A REVIEW OF MAJOR WEED CONTROL PROBLEMS IN EAST AND CENTRAL AFRICA WITH PARTICULAR EMPHASIS ON *STRIGA* AND INTERCROPPING PRACTICES

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INTRODUCTION

Weeds are the most neglected of the major groups of crop pests, despite being responsible for estimated losses of 25% of potential yield in the developing countries. Manual land preparation and cultivations to control weeds can account for 50% of the total time required to produce crops and tie up millions of man-days of labour which might otherwise be available for more productive and rewarding activities.

It is paradoxical that ever-present weeds attract less research, extension and training activities than pests such as locusts, armyworm and quelea birds which are present intermittently. This is not to imply that resources provided for the study and control of other pests is excessive, but that weed science in the developing countries is undercapitalized.

There may be several reasons for the failure to recognize the importance of weeds:

(a) damage to crops by weeds is less conspicuous than damage caused by insects, diseases and other pests. The effects of weed competition on an otherwise healthy crop are not as apparent as a few nibbled or diseased leaves;

(b) there is a fatalistic acceptance that weeds will always be present, regardless of what is done to eliminate them;

(c) cultural and social barriers can prevent effective dialogue on weed problems and methods of control between the male-dominated extension service and the women who often do the weeding.

Labour constraints during the first few weeks after sowing a crop, when it is most vulnerable to competition, are a common cause of poor weed management. Herbicides have potential but their use may be prevented or constrained by a number of factors. They may not be readily available. Farmers may not be able to afford them or have access to suitable equipment. In many cases there is little or no knowledge or information on their use. Sexist attitudes can also be a factor where men are reluctant to invest cash and resources in traditional women's activities.

Weeds occur as a consequence of cropping practices. Sedges, for example, are often associated with irrigated crops and perennial weeds can become prevalent where zero-tillage is practised. It is logical, therefore, that weeds are affected by the types of crop management being employed and this is the basis for integrated weed control. Weeds can be alternate hosts of insects, diseases, other pests and also for the predators of these pests. Hence, the control of a weedy host has implications for control of pests and their predators and, ultimately, crop yields. The control of an insect may afford some protection to the weed host as well as the crop. The concept popularly known as integrated pest management can be very complex and daunting to use by small-scale farmers.

COMMON WEEDS OF EAST AND CENTRAL AFRICA

Common weeds of the region are well-documented: inexpensive publications containing descriptions, photographs and/or line drawings of weeds are available for Kenya (10,18), Malawi (4), Tanzania (10,18), Uganda (10,18), Zambia (19) and Zimbabwe (7). As many as 200 species are described in these publications, of which 30 species are described or mentioned in every book (Table 1). Nearly all of the 30 species have a pan-tropical distribution.

Table 1. **Common and Ubiquitous Weeds of East and Central Africa**

BROAD-LEAVED SPP.	GRASSES	SEDGES & COMMELINA
Annual species		
Acanthospermum hispidum	Dactyloctenium aegyptium	
Ageratum conyzoides	Eleusine indica	
Amaranthus hybridus	Rottboellia cochinchinensis	
Bidens pilosa	Setaria pumila	
Datura stramonium	Setaria verticillata	
Euphorbia heterophylla		
Euphorbia hirta		
Galinsoga parviflora		
Gynandropsis gynandra		
Nicandra physalodes		
Oxygonum sinuatum		
Portulaca oleracea		
Solanum nigrum		
Sonchus oleraceus		
Striga asiatica		
Tagetes minuta		
Tribulus terrestris		
Trichodesma zeylanica		
Perennial species		
Oxalis latifolia	Cynodon dactylon	Commelina benghalensis
Solanum incanum	Imperata cylindrica	Cyperus esculentus
		Cyperus rotundus

Individual species of weeds are not necessarily problematical in their own right. It is more usual to see them as components of a mixed flora where competition with the crop for nutrients, water and light can arise from the growth of few or many species. This is often the case in fields where weed control is done by cultivations. Herbicides can be excellent aids to hand labour but when used as a replacement for this labour, especially if the same product is used repeatedly, resistant weeds become established and the species diversity of the flora becomes smaller. This can be seen in wheat and barley where repeated use of 2, 4-D has promoted annual grass weeds, and in coffee plantations where paraquat tends to encourage perennial grasses and sedges. Individual species, even at relatively low densities, do become important if they act as alternate hosts for nematodes, diseases, insects and other pests and for the predators of these pests. Some species can also be valued by farmers as food for themselves and their livestock, raising the question, "are these plants weeds if they are useful?"

