INTEGRATED WEED AND PEST MANAGEMENT: STRATEGIES FOR REDUCING ENVIRONMENTAL POLLUTION AND BOOSTING FOOD SAFETY IN NIGERIA

[1]Falade, A. A., [1]Labaeka, A. *and* ***[2]Oladipo, A.S.***

[1]Department *of Agricultural Education, Federal College of Education (Technical) Akoka, Lagos State, Nigeria.*

[2]Department of Agric, and Bio-Environmental Engineering, Yaba College of Technology, Yaba, Lagos State, Nigeria.

Correspondence e-mail: aafalade@yahoo.com

Abstract

The 23rd Food and Agricultural Organization of the United Nations (FAO) Conference recognized that increased food production is a high priority in many parts of the world and this need cannot be met without the use of indispensable agricultural inputs such as herbicides and other pesticides. However, the detection of herbicides / pesticides in soil, drinking water and food stuff is of great concern in Nigeria at the moment. The presence of pesticides in our environment as a result of the careless or intentional use has led to its persistence in the environment, thereby disturbing the ecosystems and non target organisms. Pesticide poisoning usually results from consumption of contaminated food. Several cases of untimely deaths have been reported in Nigeria as a result of consumption of herbicide or other pesticide contaminated food and drinks. This paper focuses on integrated weed and other pest management which is the best combination of cultural, biological and chemical means to manage weeds and other pests rather than solely depending on herbicides and other pesticides. Effort should be directed towards establishing proper surveillance and record keeping of workers involved with pesticides in Nigeria with a view of checking the activities of quacks. The Nigerian government should train farmers on integrated pest control and safety management. Manufacturers should develop less toxic or hazardous herbicides and other pesticides, increase the awareness on pesticides usage and lay more emphasis on safety precaution among users so as to reduce environmental pollution, promote food safety and enhance economic recovery.

Keywords*: Weed, management, pest, herbicide, pollution.*

Introduction

Weeds are traditionally controlled using manual labour through hoe weeding and slashing with cutlass. Babalola (2002) reported that one of the greatest constraints facing agricultural production is the scarcity and cost of labour for farm operations which is estimated to cost about 60% of farm account. This is as a result of competing demands amongst industries, construction work and agriculture. He also opined that the situation is further worsened by rural-urban migration of the young people who normally assisted their parents on the farm seeking as it were "greener pastures" not realizing that the pasture on the farm are usually greener than those in the town. Since labour involvement in agriculture is decreasing, this hurdle can best be overcome by intensifying agricultural mechanization and use of herbicides (Iyagba, 2013). Herbicides are important parts of weed management in the world of agriculture. Kolo (2004) noted that the 23rd Food and Agricultural Organization of the United Nations Conference recognized that increased food production is a high priority in many parts of the world and this need cannot be met without the use of indispensable agricultural inputs such as herbicides. Tjornhom et al (1998) also opined that one of the factors that had contributed to meaningful productivity gains in agriculture worldwide has been the use of herbicides and other pesticides.

Although herbicides have led to increased food production; there is need to use them properly to protect the people and the environment (Iyagba, 2013). Farmers' knowledge regarding safety application techniques, timing and dosage of herbicides use is often shallow (Wopereis et al., 2009). Exposure to pesticides and herbicides are very common especially for applicators that use these chemicals on a regular basis (Rell and Galvin, 2011). They further noted that the three main entry routes for these compounds into the body are dermal (exposure through the skin or eyes), respiratory (inhalation into the lungs) and oral (ingestion by mouth. Erhunmwunse et al (2012) reported that the presence of herbicides and other pesticides in our environment as a result of the careless or intentional use has led to its persistence in the environment, thereby disturbing the ecosystems and non target organisms. Pesticide poisoning usually come from consumption of contaminated food, chemical accident in industries and occupational exposure in agriculture. It was further noted that about 15,000 metric tons of chemicals comprising about 135 pesticide chemicals are imported annually into the country. These are the major causes of life threatening diseases such as cancer, cardiovascular disease, dermatitis, birth defects, morbidity, impaired immune function, neurobehavioral disorder and allergy sensitization reaction.

World Health Organization (WHO) reported that at least 3 million cases of poisoning and 20,000 death occur annually due to exposure to pesticides (Orhii, 2010). He also reported that there is a rapid annual increase in sales, use and dependence on herbicides and other pesticides in developing countries. Herbicides have widely variable toxicity. The pathway of attack can be transported via surface run off and leaching to contaminate distant water source (Daniel et al., 2013). Herbicides decompose rapidly in soil via soil micro bid, hence inhibiting the activities of micro organisms in the soil.

Ali and Muhammad (2016) noted that constant discharge of agricultural waste (residues in spray tanks) into aquatic environment has led to accumulation of heavy chemicals and other variety of pollutants. Herbicides present in these wastes are washed down, carried by rains and flood to nearby aquatic environment.

