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Weed Control in Small Farm Systems

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Small farmers in the East Caribbean spend about 30% of total crop labour on land preparation, and another 30% on post-planting weed control depending on the cropping system. Methods rely largely on hand labour, using cutlasses, hoes, forks and hand pulling of weeds. The only herbicide used in any quantity is paraquat. Constraints to the adoption of improved technologies include cash availability, the practice of mixed- or inter-cropping, and the complexity of many farm systems. Many herbicides are susceptible to rain, and their species spectrum is often limited. A holistic approach is necessary to ensure integration of weed control into the entire cropping system. Guidelines for the design of improved weed control systems are discussed and CARDI's programme in weed control in the FSR/D project is outlined.

In a study of small scale farming in the English-speaking countries of the East Caribbean (from north to south, these countries are: St. Christopher and Nevis, Antigua and Barbuda, Montserrat, Dominica, St. Lucia, St. Vincent and Grenada), carried out between 1978 and 1982, weed control was identified as a major constraint to crop production and to profitability (CARDI, 1983, a,b,c,). This paper presents some of the data collected on labour use for weed control and on the economics of small scale farming, describes the traditional methods of controlling weeds, and outlines CARDI's approach to developing improved weed control systems. Since land preparation almost invariably involves the destruction of weeds, this activity is also considered along with "post-planting" or "in-crop" weed control.

Labour Use

Table 1 summarizes some farm characterisation data collected over 12-month periods during 1980-81, in five countries (Hammerton, 1984a). Thirty-three farmers, out of 79, devoted between 20 and 40% of total crop labour time to post-planting weed control, and eight farmers spent more than 40% on this activity. The St. Lucia data may be atypical as Hurricane Allan struck partway through the characterisation period. Forty farmers used more than 20% of total crop labour for land preparation, 13 of these using over 40%.

One root crop farmer in Nevis devoted 85% of crop labour to land preparation, and a tree crop farmer in Grenada spent 81% of crop labour time on post-planting weed control. At the other extreme, there were farmers devoting 5% or less of crop labour to land preparation or weed control. These were generally livestock farmers or farmers with established tree crops.

On 36 of the 79 farms, the farmer him- (or her-) self was the sole or major source of labour for crop production activities. On only 11 farms, mainly in Grenada, was hired labour the major source of crop labour. The remaining farms used a mixture of farmer, family and hired labour, in varying proportions (Hammerton, 1984a).

Economics

Analysis of the economic data from these characterisation studies (CARDI, 1983b), spanning 87 farms in the same five countries listed in Table 1, shows wide variations in output and input levels both between and within countries. Total farm pro-

TABLE 1. The number of farms, in five countries, and the total number of farms, devoting differeing percentage ranges of total crop labour* to postplanting weed control and to land preparation.

Activity, and % of total crop labour		Country					Total
		Antigua	Grenada	Montserrat	Nevis	St. Lucia	
Weed Control	< 20	4	7	6	9	12	38
	20 - 40	7	9	11	2	4	33
	> 40	2	4	2	0	0	8
Land Preparation	< 20	8	14	6	7	4	39
	20 - 40	2	6	9	2	8	27
	> 40	3	0	4	2	4	13

*Labour days were weighted at 0.75 for women and 0.50 for children.
Source: CARDI (1983b), based on data from CARDI's farm characterisation studies carried out over 12-month periods during 1980-81.

duction over the 12-month period—including livestock—ranged in value from EC$66 to EC$33,500 (EC$2.70 × US$1.00). Cash incomes (gross) from crop sales varied from nil to over EC$32,000, with 54 of the 87 farmers earning less than EC$2,000. Only 16 farmers earned more than EC$4,000, and only five of these more than EC$10,000. Of course, some of the farmers with low crop incomes were livestock farmers. Twenty of these 87 farms sold less than 50% of their total production for cash; 42 sold more than 75% for cash. Output:input ratios (*i.e.*, the ratio of the total value of production to the cash cost of inputs used) ranged from less than one to infinity, the latter indicating no cash expenditure on inputs. Twenty farmers had a ratio exceeding ten, and 44 had ratios less than five.