SELECTED PROBLEM WEEDS AND THEIR CONTROL

There are several species of weeds of considerable importance in East and Central Africa which are difficult or expensive to control. They are natural targets for research aimed at all levels of agriculture. Methods appropriate for estates growing cash crops may be inappropriate for use by subsistence farmers.

When devising priorities for research programmes, it is clearly important to have some idea of the magnitude of the problem and the likelihood and possible benefits of success. For some weeds, such as perennial grasses, the technology for control exists but the challenge is to find methods appropriate to most farmers. For others, such as the parasitic *Striga* species, there are no known methods of reliable control which are appropriate to the majority of farmers who are afflicted. Whilst it is obviously desirable to solve the intractable problems, it is questionnable whether a single country's scarce resources and manpower should be committed to trying to do so when success seems remote. Collaborative programmes with shared commitment and resources could be a better justification for pursuing research on difficult species. *Striga* is a weed which is suitable for this type of research, with its requirement for technologically advanced facilities and good field sites.

Examples of problem weeds in the region are given below.

Annual grasses

Common grasses of the region are given in Table 1 but other genera which contain common weed species are *Avena*, *Brachiaria*, *Bromus*, *Chloris*, *Echinochloa*, *Eragrostis* and *Lolium*. Some of the common grasses are of particular importance as weeds.

Avena fatua L.

> *A. fatua* is the commonest species of wild oat in the region, existing in several types and as hybrids with cultivated oats. *A. sterilis* L. ssp. *ludoviciana* (Dur.) Nyman, *A. sterilis* var. *maxima* Perez Lara. and *A. sterilis* var. *macrocarpa* Moench are also present (18). In Zimbabwe, *A. fatua* is occasionally a weed of irrigated cereals and is the only serious weed of agricultural land to have been legislated against in the Noxious Weed Act (7). It is not yet a permanent weed in Zambia but has the potential to become a serious problem (19). It is present in all the wheat- and barley-growing areas of Tanzania and Kenya, infesting 30,000-40,000 ha of cereal land in the latter, causing total crop loss where weed densities are high.

The biology and distribution of *Avena* spp. in East Africa is worthy of study because of the existing and potential danger to cereal crops.

Preventive control needs to be practised to avoid introducing seeds of wild oats to uncontaminated areas by means of farm machinery, animal feedstuffs, gunny bags etc. Small infestations in fields should be removed by hand roguing but large populations will probably need to be treated with one of the proprietary herbicides (e.g. chlorfenpropmethyl, diclofop-methyl, difenzoquat, flamprop-isopropyl, etc.) alone or in mixtures with other herbicides (17).

Bromus spp.

Bromus pectinatus Thunb. is a tufted annual grass, locally important as a weed of highland cereals in Kenya and Southern Tanzania. *B. diandrus* Roth is a related weed. There is concern that these species are becoming more serious and there is need for research on their biology and control. Some herbicides are available but *Bromus* spp. are difficult to control and appear to be gaining in status worldwide.

Rottboellia cochinchinensis (Lour.) W.D. Clayton

This grass, known also as *R. exaltata* L.f., itchgrass, guineafowl grass, shamva grass and mulungwe, is one of the most serious weeds of sugar cane, maize and other annual crops in the region, particularly on medium to heavy soils of good fertility (7, 19).

Seeds of *Rottboellia* only live for 3-4 years, so control is theoretically possible by preventing seeding for that period of time. This has proved difficult in practice as *Rottboellia* is resistant to most herbicides which are applied in maize. Pendimethalin is safe in maize but performance against *Rottboellia* is variable. There is scope for using herbicides in other crops rotated with maize, such as trifluralin in sunflower, but it is advisable to follow chemical treatments with supplementary hand-weeding to remove 'escapes' (17).

Rottboellia is susceptible to cultivations within three weeks of emergence but, after that time, the development of prop roots gives stability. Seeds are vulnerable if they are not buried in the soil, offering scope for control by zero-tillage and fallowing.

Setaria spp.