In Nigeria, Glyphosate is one of the most popular herbicides used by farmers especially in Kano. Ali and Muhammad (2016) reported a toxicity test of glyphosate conducted using concentrations of 0, 0.004, 0.005, 0.006, 0.007 ml/l. The mortality rate of each concentration was determined on fish and the physicochemical parameters (dissolved oxygen and pH) were also determined. The result revealed that high mortality occurs at 0.007 ml/l and less mortality was found at 0.004 ml/l. Hence, mortality is dose dependent. Dissolved oxygen (DO) and pH decrease with increase in glyphosate concentration. Furthermore, the juveniles showed abnormal behaviour. The LC_{50} value at 96 h was 0.0072 ml/l. There was significant difference between the initial and final pH value ($p < 0.05$). On the other hand, the initial and final DO values showed no significant difference ($p > 0.05$). However, correlation between DO and pH showed no significant difference ($p > 0.05$). The findings of their study established that glyphosate has some level of toxicity on *Clarias Gariepinus* juveniles. In addition, it was found that mortality, changes in behaviour, DO and pH are dose dependent. Therefore, it was suggested that an appropriate concentration that will not be detrimental to non-target organisms should be used by farmers. Alternatively, Biological method should be used as a substitute for chemical method of controlling weeds.

PAN (2012) similarly reported that in developing countries, the effects of serious poisoning due to exposure to dangerous levels of pesticides in food are apparently more severe than in industrialized countries. For example, in 2008, Nigeria reported that 112 people had been poisoned by pesticide-contaminated food. Two children died as a result. Another report from Nigeria recorded 120 cases of poisoning of students who had eaten beans contaminated with lindane. In some regions, direct contact with pesticides used in agriculture is a widespread problem. Careless mixing and application of pesticides can result in poisoning due to uptake via the respiratory organs or through direct contact with the skin or eyes. Pesticide drift poses a further hazard for the residents of rural areas

HERBICIDE / PESTICIDE USAGE AND ENVIRONMENTAL POLLUTION

Anon (2014) identified and explained vividly the major ways herbicides and other pesticides cause environmental pollution as follows:

Soil contamination: He observed that many of the chemicals used in pesticides are persistent soil contaminants, whose impact may endure for decades and adversely affect soil conservation. Pesticides do not necessarily distinguish between “pests” and other living things. The use of pesticides decreases the general biodiversity in the soil. Pesticides can kill beneficial soil bacteria, earthworms, snails, frogs, birds, and other valuable species. Soil microorganisms play a key role in maintenance of soil structure, transformation and mineralization of organic matter, making nutrients available for plants. The application of pesticides (especially long-term) can cause significant irreversible changes in their

population. Inhibition of species, which provide key process, can have a significant impact on function of whole terrestrial ecosystem.

Water contamination: Pesticides can get into water via drift during pesticide spraying, by runoff from treated area, leaching through the soil. In some cases herbicides can be applied directly onto water surface e.g. for control of aquatic weeds. Water contamination depends mainly on nature of herbicides/ pesticides, soil properties, weather conditions, landscape and also on the distance from an application site to a water source. Rapid transport to groundwater may be caused by heavy rainfall shortly after application of the herbicide or pesticide to wet soils.

Fish and other aquatic life may be harmed by pesticide-contaminated water. Application of herbicides to bodies of water can cause plants to die, diminishing the water's oxygen and suffocating the fish. This can lead to reduced populations, decreased immunity to disease, etc.

Air contamination: During and after the application of a pesticide either in powdery form or liquid form, a substantial fraction of the dosage applied may enter the atmosphere in the gas phase and as small droplets and may be transported over shorter and longer distances. Residues arising from these deposition following volatilization, spray drift, air movement can lead to environmental contamination.

In view of the apparent danger in over-dependence on chemical control of weed and other pests, there is urgent need for safer, more productive and economical methods.

Concept of Integrated Weed Management

Increased awareness of the adverse effects herbicides and other pesticides have on the environment and consumer concern about the safety of our food has led to the need for more sustainable agricultural production systems. Integrated Pest Management and good Agricultural Practices have become essential components of sustainable agriculture. The integration of various control measures, where chemicals are used only as a last resort, ensures that pests remain below the economic threshold, thus supporting food safety and international market access

Javid et al. (2016) defined integrated weed management (IWM) as a system which involves the combination of cultural, mechanical, biological and chemical methods for an effective and economical weed control that reduces weed interference with the crop, while maintaining acceptable crop yields. IWM can lead to sustainable food production, minimize drudgery, and reduce the cost of removing weeds from crops (Waheed et al, 2008).