Production Systems

A preliminary study (part of CARDI's current FSR/D Project) has identified over 60 crop-based production systems, some of which include a livestock component, among the seven countries of the East Caribbean. Thirteen of these are banana-based, ten are vegetable-based, and seven are sweet potato-based. Some of these may prove—on further study—to be only minor variants of others, but these figures serve to illustrate the diversity of the systems with which CARDI is working. The systems include inter- or mixed-crop systems (sometimes of crops of diverse form and longevity), pure stand systems, and rotations or sequences of crops. Some systems represent points in a continuum from a multi-crop mix to a system with one or two dominants.

Thus, there is great diversity in all aspects of small scale farming. Significant—in terms of developing improved technologies—are the diversities in:

1. emphasis on sales, cash incomes (and cash flows);
2. the level of purchased inputs used, and in the ability and willingness to purchase inputs;
3. production systems, especially at the "micro" level—the crop mixes and planting patterns for example;
4. agro-ecological components, especially rainfall patterns and dry season duration;
5. weed floras, consequent upon the agro-ecological component, the production systems, and methods of production.

Weed Control Methods

Present, or traditional, methods of in-crop weed control rely heavily on manual labour.

Physical Methods

1. Topping, by cutlassing, at 50 - 70 cm, to facilitate reaping of cocoa, coconuts, etc., may be employed. The effects on weeds are only temporary.
2. Cutlassing to a stubble is common in bananas and tree crops and develops over time a sward of perennial weeds.
3. Clean-weeding by cutlass, knife or sickle, cutting close to the soil surface, is used in short-term crops, especially vegetables.
4. Hoeing for weed control and moulding-up is used in short-term crops such as peanuts and sweet potatoes. Some crop damage and root-pruning may occur.
5. Hand-pulling is used mainly in vegetables and in nurseries.
6. Mulching—usually with grass—is done in some dry areas both to control weeds and conserve moisture.

Biological and Cultural Methods

1. Grazing may be permitted, mainly under established coconuts.
2. Intercropping may contribute to weed control, but often prevents the use of herbicides, and may make manual weeding more difficult. It does, of course, increase land utilisation.
3. Cover crops or live mulches are rarely used, but viny legumes have been used in the past (Hammerton, 1984b).

Chemical Methods

1. Gramoxone (paraquat) is used as a directed or shielded spray in row crops, bananas, tree crops and in land preparation.
2. Residual (soil-acting) herbicides are mainly used in bananas and tree crops. A few (*e.g.*, Dacthal [DCPA], Enide [diphenamid] and [formerly] Tok [nitrofen]) are used in vegetables and food crops.

Herbicides are invariably applied as sprays, and water may have to be carried a considerable distance, often uphill.

Usually a sequence of methods is used, and herbicides normally require supplementary manual weeding for resistant weeds.

Land Preparation Methods

This activity also relies heavily on manual labour. Nineteen of the 79 farmers characterised (Hammerton, 1984a) used tractor services for basic land preparation, but this did not obviate the need for further manual work. Manual land preparation typically comprises the following *sequence* of operations:

1. cutlassing of weeds which are left to dry, heaped and burnt, or may be buried in mounds or ridges (Paraquat may be used before cutlassing);
2. forking, or rilling with a heavy hoe, to loosen the soil, bury residues and destroy live weeds;
3. bed, ridge or mound formation by fork, spade and/or heavy hoe.

For some crops, notably bananas and tree crops, minimum tillage based on paraquat and/or cutlassing may be used, but tillage will be necessary if intercrops are to be planted.

The amount of weed growth present at the start of land preparation depends, *inter alia*, on the duration of the rainfall during the fallow period and the use made of the fallow, if any. It may comprise woody scrub, tall grasses and vines after a fallow of a year or more. It may comprise a dense, short, grazed sward of mainly perennial grasses if it has been grazed. Or it may comprise a sparse growth of grasses and broad-leaved weeds if the fallow period was short and dry, therefore, the amount of labour required for land preparation varies widely. Few, if any, small farmers clean cultivate between cropping seasons, even though this would reduce subsequent weed problems. The weed fallow is an important forage resource for ruminants, and helps to restore soil fertility, and minimise erosion. It does ensure the proliferation of weed seed and vegetative propagules.