Several species of *Setaria* occur as weeds in East and Central Africa but the most serious are *S. pumila* (Poir.) Roem & Schult.[= *S.pallide-fusca* (Schumach.) Stapf & Hubbard] and *S. verticillata* (L.) P. Beauv. Both have a cylindrical 'fox-tail' inflorescence but that of *S. verticillata* attaches itself readily to clothing and animal hides. They can be found in most crops but are particularly serious in wheat and barley in Kenya and Tanzania.

Both species can be controlled by cultivations when young and good control is possible with a range of herbicides. The dried inflorescences of *S. verticillata* deter rats when placed over the openings of grain-storage bins (7).

Perennial grasses

Perennial grasses are probably the most important weeds in East and Central Africa, seriously affecting crop production in large- and small-scale agriculture. *Digitaria abyssinica* (A. Rich.) Stapf and *Cynodon dactylon* (L.) Pers. are the most important species but other significant problem species are *Imperata cylindrica* (L.) Raeuschel, *Panicum maximum* Jacq., *P. trichocladum* K. Schum. and *Pennisetum clandestinum* Chiov.

Cynodon dactylon

C. dactylon [= star grass, couch grass (in Zambia and Zimbabwe)] has horizontal creeping stems which can be underground (rhizomes) or on the surface (stolons). C. nlemfuensis is very similar in appearance but only has stolons. C. dactylon propagates from seed, rhizomes or stolons, rapidly colonizing land cleared of weeds and other vegetation.

It is a problem in all types of agriculture and most crops where it competes vigorously. It is also suspected of being allelopathic, i.e. being able to suppress the growth of neighbouring plants by means of toxic exudates.

Desiccation of rhizomes and stolons by means of dry season cultivations is a method of control but cultivation of soils at this time can be difficult, if not impossible. Forked hoes can be used to dig out the rhizomes with minimal damage to crop roots but it is a very laborious exercise. Cutting, grazing, burning and flooding offer little or no scope for control but long-term fallowing may have potential. A few herbicides have selective activity against C. dactylon in annual crops, including fluazifop-butyl (in beans, cotton, groundnut and soybean) and sethoxydim (in cotton, groundnut and soybean). A wider range of products is available for use in perennial crops and for land preparation before crops are planted. Glyphosate is one of the best herbicides but, like many other products, its relatively high cost deters small-scale farmers from using it.

Digitaria abyssinica

D. abyssinica [= D. scalarum (Schweinf.) Chiov., couch grass (in East Africa)] is probably the most important weed of Kenya, Tanzania and Uganda. Death or severe injury to annual and perennial crops can occur with bad infestations (10, 18) and it has been suspected that damage can be due to allelopathic properties of this weed. Propagation is by rhizomes but dispersal by seeds is also possible.

As with C. dactylon, dry season cultivations are a possible, though usually impractical, method of control. Glyphosate can be used very effectively against D. abyssinica but with the same constraints as for Cynodon.

Perennial sedges

Over 50 different sedge (Cyperaceae) weeds are found in East African crops (17) of which the most important are Cyperus rotundus L. (purple nutsedge) and C. esculentus L. (yellow nutsedge). Several bulbous sedges are of local importance in East Africa, including C. blysmoides C.B. Cl., C. bulbosus Vahl var. melanolepis Kuk., C. grandibulbosus C.B. Cl. and C. usitatus Burch. (18). Common annual sedge weeds include C. iria L. and C. difformis L. but they are less important than the perennial species.

Cyperus esculentus

This species occurs in many tropical, sub-tropical and warm-climate countries where it is a weed of virtually all crops and in all levels of agriculture. It propagates by means of seeds and tubers which break from the ends of many rhizomes.

Cultivations give only temporary suppression of shoots germinating from tubers and are not a practical method of exhausting food reserves to kill the perennating organs. Frequent cultivations, until the crop has formed a canopy, will minimize competition but control is only temporary and rapid regrowth occurs when the crop is removed.

Nutsedges do not compete well with vigorous cover crops but there is little scope for this method of weed management.

Few herbicides kill nutsedges but several give useful suppression, during which time the crop can become sufficiently well established to suppress later weed growth. Products which can be used in maize and/or beans include bentazon, butylate, 2,4-D, metolachlor and EPTC. Glyphosate is one of the best herbicides for controlling C. esculentus because it can kill the tubers when applied at the correct time.

