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THE STATUS OF WEED CONTROL IN DEVELOPED COUNTRIES

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ABSTRACT

Since the introduction of herbicides in the 1940s, they have replaced to a great extent the cultural practices used in developed countries to control weeds. More than 160 herbicides are now available commercially. Extensive use in virtually all crops has resulted in high quality food at reasonable prices to the consumer.

Problems resulting from such extensive and long-term use of herbicides are: a) soil carry over and damage to subsequent crops, b) surface water contamination, and c) development of resistance by certain weed species.

Several approaches have been initiated in developed countries to reduce and refine herbicide use. These include: a) increased research on the biology and life histories of the most serious weeds, b) integrated weed management, c) allelopathy, d) bio-herbicides, and e) organic farming.

A weed management program for Sri Lanka that does not rely exclusuvely on herbicides is discussed.

PESTICIDE USE

Pesticide sales world-wide were about US$ 16 billion in 1986, approximately US$ 4.5 billion of which were in the USA, and were expected to increase by 3-4 percent by 1990 (13). Herbicides accounted for 66 percent of the USA pesticide market at US$ 2.9 billion, with insecticides second at US$ 1 billion (13).

The use of herbicides for weed control gained great impetus with the discovery of 2,4-dichlorophenoxy acetic acid (2,4-D) in 1942. The insecticide DDT, with its broad spectrum activity on insects, was introduced in the late 1930s. Fungicides developed about the same time. It was soon recognized that these chemicals controlled insects and weeds more effectively and economically than cultural methods. Recognizing the need and the opportunity, chemical companies developed organo-phosphates insecticides and a series of phenoxy herbicides which improved the spectrum of weed and insect control. Within a relatively short time, herbicide use replaced, to a great extent, cultural practices as methods of weed control, even though they were effective (5). Large farms and a shortage of labor contributed to this trend.

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DEVELOPMENT OF THE PESTICIDE INDUST.

Commercial firms began to screen chemicals for weed control in major crops, i.e. rice, maize, wheat and other coarse grains and legumes, especially soybean. The search for chemicals to control weeds in high value crops such as sugar cane and perennial crops came later. A large market potential is necessary to justify the cost of developing a herbicide (US$ 20-30 million) and building a manufacturing plant (US$ 20 million). Hence, the potential market in many crops, particularly vegetables, does not cover registration costs for individual crops. Development costs to register a herbicide include studies in product toxicity; mode of action; metabolism; means of product breakdown to molecular components; possible teratogenicity, carcinogenicity, and mutagenicity; deleterious effects on flora and fauna; and potential environmental hazards. After a product is registered for a crop with large acreage or of high value, it is tested for efficacy and selectivity on crops with lower acreages. Testing to generate data required for registration of minor crops is usually conducted by university researchers in cooperation with the private sector.

Thousands of naturally occurring and newly synthesized chemicals have been screened each year during the last four decades. This has been done primarily by chemical companies in Switzerland, Germany, France, the UK, the USA and more recently in Japan and Australia. A single firm will screen as many as 12,000 chemical compounds annually, in the hope that one of them will become a successful product.

Several firms have screened herbicides to control a major weed species, such as wild oats (Avena fatua) or Cyperus spp., both classified among the world's 10 worst weeds. Wild oats is a severe problem in coarse grains in the temperate zones of four continents.

More than 160 herbicides are now on the market (17). These represent more than a dozen chemical families with broad and narrow spectrums, but do not include different formulations of the same basic active ingredient or similar products marketed by different firms under different names. Herbicides are available for nearly all crop types and are used, in many instances, on very high acreages of a single crop. For example, it is reported that 96 percent of the maize acreage and almost the entire rice acreage in the USA is treated with herbicides (11). Herbicides are used on

perennial crops, fruit trees, small fruits, vegetables, pastures, to manage unwanted species in forests, and for weed control in turf and ornamental crops.

Pre-emergence and soil incorporated herbicides are predominant in annual crops such as soybean, groundnut and potato. Post-emergence herbicides are important in perennial crops such as fruit trees, small fruits, pastures, forests, sugar cane, turf and ornamentals and for aquatic and wasteland weed control. Granular herbicides are used on large acreages of maize, soybean and coarse grains.

The present emphasis by chemical companies is to develop post-emergence herbicides which are applied to plants instead of soil. This avoids environmental problems which sometimes develop with soil applied, pre-emergence herbicides or soil sterilants.[1]

Herbicides, mainly in the form of emulsifiable concentrates and wettable powders are applied by air or sprayers with 50-foot booms. Granular herbicides are applied with 30-foot granular applicators.

SOME PROBLEMS ASSOCIATED WITH HERBICIDE USE

The pesticide revolution resulted in unprecedented high quality food products available to consumers at low cost. Although herbicides as a group are less toxic and less hazardous than insecticides, some problems have developed as a result of widespread herbicide use.