Constraint to Change

Weed control is often poor on small farms: control is delayed into or beyond the critical period of weed competition. The small farmer, however, must optimise the use of his resources over the entire farm—often over several crop production systems. If hired labour is difficult to obtain when required and/or cash is not available to pay hired labour nor to purchase herbicide, then the farmer may be justified, for example, in:

1. concentrating on land preparation and planting rather than weeding crops already planted;
2. neglecting weed control in hardier or lower value crops in favour of the more weed-sensitive and higher value crops;
3. allowing weeds to grow in later banana ratoons, or among tree crops, to ensure forage for livestock;
4. intercropping to maximise production from a limited land area, even though this makes manual weed control more time-consuming and may preclude herbicide use.

TABLE 2. Foliar-applied herbicides[1], classified according to their requirement for fine dry weather following application.

Less than two hours required ("Low risk")[2]	Four hours or more required ("High risk")
Fusilade (fluazifop-butyl)	Asulox (asulam)
Gramoxone (paraquat)	Basagran (bentazon)
Reglone (diquat)	2,4-D
	Round-up (glyphospate)
	Talent (asulam + paraquat)

[1]Inclusion of a herbicide in the above Table and mention in the text, does not constitute an endorsement. Nor does omission imply criticism.
[2]Within the "Low risk" group Gramoxone and Reglone carry less risk than Fusilade, as they require only about 30 minutes of fine weather, compared to about 1.5 hours for Fusilade.

TABLE 3. Soil-applied herbicides[1], classified according to ease of leaching in soil.

Not readily leached ("Low risk")	Readily leached ("High risk")
Dacthal (DCPA)	Alanap (naptalam)
Enide (diphenamid)	Amiben (chloramben)
Gesagard (prometryn)	Dalapon
Gesaprim (atrazine)	
Lasso (alachlor)	
Lorox (linuron)	
Maloran (chlorbromuron)	
Probe (methazole)	
Randox (CDAA)	

[1]See note to Table 2.

Furthermore, good weed control may only be justified if inputs of fertilisers, nematicides, etc., are near-optimal.

Herbicides can benefit the small farmer by easing the labour of land preparation, and extending the critical period of weed competition, even if the control obtained is only partial. The farmer may therefore be able to manage a greater area of cultivated land with herbicides (Hammerton, 1974). But herbicides have several constraints. Many are susceptible to rainfall either, in the case of foliar-applied herbicides, by washing-off, or in the case of soil-acting herbicides, by leaching. Tables 2 and 3 classify some common herbicides in terms of susceptibility to rain. Clearly the risk of washing-off or leaching varies with the rainfall pattern. "High-risk" herbicides stand a higher chance of failure during seasons of heavy, frequent rains, than "low-risk" herbicides. Weed growth is more rapid during seasons of high rainfall. Cost is another constraint. A farmer may require only a few fluid ounces, but may need to buy a litre at a cost of EC$100-200. Cost per unit area can be reduced by spot treatment, but with labour rates of EC$15-20 per day, manual weeding may be a better proposition—provided labour is available. No weeds are resistant to manual methods. Partial budgetting is necessary before recommending the introduction of a herbicide—but a holistic or whole-farm perspective is essential (Hammerton, 1984b). Paraquat (formulated as Gramoxone in the East Caribbean) currently sells for about EC$16-17 per litre, and although ineffective against many weeds—vines and perennials, for example—it is easily the most cost-effective and attractive herbicide for most small farmers. Advantages are its "rain-fastness" and its rapid and visible action.

A Systems Approach

CARDI, under its current FSR/D Project, is engaged in developing and testing improved weed control systems for small farmers. Attention is being focussed on those production systems rated high priority in terms of contribution to domestic food supply and potential for export.