Cyperus rotundus

This species is generally more tropical in its distribution than C. esculentus but it is widely found as an important weed of most crops in East and Central Africa, especially where irrigation is employed and minimum tillage is practised. Propagation is by means of tubers which are linked to each other and the parent plant by slender rhizomes. Propagation by seed is thought to be insignificant.

Desiccation by winter tillage helps to reduce populations in Zimbabwe (7) but, in East Africa, the dry seasons are probably not long enough. Tillage at this time is also be difficult for farmers who can use only hand labour.

Few herbicides give more than temporary suppression of C. rotundus in maize and/or beans and these include butylate, 2,4-D, EPTC and vernolate. In perennial crops, it is also possible to use bromacil, dichlobenil, MSMA and terbacil. Glyphosate gives the best control of C. rotundus but it must be applied at a time when it can be taken up and translocated to the tubers connected to parent plants.

Broad-leaved weeds

Many broad-leaved weeds cause problems in the region. Some species, such as Ageratum conyzoides L. and Galinsoga parviflora Cav., have been common problems for many years. Others, such as Acanthospermum hispidum DC., show signs of increasing their range and becoming more important than in the past. As herbicide usage expands, minor weeds may be elevated to become species of some importance if they are resistant to the treatments. Such is the case with Parthenium hysterophorus L., a species which is becoming increasingly troublesome in minimum-tilled coffee in Kenya. For most of the problem broad-leafed weeds, control is possible at a price but two common genera, Oxalis and Striga contain species which defy control by methods which are economical and practical.

Oxalis latifolia

The Oxalis genus contains several weed species in Eastern and Central Africa, including O. abercornensis Knuth, O. anthelmintica A. Rich., O. barrelieri L., O. cornicultata L., O. corymbosa DC., O. obliquifolia

A. Rich., O. radicosa A. Rich., O. semiloba Sond. and O. trichophylla Bak., but it is O. latifolia Kunth. which is of major importance.

O. latifolia is widely distributed in the region where it occurs as a weed of many crops. It tends to be most serious in nurseries and gardens but is often a problem in field crops such as cotton in Uganda. It commonly occurs as a ground cover in coffee plantations but there is no agreement as to whether this is desirable or not. Little is known of crop losses due to O. latifolia but grain reductions of 24% have been observed in maize (17).

Control of O. latifolia has proved to be difficult. Cultivations alone do not seem to be appropriate, neither does slashing. Organic mulch gives temporary suppression but black polythene gives good control where it can be used. O. latifolia is shade tolerant but can be suppressed by dense crop stands and grass pastures. Eradication of this weed is possible by soil sterilization but this is impractical on all but small areas used for high value crops. Trifluralin, EPTC and oxadiazon are the most reliable of herbicides to be used against O. latifolia and control, under some conditions, has been obtained with bromacil, chlorfenac, dichlobenil, diuron, linuron, oxyfluorfen and simazine. Glyphosate can be used to give control but only after several applications in one season.

Good control of Oxalis appears to be dependant on timing of treatments, whether they be cultivations or herbicides. Some studies have been made on the biology of O. latifolia but these need to be continued and related to practical situations.

Striga spp.

Striga is a genus of parasitic weeds which contains some of the most serious weeds in Africa. S. hermonthica (Del.) Benth. (purple witchweed) is of widespread but localized importance in Kenya, Uganda and Tanzania, mostly on sandy soils of low fertility, where it is parasitic on maize, sorghum, finger millet, pearl millet and sugar cane (10,15,18). S. asiatica (L.) Kuntze (= S. lutea Lour., red witchweed) is found throughout East and Central Africa where it parasitizes upland rice and the crops listed for S. hermonthica, again on soils of low fertility (7,10,15,18,19). S. forbesii Benth. (giant maize witchweed) is less common but occurs as a parasite of Setaria sphacelata (Schumach.) Moss (= Nandi setaria pasture grass) and of rice and sorghum in Tanzania (18) and of maize in Zimbabwe (7). S. gesnerioides (tobacco witchweed) is commonly found in East Africa but shows little sign of becoming the serious pest of tobacco and legume crops that it has in other countries (17). A strain of S. gesnerioides was locally important as a parasite of tobacco in Zimbabwe but it has not caused trouble in recent years (7). S. aspera (Willd.) Benth. and S. euphrasioides Benth. occur in Tanzania and Malawi as occasional parasites of rice, maize, sorghum and sugar cane (15).

