or diseases	Protects soil from wind erosion
Competition for water, space & nutrients	Provides organic matter, as weedy biomass breaks down
Makes cultural practices more difficult	Provides habitat for beneficial organisms

Source: Website information on managing weeds without herbicides. National Coffee Association. ANACAFE,Guatemala, via: https://www.anacafe.org/glifos/index.php?title=CaficulturaOrganica_Malezas Based on guidance developed by the coffee IPM and agroforestry programme conducted in Nicaragua by CATIE research institute in the 1990s.