Integrated Weed Management in Zimbabwe's Smallholder Sector, Where Are We?: A Review

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Abstract

The introduction of the Integrated weed Management (IWM) in Zimbabwe's small holder sector seemed to be the answer to the weed management problem in the sector. However up to the present moment the drudgery associated with weeding still dominate in the sector. Research in Zimbabwe has investigated various techniques varying from cultural, chemical to mechanical weed management techniques. Despite the fact that some of them have produced excellent results, the integration of these techniques into a weed suppressive cropping system still lags behind. Research information accessibility by both extension personnel and the smallholder sector constitutes one of the major challenges.

Keywords: Integrated weed management, Cultural, Mechanical, Chemical, Adoption, Weed management, Smallholder farmers

1. Introduction

Integrated weed management (IWM) can be defined as the use of 'many little hammers', that on their own are not stand alone weed control measures but, if applied in a systematic way will control weeds (Swanton et al., 2008). This technique utilises all suitable methods in as compatible a manner as possible. It involves the tactical use of multiple tools for weed management, including combinations of herbicides, crop rotation, mechanical and biological controls as well as other cultural practices designed to reduce damage by weeds (Cardina et al., 1999). It is about putting components together and integrating them into existing crop production systems to produce a cropping system that resist weed invasion, tolerate weed presence and decrease population, survival and persistence of weeds. This approach recognises that single-tactic management has often been ineffective in the long-term weed management and that reliance on a single tactic has resulted in shifts among weed species or to herbicide resistant biotypes (Gressel and Segel, 1990). The multiple control tools can exploit

synergistic or cumulative effects that are not evident when a single technique is used. By basing management on several different methods, the risk of failure is lessened if one approach fails (Cardina *et al.*, 1999).

Considerable research has been carried out in Zimbabwe on individual weed control techniques. The majority of these techniques have not consistently provided acceptable weed control when used alone but could contribute significantly when incorporated into an IWM program. Despite the research that has occurred in Zimbabwe, smallholder farmers still struggle with weeds in their fields. The drudgery associated with weeding has not lessened despite the generation of techniques some of which have little or no cost attached in their implementation. In Zimbabwe, Chivinge (1990) found that small holder farmers spend more than 75 % of their time hoe weeding in the peak period of November and February. This includes female members of the family and children who in many cases fail to attend school regularly. Complete weed control can not be achieved by using one method alone. An integrated approach to weed management is necessary to effectively control weeds in a less costly and environmentally friendly manner (Thembani, 2002). Therefore, this paper seeks to take stock of individual elements that have been explored by Zimbabwean researchers and the probable causes of reduced adoption of IWM.

2. Principles and components of IWM

According to Sanyal *et al.*, (2008), the basic principles of IWM are (1) suppression of weed growth, (2) prevention or suppression of weed seed production, (3) reduction in weed seed bank and (4) prevention or reduction in weed spread. These have got to be achieved through techniques that fit into the economics and decision making process of the small holder farmer (SHF). Many a times, weed control techniques have been forced down the throats of SHF without a proper look at the economics of the sector. This is usually evidenced by disappointingly low rates of adoption. The components of IWM need to be viable and safe. The components that have been studied in Zimbabwe include cultural weed control (intercropping, early plating, fertilisations, plant population and tillage), chemical (reduced herbicide dosages) weed control, mechanical weed control and hoe weeding.

3. Cultural weed management

This is a collective term used to describe those measures instituted by farmers to reduce the germination, growth and competitiveness of weeds during the growing or culture of the crop. It is indeed the wholemark of integrated weed management that the farmers must gear their crop production systems to minimise weed problems in the short and long term. It constitutes the first line of defence in the fight against weeds for the small holder farmer.