Yield losses due to Striga vary with the level of infestation but total crop failure is possible in the worst situations. Small-scale farms tend to be more afflicted with Striga than are large, mechanized estates, a fact which may be equated with better cultural practices such as crop rotations, use of fertilizers and improved varieties, etc.

At present, there are no completely reliable and practical recommendations for the control of *Striga* that can be given to small-scale farmers. Crop management practices and other methods of controlling *Striga* are summarized below but reviews of this subject have been prepared by several authors (5,6,8,13,15,16). An integrated approach employing two or more of these methods is most likely to succeed. The methods used to control *S. asiatica* and *S. hermonthica* are broadly similar so no distinction is drawn between them.

a. Cultivations

Cultivations are largely ineffective for controlling *Striga*. Hoeing can remove *Striga* but only by damaging the crop roots. After shallow cultivations, *Striga* can produce tillers from the broken or cut stem.

b. Hand-pulling

Seed production is halted and viable seed populations in the soil are diminished by repeatedly pulling *Stringa* from the ground before it produces seed. In practice this means pulling every two weeks but other frequencies of pulling have also been shown to benefit the crop (6). It takes many years to eliminate *Striga* by this laborious method but it is a simple procedure for a small-holder and his family. Because *Striga* continues to grow and mature on the stubbles of harvested crops, it is important that the parasite and stubbles be pulled out before seed is produced.

c. Trap and catch crops

Many plants produce exudates which stimulate the germination of *Striga* seeds. Trap crops do this without becoming parasitized, thus luring *Striga* into suicidal germination. Soybean, lucerne, sunn hemp and cotton can do this for *S. hermonthica* whilst soybean, field pea, cowpea, sunflower, linseed, castor bean and cotton can do likewise on seeds of *S. asiatica*. It is possible to deplete the *Striga* seed population over several years by including trap crops in rotation with susceptible crops. However, complications arise where a trap crop stimulates germination of, for example, a "sorghum strain" of *S. hermonthica* but not the "millet strain".

Catch crops also stimulate *Striga* germination but, unlike trap crops, are themselves parasitized. They include such plants as wild sorghums and Sudan grass [*Andropogon sorghum* (L.) Brot.]. These crops are utilized by planting them at a high seed rate before the main crop is sown and then destroying them, together with the attached *Striga* plants after 5-8 weeks and before the parasite produces seed. Land can gradually be cleared of *Striga* if catch crops are grown repeatedly but it necessitates sacrificing part or all of the growing season.

d. Nitrogen fertilizer and manuring

Striga tends to be less damaging to crops under fertile conditions. The exact timing of application is not critical, so long as the crop responds. Very high levels of nitrogen would be required to completely suppress *Striga* but even relatively modest levels can help to reduce the harmful effects of the parasite. The reasons for this response are not fully understood but there is evidence that crops produce less stimulant and become more tolerant of *Striga*. Farmyard manure and compost are reported to reduce *Striga* densities and improve crop yields.

e. Crop spacing

There is some evidence that increasing the space between sorghum plants on heavily infested land can decrease infestations on the crop. This may be explained by the fact that less stimulant is produced in a unit area of soil.

f. Date of planting

Early-sown sorghum in Sudan tends to be attacked more by *Striga* than the crop sown later in the season. This may be related to soil temperatures and rainfall: by the time that the late crop is sown, rain reduces soil temperatures to below the optimum needed for preconditioning and/or germination of the *Striga* seeds.

g. Irrigation

Striga rarely persists in wet or irrigated land so it can be suppressed by applying supplementary irrigation. Conversely, water stress can accentuate the severity of *Striga* attack.

h. Early maturing crop varieties

Crop varieties which can mature early may be able to escape the most damaging effects of *Striga* whilst also acting as catch crops. There is evidence that better yields on *Striga*-infested land can be obtained with early maturing finger millet, maize and sorghum.

i. Resistant crop varieties

Some crop varieties are resistant to *Striga* attack because they produce little or no root exudate to stimulate the germination of the parasite's seeds. Other varieties stimulate germination but resist penetration of their roots or do not allow normal development of the parasite after attachment. Selection and breeding programmes are endeavouring to exploit these forms of resistance. Cultivars of sorghum which show resistance include N-13, Framida, SPV 103, IS 9830, Dobbs, SB19 and Serene. Bulrush millet cultivar Serere 2A-9 is less susceptible to *Striga* than other types but varietal resistance in maize is not known.