Herbicide residues in excess of tolerance levels

There have been a few examples of herbicide residues which exceed legal tolerance levels, e.g. amino triazole in cranberries, but the compliance record has been good. A recent in-depth study of pesticide use on fruits and vegetables in the USA showed that 50-75 percent of the samples contained no detectable residues (5). Of the remaining samples, about 1 percent were in violation of tolerance levels but it was concluded that these did not involve a health risk (5).

Soil residues

Long residual herbicides such as the triazines and carbamates are known to carry over in the soil and damage subsequent susceptible crops.

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[1] E. Knake, Extension specialist, University of Illinois, Ag Consultant, Willoughby, Ohio.

Contamination of water

There have been incidents of herbicide contamination of ground water and surface water bodies. This has usually resulted from spills or inadequate disposal of containers, but has resulted occasionally from field applications.

Unsafe herbicides

A few herbicides, e.g. 2,4,5-T, endothal, nitrofen and dinoseb, have been banned as carcinogenic or otherwise unsafe for use.

Development of resistance to herbicides

About 100 weed species have developed resistance to certain herbicides. Examples of acquired resistance are biotypes of Amaranthus and Kochia to triazines and sulfonurea herbicides, rigid rye grass to several herbicide families (2), wild oat to triallate, wild mustard to auxin-type herbicides, and two species of Echinocloa to propanil.

Crop variety differences in herbicide tolerance

Herbicide tolerance studies have shown crop tolerance to a herbicide does not ensure selectivity in all varieties. Varieties of peas, soybeans, sorghum and other crops have different tolerance levels. Physiologists are studying the mechanism of tolerance, which often involves rapid metabolism of the herbicide. Determination of the nature and mechanism of crop and weed resistance to herbicides is a major research activity.

RECENT DEVELOPMENTS IN WEED CONTROL

Integrated weed management

An intensive media program sponsored by environmental organizations, such as Friends of the Earth and The Sierra Club, and anti-pesticide groups (14) alarmed the public by claiming that pesticides are poisoning our food. The general public would welcome reduced pesticide use on food products (11) and there is a general consensus in the scientific community that herbicide use can be reduced without reducing crop yields and food quality or decreasing profits.

In an effort to reduce herbicide use, research is focusing on integrated weed management, using computerized models, linear programming and bio-economic modelling techniques (11). A bio-economic study in maize over a 4-year period managed weeds effectively, decreased herbicide use and increased profit margins (12). A study using linear

programming in maize-soybean rotations in the East-Central corn belt of the USA showed that in most years net farm income can be increased by reducing herbicide use, usually by decreasing application rates (12).

Detailed information on weed biology and life histories of the most troublesome weeds is critical to an effective integrated weed management program. Hence, weed biology and the interference of various weed species on crop yields in relation to density continues to be an important area of research (4, 8).

An effective integrated weed management program must also consider farming systems, tillage systems, soil types, crop varieties, weed species, herbicide type and application rates, and cost-price relationships between crops and herbicides used.

Organic farming

Another response to public concern about the use of pesticides in food production is organic farming, i.e. crop production without the use of chemicals. This system, which has been adopted by some farmers in the USA and the UK, has resulted in decreased production costs but has also reduced crop yields. However, profits have been maintained through sales of produce at higher prices to specialty food shops. The system, which of necessity requires crop rotations, carefully managed cultural practices and cover crops, has side benefits of decreased soil erosion and increased soil stability and fertility.

Bio-herbicides

Bio-herbicides (micro-organisms which are sprayed on crops) represent a new biological method to selectively kill weeds (15). Myco-herbicide development has concentrated on specific weeds which escape the effects of most herbicides, e.g. sickelpod, a serious weed in groundnut in the USA; and velvetleaf, troublesome in soybeans. *Alternaria cassia*, a bio-herbicide, alters phenylpropanoid metabolism of *Cassia alata*. A fungus, *Fusarium solani* shows promise for the control of wild morning glory.

Bacterial diseases also are being considered for weed control. *Rhizobacteria* shows promise for weed control in wheat, *Pseudomonas fluorescens* for control of downy brome grass and *Xanthomonos campestris* for the control of annual bluegrass.

Allelopathy

Allelopathy, a common phenomenon in nature, occurs when breakdown products of one species inhibit seed germination and plant growth of another (16). In certain desert plant communities, allelopathy is the main means of plant competition. Examples of plants which exhibit this characteristic in nature are quackgrass (*Agropyron repens*) and walnut trees. Chemicals exuded from the roots of walnut trees prevent growth of weed species in a area around their trunks. Certain crop residues also inhibit plant growth, e.g. flax and oat straw. Studies are ongoing to determine the allelopathic effects of crop mulches.

There is an attempt to utilize allelopathy of some crops for weed control. It has been recognized that sweet potato interferes with the development of yellow nutsedge (*Cyperus esculentus*) (10), a variety of cucumber inhibits growth of annual weeds, and certain rice varieties inhibit growth of aquatic weeds, duck salad and redstem.