3.1 Intercropping

Intercropping is the simultaneous growing of two or more crops in the same piece of land in the same growing season. A crop mixture is more dynamic biologically than sole crops and is less likely to succumb to adversities of nature (Andrews, 1977). The most common crop combinations that are prevalent in the small holder sector in Zimbabwe are cereals and low density pumpkins, cow peas, ground nuts, cucumber and water melons (Mariga, 1990). Shumba et al., (1990) reported that despite the effective discouragement of intercropping in Zimbabwe by pre-independence government extension agencies, the practice could still have a useful role in the small holder sector. Initial research on intercropping in Zimbabwe, mainly concentrated on yield advantages (Mugabe et al., 1980; Mariga, 1990, Mariga and Munetsi, 1990, Shumba, et al., 1990). The dimension of weed suppression under intercrops was added later in the mid 1990s when research was initiated on the ability of intercrops to suppress weeds. Results from studies by Mashingaidze et al., (2000) and Mashingaidze (2004) revealed that intercrops had lower weed dry matter compared to sole crops although weed density was not affected. Reduced weed biomass show that the weed has reduced ability to capture resources in intercrops. Experiments with sole crops have shown that large differences in weed suppression exist among genotypes within species. Studies by Katsaruware (2006) found that upright cowpea varieties were more suitable for intercropping with maize as they suppressed weeds and did not lower cereal yields. This calls for proper selection of varieties within species that suppress weeds.

3.2 Tillage

Tillage operations have a major impact on distribution of weeds in the soil and weed survival (Carter and Ivany, 2006). Primary tillage was described as a 'filter' (Smith, 2006) or a 'sieve' (Legere *et al.*, 2005) that influences weed species diversity in a given cropping system. The type of tillage offers a selection pressure on the weed population. The abundance of a species has more to do with the abundance of habitable sites and genetic and phenotypic plasticity that permit a wide range of sites to be occupied (Harper, 1977). Weed species that possess traits that make them susceptible to a given filter or set of filters are less likely to be present in a given

community. Rotation of tillage systems exposes weeds whose establishments are promoted by a certain tillage system to management factors by the farmer.

Although not much research has gone into the effect tillage on weeds, studies by Mandumbu (2008) found that grass weeds, *Setaria spp* and *Corchorus tridens* were higher under the ripper and basins compared to conventional tillage. The same studies revealed that broad leaf weeds were less in minimum tillage compared to conventional tillage. Rotation with conventional tillage systems controls the grasses and perennials but other weeds or weed groups may assume numerical dominance. To balance the pressure of tillage there may be need to consider rotational tillage where appropriate.

3.3 Fertilizers and manures

Agricultural weeds are high consumers of nutrients and are therefore capable of reducing available nutrients for crop growth. Manipulation of fertilizer timing and placement can help reduce weed interference of crops. Placement of fertilizers or manure can affect weeds. More weeds grew vigorously in cases where manure was broadcast compared to banding and spot application (Munguri *et al.*, 1995). According to Rupende *et al.*, (1995) manure may contain considerable numbers of germinable weed seeds or stimulate increased weed germination. Manure need to be cured before use in the farmer's fields. Curing is a process where animal manure is dug from the kraal and heaped for periods ranging from 1 - 5 months, on the side of the kraal (Mashingaidze and Chivinge, 1998). Heaping manure generates high temperatures within the manure heap and is accompanied by the release of toxic gases such as methane and ammonia which will kill weed seeds in the heap. Heaping also improves mineralisation of the manure. *Amaranthus hybridus, Eleucine indica, Cynodon dactylon* and *Acathospermum hispidium* were associated with uncured manure in Manicaland in Zimbabwe (Rupende *et al.*, 1995).

3.4 Early planting

Weeds have a life cycle synchronised to that of the crop such that more weeds emerge with the crop in November or December (Mabasa and Rambakudzibga, 1993). Intermittent wetting and drying of weed seeds brought about by early showers in September and October break seed dormancy. Conventional tillage brings buried weed seeds to the surface where they germinate. Early planting gives the crop a starting position advantage over the weeds (Mashingaidze and Chivinge, 1998). Early planted crop gets the highest sunshine and temperatures and grows before the first flush of weeds. By the time weeds emerge in November and December the crop will have established and are strong competitors against weeds.