The breeding of resistant varieties is likely to be one of the best methods of overcoming *Striga* as it requires little or no inputs from the farmers who suffer most from this pest.

j. Biological control

Organisms which damage *Striga* include a weevil (*Smicronyx umbrinus*), a butterfly larva (*Precis* sp.) and a range of fungal diseases but no practical biological control techniques have yet been developed.

k. Synthetic germination stimulants

Ethylene and an ethylene-releasing compound, 2-chloroethane phosphonic acid, stimulate the suicidal germination of *Striga* seeds when injected into the soil. This method has been used successfully against *S. asiatica* in the USA but would be difficult technology to adopt in the *Striga*-infested areas of Africa. Synthetic analogues of the naturally occurring stimulant, strigol, have been tested with some success but these products are not commercially available.

l. Antitranspirants

Recent research by Prof. G. Stewart and his colleagues at University College, London have shown that an antitranspirant applied to *S. hermonthica* causes rapid death of the parasite. It is suspected that preventing transpiration in the parasite causes it to overheat. Research is continuing on this novel method of control and a search is being undertaken for inexpensive, readily available compounds which can be used as antitranspirants.

m. Herbicides

Limited success has been achieved in the control of *Striga* with herbicides but practical methods applicable to poor, small-scale farmers are elusive. Products with reported activity include 2,4-D, MCPA, ametryn, atrazine, linuron, butylate, chlorfenac and 2,3,6-TBA. Methyl bromide can be used to fumigate the soil but it is of little practical value.

WEEDS AND INTERCROPPING

Weed management in intercrops has been the subject of very little research (2). Even so, it would be difficult in this paper to adequately review all the information available on weeds and intercropping, so outline remarks are given and the reader is advised to seek more information in the literature cited and, in particular, from references (1,2,12).

What is intercropping?

Intercropping has been defined as the growing of two or more crops simultaneously on the same land in different but proximate stands. The crops may be grown in distinct rows or intermingled with no row arrangements. Multiple cropping is defined as the growing of more than one crop on the same land in a year (1). Hence, by these definitions, intercropping is a form of multiple cropping. Both are traditional systems of farming used throughout East and Central Africa, commonly, but not exclusively, practised by subsistence and small-scale farmers. There is a considerable volume of literature available on multiple cropping and intercropping, much of which has been conveniently reviewed (9).

There are several reasons why farmers intercrop, including insurance against crop failure, better and more efficient use of labour, prevention of soil erosion and protection against crop pests (1).

Relationships between weeds and intercropping

The desire to control weeds may have influenced the evolution of cropping patterns (1,11) and there is evidence that weeds are often a greater problem in single crops than in multi-crop associations. However, if the plant density of the intercrop is the same as in the component crops grown alone, or if both are planted at their optimal densities, there may be little advantage with respect to weed control from intercropping. In some cases, weed growth where intercrops are grown may be as serious or even worse than where sole crops are planted (11).

The weed-suppressing ability of intercrops is dependent upon factors such as the characteristics of the component crops and the selected cultivars, plant density, proportions in which the component crops are grown, their spatial arrangement, and the fertility status of the soil. Other environmental and biological factors may also play important roles (2). Intercropping has potential as a means of weed control because it offers the possibility of a mixture of crops capturing a greater share of available resources than in monocropping, pre-empting their use by weeds (2). Conflicting results are reported for the effects of intercropping on weed growth, not only between different intercrop combinations but also within them and it is evident that no clearcut statement can be made as to whether intercropping reduces weed growth (11). Some examples which illustrate this point are given below.

a. The competitive ability of maize is enhanced if it is intercropped with mung bean (3). As the level of weed control is reduced, the relative advantage of intercropping increases to a point where its productivity is 75% greater than that of monoculture.

b. A 50-75% reduction in weed infestation can be achieved by intercropping pigeon pea with crops like sorghum, millet, cowpea and field beans. Sorghum-based intercropping systems are 25% more efficient in keeping down weed growth than single crop systems. However, intercropping systems based on pigeon pea do not improve their competitive ability over their respective single crops (14).

c. Growth of weeds in an intercrop may be severely depressed or hardly affected, relative to crop-free control treatments. Moreover, weed growth in intercrops may be lower than in all the component monocultures, lower in one of the monocultures, or equal in the intercrop and monocultures (12).

d. Mung bean gives better control of weeds than groundnut and sweet potato when they are intercropped with maize at low maize plant populations and wide row spacing but not at high maize populations (3).