Equipment and machinery

A newly-developed spyder-torsion weeder (thin strips of spring steel) probes beneath the soil surface and removes small weeds adjacent to crop plants (3). Farmers in New York State have used this implement to control weeds in onions and celery for entire seasons without the use of herbicides.

Another tool for weed control is a "weed burner" which destroys weeds between crop rows by burning them with an ignited jet of oil.

No-till and minimum tillage systems

The introduction of no-till systems compared with traditional tillage systems resulted, in the short run, in decreased profits and increased requirements for herbicides to manage weeds. It was concluded that no-till systems should be used on erodible soils and conventional tillage on stable soils.

Genetic engineering

Geneticists have inserted herbicide resistant genes into crops, e.g. potato, and glyphosate resistance in tomato. This permits the use of glyphosate for weed control in tomatoes (1).

Seed protectants

The slower proliferation of new herbicides in the last decade due to more stringent environmental regulations has led to more intensive use of the more active herbicides on crops with marginal tolerance. To improve tolerance, seeds are treated with protectants to avoid crop toxicity from highly efficacious herbicides (7), e.g. carbamates and triazines in coarse grains and sorghum.

Interaction of herbicides

Studies of herbicide antagonism, synergism and phytotoxicity have increased due to a greater tendency in the last decade to tank mix or formulate mixtures of herbicides for broad spectrum weed control (9).

Soil run-off studies

Considerable research is underway to determine the effects of tillage practices on soil runoff and transport of herbicides, using different residue management systems. Studies also include soil water and rainfall effects on macropore transport of soil applied herbicides and the fate of post-emergence sprays delivered in the atmosphere.

Herbicide waste and container disposal

Studies are underway to minimize waste in herbicide use. A Spray Drift Task Force has been formed to deal with minimizing spray drift. Research is developing shielded spray nozzles to minimize drift in herbicide applications.

Investigations are being conducted on the recycling of herbicide containers, both mini-bulk and small volume returnables. Nearly every major company offers a mini-bulk service for one or more of its products (6). A Dupont soybean herbicide is formulated as a tablet which dissolves when dropped in the appropriate volume of water (6). Ciba-Geigy offers its post-emergence herbicide in water-soluble packets of pre-measured doses, thus eliminating the need for disposing of containers (6).

RECOMMENDATIONS FOR A WEED MANAGEMENT PROGRAM IN SRI LANKA

The insidious nature of weeds can reduce crop yields by 50 percent and in some cases prevent yields altogether. Weeds are a major constraint to crop production in Sri Lanka and apart from plantation crops, weed management is not effectively practised at the farm level.

Development of an effective strategy for weed management requires a knowledge of the biology of individual weed species. Hence, research should concentrate on the biology and life histories of the important weed species in Sri Lanka.

An integrated approach to weed management should be developed without relying exclusively on herbicides. However, adoption by farmers of the technology involved in such a program will be handicapped by their lack of improved field equipment. Most farmers in Sri Lanka control weeds by hand weeding or hoeing with a mammoty. Both systems represent backbreaking drudgery; hoeing is usually ineffective because weeds are scraped off at the soil surface and regrowth occurs within a few days. Power equipment for weed control is not affordable by most Sri Lankan farmers. However, the technology that permits use of a single draft animal to pull a cultivator to weed between crop rows is available and, if adopted, would represent a significant advance in managing weeds by cultural practices.

Several measures to improve weed control can be implemented with present resources:

a) Prevent weeds from going to seed by keeping fields mowed or planted to cover crops after harvest.

b) Till soils at appropriate times to control germination of weeds and thus permit their destruction at a convenient time.

c) Apply a straw mulch on the soil surface to inhibit weed growth and to protect soils and applied inputs from the impact of rain.

d) Crop rotations representing different crop families will assist in limiting weed, disease and insect infestations.

e) Intercropping with appropriate crop combinations limits weed growth, as well as utilizing more effectively the resources required for crop production.

f) Promote the use of sprayer nozzles which can be attached to the hose of a knapsack sprayer and will spray herbicides at selected swath widths of 0.5, 1.0 or 1.5 meters. This would not only improve efficacy and reduce phytotoxicity, but also reduce spraying time and labor costs.

g) A media program on herbicide use as a weed management tool should be initiated. Extension should concentrate on providing information on herbicide use, not only to farmers but to sprayer operators and buyers of farm produce. Rules for herbicide use should be emphasized, e.g. avoid over use, bury empty herbicide containers, avoid cleaning herbicide equipment near bodies of water.

SUMMARY

The economic benefits and contributions to food quality of herbicide use in crop production are well documented. However, there are intensive research and extension efforts in developed countries to use herbicides more efficiently in combination with all other available methods. Research continues to determine yield losses by crop species and to study the weak links in weed biology. Improved packaging and formulations are decreasing potential environmental hazards and making herbicide applications more 'user friendly'. According to Ellery Knake (1990)[2], University of Illinois, herbicides will very likely continue as a major "front line offensive against weeds for the forseeable future".

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