3.5 Crop rotations

Crop rotations are a useful tool for weed management (Liebman and Gallandt, 1997). Crop diversification encourages operational diversity that in turn can facilitate improved weed management. According to Sanyal *et al.*, (2008), different planting and harvesting dates among these crops provides more opportunities for producers to prevent either plant establishments or seed production by weeds. Different crops are naturally planted and harvested at different times of the year. If sufficient differences exist—in the germination requirements of crops and weeds then seed date can be manipulated to the benefit of the crop for example, weeds can germinate after canopy closure and they become non competitive. In the smallholder sector of Zimbabwe, diversification of component crops in rotation is limited. However intentional and scrutinised selection of component crops in rotation is limited. The effectiveness of a crop rotation in weed suppression may be enhanced by crop sequences that create varying patterns of resource competition, allelopathy, soil disturbance and mechanical damage to certain species. Many aspects of rotation still need to be explored in the Zimbabwean context. Diversified crop rotations are likely to provide best opportunities for exploiting diverse sets of tactics and ecological processes to suppress weeds (Westerman *et al.*, 2005)

4. Chemical weed control

The adoption of herbicide technology in the small holder sector in Zimbabwe has been low. Both farmers and extension agents lack technical knowledge on herbicide usage and resources for the purchase of associated application devices together with the fear phytotoxic (Chivinge, 1984). The aspect that has been tested in Zimbabwe which is worth including in an integrated weed management system for the small holder sector is reduced herbicide dosages.

4.1 Reduced herbicide dosages

According to Mashingaidze and Chivinge (1995), reducing herbicide dosages would reduce expenditure on herbicides to a fraction of the cost of full label herbicide rates while maintaining efficacy and other benefits derived from herbicide use.

Results from a detailed study by Mashingaidze (2004) revealed that half the recommended dosages of atrazine and nicosulfuron resulted in the lowest weed biomass. Mixing a third of the recommended herbicides of Atrazine and Nicosulfuron resulted in equivalent weed control to the atrazine label recommended dosages. Weed seed production was reduced. Reduced herbicide dosages may fit into the economics of the SHF and hence has the potential to be a 'small hammer' in the IWM programme.

5. Mechanical weed control

Mechanical weed control is the use of machines or mechanical devices driven by animal or fossil fuel energy. Mechanical weed control was improved by the introduction of the plough, spike toothed harrow and animal drawn tyne cultivator (Chivinge, 1990). Mbanje et al., (2001) reported that a plethora of animal drawn weeding equipment is now available which include reversible tynes, cultivator with hilling blades (BS221) and the BS41 five tined cultivators.

5.1 Ox-drawn plough as a weed control implement

The ox-drawn plough has been used as a weed control tool in two ways (Mashingaidze and Chivinge, 1998). Firstly farmers plough the interow area in opposite directions. Weeds in the interow area will be removed but those along the row will be buried. No extra weeding will be required to remove further weeds as this is an efficient process (Ellis Jones et al., 1993). The second way is to remove the mouldboard such that the plough share is the operating blade. Three or four passes will be required to completely remove weeds within a row.

5.2 Ox-drawn tyne cultivators

Most smallholder farmers in Zimbabwe use ox-drawn tyne cultivators. The ox-drawn tyne cultivator is an efficient way of removing weeds in the interow space especially when the weeds are less than 15 cm in height (Chivinge, 1990). However the demerits of most of the implements for mechanical weed control is that they cause about 5 % crop damage each time an implement passes through the land, failure to remove intra-row weeds and inability to control weeds once the crop is about 60 cm tall as they can result in crop damage (Chivinge, 1990).

6. Manual weeding

This is the use of direct human effort to remove weeds and it is a common method in both the small scale farmers and the commercial sector. In both sectors it can be used to complement other weeding methods such as mechanical or cultural methods or both.