Weed management in intercropping systems

Just as in single crop situations, the methods employed to control weeds in intercrops can be very diverse. However, intercropping does impose constraints on the use of some methods (e.g. herbicides) whilst allowing the exploitation of others (e.g. crop competition). Examples of various weed control strategies in intercrops are outlined below.

a. Manual and mechanical methods

Manual and mechanical methods of weeding are most commonly practised in intercrops. Intercropping may or may not help to suppress weeds but controlling these weeds by hand and mechanical cultivations is difficult if the crops are not sown in rows. Tillage operations are further complicated if the critical periods of weed competition in intercropping are longer than those for sole cropping, thereby extending the weeding operations to secure optimum yields (11). Cultivations can be facilitated if the crops are conveniently spaced. For example, it has been noted that two rows of legumes planted very close to a row of maize with a distance between maize rows of one metre, allows cultivation between the intercrop rows and the weeds within them can be removed by hand (11).

b. Crop selection and spacing

Crops vary in their growth rates, spreading habit, weight, canopy structure, inherent competitive character and, by virtue of these characteristics, their ability to suppress weeds (14). By growing two or more crops together, one is able to combine the different weed suppressing characteristics of these crops. For example, quick-growing ground covers such as groundnuts can be grown with erect crops such as maize. Individually, they are susceptible to particular types of weed competition but this is reduced when these crops are grown together.

Crop cultivars may also be selected for being better able to compete with weeds. Little work has been done on this in relation to intercropping but there is evidence that some maize and mung bean cultivars are better than others (2).

Spatial arrangements and the proportions of component crops influence yields and weed growth. It is difficult to generalize about this because of the complexity of the interactions between crops and weeds but there are examples throughout the literature extolling the virtues of one system compared with others.

c. Herbicides

The use of herbicides by the types of farmers who tend to practise intercropping is a subject worthy of review in its own right. Putting aside the arguments for the against herbicides, and considering only the feasibility of using herbicides in intercropping, one can conclude that chemical weed control is possible in some circumstances. The greatest limitation is in finding products which can be safely used in all the component intercrops whilst also having activity against the weeds that are present. It is relatively easier to achieve this when one or none of the crops are present, such as before planting, than when the crops have been sown or have emerged together. However, products do exist and, taking a maize/bean intercrop as an example, they include alachlor, linuron, metobromuron, metolachlor and pendimathalin (17).

d. Integrated weed control

This is one of the best and most appropriate methods of managing weeds in crops grown alone or together. Absolute reliance upon one method of weed control can lead to the establishment of weeds resistant to that method but combining one or more different methods reduces this threat. Many permutations of weed control treatments (e.g. cultivations, herbicides, timing of weeding operations etc.) and crop management practices indirectly related to weed control (e.g. planting dates, crop spacings, crop varieties, fertilizer applications, irrigations etc.) can be identified. All farmers can benefit from integrated weed control by selecting methods most appropriate to their needs.

Weed research needed in intercropping systems

Intercropping is practised in many different ways but numerous interactions confound attempts to find simple rules for the management of these systems. Despite this, intercropping is widespread in the developing countries and, as there is a strong requirement to improve agricultural production, the problems of pest management in these systems must be addressed. Weeds are no less important in intercropping than other pests but there has been remarkably little research done on their control. Willey (20,21) has summarized the research needs for intercropping in general and Akobundu (1) has identified the following research needs for weed management in these systems.

a. Weed-crop competition

Competition within crop species and between crops and weeds needs to be understood as a basis for the efficient management of weeds and the adoption of appropriate agronomic practices. Not enough is known about optimum plant populations, spacing, fertilizer requirements and planting times. It is also necessary to identify the economic threshold level of various weed associations in the major intercropping systems.

b. Allelopathy

Crops which exert allelopathic influences on other crops and/or weeds need to be identified with regard to their suitability for intercropping systems.

c. Shifts in weed flora

It is desirable to monitor shifts in weed floras in relation to land-use pattern since an ability to predict them could be important in weed management.

d. Chemical weed control

Modifications in formulations and the use of protectants offer opportunities for the development of economical [and safe] herbicides for mixed cropping systems. Research is needed to identify appropriate herbicides and application equipment.

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