INTEGRATED WEED MANAGEMENT SYSTEMS: AN APPROPRIATE TECHNOLOGY FOR SUSTAINABLE AGRICULTURE IN THE CARIBBEAN

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ABSTRACT

Weeds are serious pest in crop production in the Caribbean accounting for a major portion of the capital and labour cost. Control has been characterized by heavy inputs and mis-use of herbicides in a fragile ecosystem. This paper attempts to examine the use of Integrated Weed Management (IWM) as an agro-ecosystem approach for the management and control of three noxious weeds - corn grass *(Rottboella cochinchinensis)*, white-top *(Parthenium hysterophous)*, and nut grass *(Cyperus rotundas)*, as an appropriate control strategy within the context of sustainable agriculture in the Caribbean.

INTRODUCTION

The control of weeds by chemical methods in agricultural fields, industrial sites, airports, road ways and recreational areas in the Caribbean is under severe scrutiny because of off-target herbicide effects, ground and surface water contamination, and an emerging high rate of suicide due to poisoning *[Bridgemohan, 1990]*. It has become evident that herbicide use can have deleterious effects upon the integrity of the environment and consequently, upon the sustainability of agriculture itself.

Sustainable agriculture involves the judicious use of natural resources - land, water, air, and sunlight - to produce food and other requirements in adequate quantity and quality for the sustenance of a population, without diminishing (or damaging) the natural resource base over time. It is therefore crucially important to employ techniques in agricultural production which will preserve the environment.

Prior to the introduction of 2,4-D in the 1940's *[Ross and Lembi, 1985]* and paraquat in the 1960's *[Bridgemohan and Brathwaite, 1987]*, farmers controlled weeds through the integrated use of manual weed removal methods using crude hand implement, tillage, competitive or *'smother crop'*, crop rotation or simply animal grazing and mulching *[Runnels and Schaffner, 1931]*. With increasing availability and convenience of use (sometimes abuse) of herbicides, these traditional methods of weed control have declined considerably in importance. Farmer recommendations by researchers and extension workers now include a pesticide listing of various insecticides, fungicides, nematicides, acaricides and herbicides, along with the fertilizer and usually imported hybrid seed material.

The heavy dependence and continued use of herbicides in most vegetable, cereal, legumes, banana and fruit crops have destroyed the traditional intercropping and mixed farming systems. Farmers no longer tend to cut and carry forage that were weeds within the crops or bordering his fields for their animals. Total weed-free and sometimes bare soil conditions have been promoted and are not unfamiliar sights in citrus, banana and other crop fields *[Daisley, pers. comm., 1991]*.

The objective of this paper is to examine weed management systems as an appropriate control strategy within the context of sustainable agriculture in the Caribbean, and highlight its application in the control of three major weed species.

WEED CONTROL PRIOR TO HERBICIDE INTRODUCTION

Many farmers today practice the same weed control measures as was practised before the introduction of herbicides *[Kasasian, 1971]*. These include crop rotation, use of smother crops and tillage. The most successful control was achieved by the integration of all these traditional practices. Hence, this was the earliest identification of the IWM system *[Regnier and Janke, 1990]*.

Crop rotation functioned on the principles of:

(i) disrupting the weed life cycles
(ii) preventing the build up of adapted weeds, and
(iii) facilitated other non-chemical methods e.g. tillage, mowing, hand weeding, cutlassing, or slashing.

Smother crops are very competitive crops, when seeded in narrow rows, they can effectively suppress annual and perennial weeds. Cowpeas, forage soybeans, sudan grass, kudzu and pumpkins are examples of smother crops.

Integrating tillage practices with crop rotation and smother crops operates on the principle of preventing the development of weed species by limiting sexual or asexual reproduction, thereby depleting the soil seedbank. Spot hand-weeding is employed to prevent seed production by low densities of highly competitive or perennial weeds *[King et al., 1986]*. These control methods are routine or *'chore-like'*, i.e. they are undertaken without knowing the actual weed population and its ability to reduce yield.

INTEGRATED WEED MANAGEMENT SYSTEMS (IWM)

Integrated weed management systems employ a directed agro-ecosystem approach for the management and control of weeds at threshold levels which prevent economic loss in the current and future years *[Shaw, 1982]*. The IWM systems approach includes any or a combination of the following practices:

1. The use of multiple characteristics such as pest resistance, high yielding, well adapted crop varieties that resist weed competition;
2. Precision placement of fertilizers to give a crop comparative advantage in competing with weeds;
3. Timing the fertilizer application for maximum stimulation of the crop and minimum stimulation of the weed population;
4. Effective seedbed preparation and seeding methods that enhance crop growth and minimize weed growth;
5. Optimum plant population, including close intra- and inter-row spacing to optimize crop growth and minimize weed growth;
6. The use of crops which provide a canopy for shading as early in the growing season as possible to discourage weed growth;
7. Judicious irrigation practices, timely and appropriate cultivation;
8. Crop and herbicide rotation, and intercropping;
9. Field sanitation, and harvesting methods that do not spread weed seeds and vegetative propagates;
10. Use of biological agents such as insects and pathogens, and effective chemical methods.

Essential to an IWM System are the following:

1. An integration of effective, dependable and workable weed and crop management practices into crop and livestock production systems for economic benefit to producers.
2. Part of an overall crop and livestock management system rather than just weed control.
3. A sound stratagem for encouraging the judicious use of herbicides along with other safe, effective, and economical pest-control, methods and strategies.