6.1 Hoe Weeding

This is by far the most commonly used weed control method in Zimbabwe. Weeds are removed by iron blades attached to wooden handle. The method is slow, labour intensive, cumbersome and inefficient such that in most cases timely weed control is rarely achieved. Hoe weeding is simple and does not require investment in expensive equipment or periodic purchase of inputs like herbicides nor does it require the farmer to be literate or numerate (Thembani, 2002). Smallholder farmers spend a disproportional amount of time during the cropping season battling to control weeds and get very little for their misery and toil at the end of the season (Akobundu, 1987, Chivinge, 1990). Hoe weeding requires a large labour force which can complete the weeding in time before weeds inflict negative effects on the crop which is usually not available in the rural communities. Despite its demerits, this control is going to be present as long as the small holder sector is present but the effort researchers and extension agents should put is to make sure that it is integrated with other control methods so that the number of weeding regimes done on a single crop during the season is reduced. The impact of HIV/AIDS on the labour force in the small holder sector has worsened the scenario. In worst cases the disease has left the aged and children in the household to battle with weeds and under such cases food security in the household is threatened.

7. Developing IWM systems for the SH sector

Good control of weeds can be attained through combining several techniques which can work co-operately to produce a weed suppressing cropping system. Studies by Munakamwe (2004) found that a combination of 66 % of the recommended dosage of metolachlor in a maize/bean intercrop produced the best results under weed suppression and therefore it is the best package for small holder farmers. The same study revealed that a combination of intercropping and reduced herbicide dosages reduced the number of weeding in a maize crop from three to two. In some cases intercropping components (a cereal and a broad leaf) may lack compatibility as some herbicides in the market are not selective to both cereals and broad leaf

A combination of early planting, choice of varieties, tillage, increased plant population, judicious use of fertilizers and manures and reduced herbicide dosages is a candidate for adoption. Farmers may need to make a conscious decision to implement it. This can give a concerted set of control tactics and ecological interactions whose individual effects are weak but whose cumulative effects prevent population growth and competition against crops. A weed suppressive cropping system can be produced. An IWM programme has got to be long term and chosen in the context of the associated cropping system and prominent weeds.

8. Barriers of IWM acceptance

Considerable research has gone into techniques used within the IWM program but there has been little implementation in the SH farming community in Zimbabwe. Deliberate integration of these systems into functional cropping systems has been limited. Farmers still rely on hand weeding which requires high energy expenditure. According to Akobundu (1997), weed problems of low input agriculture are compounded by low resource base of farmers and the fact that there are few weed control technologies whose economics of use are based on the farm sizes of these farmers. There has been lack of on-farm research where various techniques of IWM are incorporated and hand weeding is eliminated or the number of weeding times reduced. We have not come across any research in Zimbabwe which documents the response of weeds to a sequence of IWM techniques. Relationships between or among IWM tools need to be explored so that those that are synergistic are used simultaneously and antagonistic ones separated.

There has been lack of promotion of IWM tools to SH farmers in Zimbabwe. Much research into the components of IWM was carried out by researchers in Zimbabwean universities and research centres. Despite the results showing remarkable effects of component tools on weeds or weed groups there seems to have been limited publicity to extension agents and farmers. The information has not gone down to the intended consumer who is the SHF. Various reasons have been sited chief among the funds to carry out promotions.

There could be a lack of industry support since there is no direct benefit to agrochemical companies. Many agrochemical companies participate in programs that increase the sales of their products. IWM seeks to reduce the volume of agrochemicals used in agriculture and if taken up will impact negatively on their sales volume although they benefit through reduced cases of resistance development. Industry promotes herbicide usage at the expense of IWM ant their main customers are the large scale farmers. In Zimbabwe, companies have the resources to finance extension programs compared to government. Other stake holders such as non -government organisations with no business intentions can assist to promote IWM programs.

9. Conclusion

Although the IWM systems are regarded as the best approach to dealing with weeds in the small holder sector, there seems to be a large gap between theory and practice in Zimbabwe. Development of a weed suppressive cropping system that eliminates manual weeding has not been practical in Zimbabwe's small holder sector.

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