Improved systems should satisfy some, at least, of the following criteria:

1. integrated systems, utilizing several components;
2. integrate into existing production systems with minimal disruption, or *be* an integral part of an improved total technology;
3. require levels of expenditure realisable by the target farmers;
4. economically sound, as shown by partial budgetting, cost:benefit ratios, etc.;
5. ecologically sound, especially the herbicide component, if any;
6. minimal risk of failure associated with soil and weather factors.

The components include:

1. cultivations for land preparation;
2. herbicides for land preparation;
3. post-planting cultivations (*e.g.*, hoeing, cutlassing, etc.);
4. post-planting herbicides, directed, overall or spot;
5. live or dead mulches
6. intercropping
7. "managed" weed swards.

The programme of work comprises both component testing and evaluation of systems. Component research includes herbicide evaluation, testing of herbicide wipers and of wheel hoes and hand tools, etc. System evaluation is the testing of systems which may include land preparation herbicides and methods, pre-emergence herbicides, and sequences of post-planting herbicides and/or physical methods of weed control. Cost is a major consideration in selecting systems for evaluation. The programme includes field station experiments and on-farm testing and evaluation. Basic to this programme is a weed control survey at present underway in several countries.

As a logical basis for developing weed control systems, and ultimately recommendations, four "domains" are recognized (Table 4). Generalised systems suggested for these domains are as follows:

High rainfall—wet season Manual methods give only short-term control. Intercropping may suppress weeds, if weeds are known to be sparse, but may complicate control under very weedy conditions. Low risk foliar applied herbicides, especially Gramoxone can be used, but control will be temporary. Fusilade can be used as a spot treatment and over the top of broad-leaved crops for grass weeds. Manual methods must be used for resistant weeds, especially woody species. Low risk soil-acting herbicides should be avoided, unless there is adequate ground cover from the crops and/or intercrop(s). High risk soil-acting herbicides should not be used.

High rainfall—dry season Manual methods are moderately effective. Round-up can be used judiciously for land preparation, and spot treatment of perennial weeds. Gramoxone can be used as a management tool to maintain a cover of perennial grasses on steep slopes. Fusilade can be used for ring-weeding control of perennial grasses. Gramoxone should be used for annual weeds. Low risk soil-acting herbicides can be used at the start of the dry season on flatter lands.

TABLE 4. Some characteristics of four domains based on rainfall and season, as a basis for developing weed control recommendations.

	Wet season	Dry season
High rainfall areas (more than ca. 65 ins [1625 mm] per annum)	Rapid weed growth; ready re-establishment of uprooted weeds and of fragments.	Moderate weed growth; some risks of re-establishment of uprooted weeds and of fragments.
	High risk for foliar-applied herbicides.	Moderate risk for foliar-applied herbicides.
	High risk of leaching.	Some risk of leaching.
Low rainfall areas (less than ca. 65 ins [1625 mm] per annum)	Rapid, but sporadic weed growth; some risk of re-establishment of uprooted weeds and of fragments.	Little weed growth; very little risk of re-establishment of uprooted weeds or of fragments.
	Moderate risk for foliar-applied herbicides.	Low risk for foliar-applied herbicides.
	Moderate risk of leaching	Low risk of leaching.

Low rainfall—wet season Manual methods are effective except during wet periods. Rainfall is likely to occur as short, high intensity showers: high risk foliar-acting herbicides should be used only when showers are not expected. Round-up can be used in land preparation if perennials are dominant, or Fusilade if perennial grasses are dominant. For annuals, Gramoxone should be used. Low risk soil-acting herbicides can be used, supplemented by Gramoxone sprays. Mulches can be used.

Low rainfall—dry season Manual methods and mulching should be effective against the generally slight weed infestations. Soil-acting herbicides may be ineffective, and Round-up and Fusilade may not be effectively translocated unless showers stimulate active weed growth. Cultivations will control many perennials by desiccation. Gramoxone should be used only on growing green weeds.

Special weed problems will require special herbicides: Reglone (diquat) for white heads (*Parthenium hysterophorus*), Talent for water grass (*Commelina* spp.) in bananas and tree crops, and 2,4-D amine (directed) for vines.

It is hoped in the next few years to recommend systems based on the above guidelines.

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