IWM reduces the dependence on any one

type of weed control measure. Experience has shown that the overuse of herbicides has led to a shift and selection of specific weed series. For example, paraquat overuse in vegetables resulted in the predominance of white-top, also the continuous use of atrazine in corn resulted in a serious infestation of corn grass *[Bridgemohan and Brathwaite, 1988]*. The combination of various methods is important for control of competitive perennial weeds which are generally inadequately controlled by any single method *[Glaze, 1988]*. The application of IWM also includes knowledge of past weed history, competitive crop cultivars, improved crop and soil management practices, regular monitoring for annual and perennial weeds, hand weeding, spot-treating, and the appropriate selection of herbicides *[Schweizer, 1988]*.

CASE STUDIES OF THE APPLICATION OF IWM FOR THE CONTROL OF OBNOXIOUS WEEDS IN TRINIDAD

1. Control of *Rottboellia cochinchinensis* (corn grass):

Studies of weed management strategies for the control of *R. cochinchinensis* in maize *[Bridgemohan and Brathwaite, 1989]*, as well as seed survival and pattern of weed emergence studies of the weed in cultivated soils *[Bridgemohan, Brathwaite and McDavid, 1991]* have demonstrated the persistence of the weed in the seed bank, and its ability to survive due to enforced and innate dormancy characteristics. The results indicated that burial depth and duration had no marked effects on the depletion and persistence of the weed. The persistence component could range from 40-60 percent in cultivated soils. The presence of viable spikelets at depths of 45 cm in cultivated soils, supports the findings that the deeper the seed burial, the longer the survival, and that ploughing enhances the survival and persistence of the weed by burial. Shallow tillage (15 cm) cultivation methods at intervals of 10 to 15 days reduced the seedbank by 32 percent.

With regard to the development of a systematic management strategy to eradicate or reduce the persistence of *R. cochinchinensis* in cultivated soils, it is suggested that deep ploughing will have the effect of bringing buried dormant seeds closer to the surface, where conditions may induce their germination. This should be followed by a shallow tillage or rotovation 10 to 15 days later, which will destroy the emerged seedlings and may stimulate additional germination.

It is recommended that a soil acting herbicide should be incorporated at this time so that any further emergence is inhibited. The application of post-emergence herbicides and/or interrow cultivations will further eliminate any escaped seedlings that may interfere with crop growth and development. However, while this approach may reduce crop loss, it does not provide a complete solution to the problem of the persistence of the noxious weed *R. cochinchinensis*.

2. Control of *Parthenium hysterophorous* (white top).

Bridgemohan [1987] in reviewing the biology and control of white top described the weed as having wide ecological amplitude and adaptability, and displaying characteristics of profuse seeding ability, photothermal insensitivity, non-dormancy, prolificacy and low photo-respiratory rate. The weed which is native to Trinidad was not deemed/reported as a problem until the 1960's after the introduction of *bypridylium* herbicides e.g. paraquat.

The weed has shown resistance to paraquat and other methods of control including the carbohydrate depletion approach (hand weeding and mowing). Its presence at high densities was found to reduce crop yield by 75 to 100 percent in most vegetable crops. It served as a reservoir and *'resting site'* for a range of insect pests including the adult *Pletella xylostello* (L) and *thrip palmi,* which are major pests of cruciferous and solanaceous crops. The control strategy involved a combination of mechanical and chemical cultural methods. Shallow tillage was used to stimulate germination of dormant buried weed seeds. In the early vegetative (2-3) leaf stage, paraquat gave excellent control, but its efficacy declined when the plant approached flowering and seeding. It then become essential to rotate herbicides to glyphosate at that point. If the population was sparse, and the chemical control was not economical, deephand weeding 2-5 cm below the soil level or inter-row cultivation become essential. While this strategy reduced weed competition and improved crop yield significantly, the persistency of the weed was not reduced due to the long dormancy period of the weed seeds in the seed bank.

3. **Control of *Cyperus rotundas* (nut grass)**

Nut grass was found to be the predominant sedge weed in the major vegetable production areas in Trinidad *[Bridgemohan and Brathwaite, 1988],* the total crop loss was not uncommon. The control strategy *[Bridgemohan, unpubl., 1987]* required a program of crop rotation, that included crops with rapid canopy development; preplant tillage to stimulate germination and promote tuber decay by binging tubers to the soil surface; high plant population of competitive crops to cause shading; and cultivation plus herbicides (glyphosate applied using a rope-wick applicator) during the growing season to keep population at manageable level.

All components of this program were essential for control of moderate and severe infestation. Cultivation is particularly necessary as the weed proliferates under systems of reduced tillage with herbicides, especially paraquat.

CONCLUSION

The integrated weed management systems approach examined in this study, clearly indicated the merits and value of traditional farming practices. Values are best learnt in the field under specific sets of socio-economic, physical, environmental and management conditions. The dependence on an overly generalized and increasingly expensive chemical input packages, developed elsewhere under a different set of conditions, and aggressively promoted by researchers, extension agents and agro-chemical companies is grossly inappropriate.

The IWM systems approach fits into the work habit of farmers and gave effective control than when only chemical methods were used. In addition, yield improvements in the order of 40 to 100 percent were realized. While the IWM systems are considered technologically sound, the social and environmental advantages, as well as the economic costs associated with the practice needs to be ascertained. If farmers are not convinced of the economic viability of the system, then the technology no matter how sound, will not be adopted.

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