Possible Procedure in Integrated Weed Management

The first step is surveying. Surveying involves walking in the fields and assessing the population of key weed species in the field. Surveying defines the scope of the problem and allows the best management practices to be selected. Number of weeds, species present, and

their locations are important. Farmers must take note of the dominant species along with uncommon or perennial weeds. The management strategies to be adopted must control the dominant species, while preventing the spread of uncommon weeds. With proper surveying and weed identification, the right chemical, dilution and timing can be determined, and thus reducing the quantities of pesticides as well as mechanical effort required to control weeds.

At surveying stage, the farmers must differentiate weeds by their life cycles into winter annuals, summer annuals, biennials, simple perennials and spreading perennials. Each of these have characteristic well detailed in any standard weed science textbook and farmers should refer to these for clear understanding of weeds in their fields. Farmers should also differentiate weeds into broadleaved.

Both life cycle and the classes help to determine timing of control and the best combination of strategies to adopt. Annuals and biennials for example are best controlled before they seed so as to reduce next season infestation, while spreading perennials propagate by seed and underground reproductive structures which make their control difficult. Weed population and density helps in determining economic threshold, the density at which control measures can be implemented.

Cultural methods

This involves the management of the crop to make it more competitive against weeds. If properly employed cultural techniques reduce weed numbers in the crop field and the few weeds that appear can easily be controlled using reduced levels of chemicals and simple mechanical effort. Cultural control measures include tillage and good seed bed preparation, optimising planting date, seeding rate and depth, fertility management, understanding of the crop, field sanitation and the use of adapted varieties (Blackshaw et al, 2006).

Deep tillage ensures that weeds are buried to deep levels that have a high carbon dioxide to oxygen ratio where they die from lack of oxygen (Gardner et al, 1985). Also, early land preparation allows the farmers to plant their crops early enough to ensure fast canopy development before the weeds emerge. Proper seed bed preparation also ensures that the crop, and not the weed, is placed on an ideal environment which gives the latter competitive edge. Practices of minimum and conservation tillage should also be part of an integrated weed management programme, as they leave crop residue in between rows, shading the soil and suppressing weed emergence. With few weeds in the field spot treatment of weeds becomes possible, thus achieving the goal of cost minimisation and environmental protection.

High seeding rates help in shading the weeds and make it difficult for them to take water and nutrients. This weakening gives herbicides in spot treatment a boost. In small holder systems low seeding rates allow light to penetrate into the wide spaces in the canopy and stimulate weed growth (Cralle, 1986). In addition, farmers should calibrate their equipment in order to ensure uniform seeding at correct depth, for fast crop emergence and good establishment, thus making the crop more competitive.

Fertiliser application methods like broadcasting benefit the weed as well, while placing the fertiliser where the crop only has access allows the crop to outcompete and suppress weeds. After banding nitrogenous fertiliser for four consecutive years, the density of Eulesine indica in maize under both conventional and reduced tillage systems was found reduced by 95 % by Kelner, and Derksen (1996).

Following recommended planting dates are important in IWM. Weeds that emerge after the crop has emerged cause less yield loss than those that emerge before (Liphadzi and Dille, 2005). Late planting makes the need for pre-emergence herbicides, post emergence herbicides and early cultivation to control germinating weeds a necessity. Choice of the correct weed control programme becomes easy if the planting time is planned and well distributed across the season within recommended range.

It is also important that farmers are aware of the developmental stages of their crops. For instance, maize grows slowly and develops a full canopy after 6-8 weeks and weed control effort should be strong during this period. IWM technique would also require that correct hybrids adapted to the agroecological zone are planted so that the crops grow vigorous to outcompete weeds. Proper farm sanitation prevents weeds from spreading into the field. Practices such as use of clean seed, clean equipment are examples of good farm sanitation. Controlling weeds on the edges of the farm, patches of new invading weeds and herbicide resistant weeds should also be done. Weeds should be removed before they seed.

Mechanical methods

This method can be employed right from the period before crop establishment. Incorporation of mechanical weed control strategies ensures a reduction of weed pressure late in the season and the few remaining weeds that escape destruction can be controlled using chemical spot spraying. Mechanical weed control methods include, hand weeding, hand hoeing, interrow ploughing and interrow cultivation.

Hand weeding is necessary for removing weeds within crop rows and too near crop plants for them to be controlled. Hand-weeding is often used as a supplement and in combination with other control techniques. Success with hand-weeding depends on the proper timing of removal, size of the weeds, size of the field and the thoroughness of the people doing the weeding. It is most effective when the weeds are small and not well established.

However, hand weeding does not control large or perennial weeds like shamva grass (Rottboellia Cochinchinensis), those with mechanical strength like cats tail (Sporobolus Pyramidalis) and rapoko grass (Eleusine indica). Most importantly, hand-weeding is very labour intensive, thus potentially expensive.

The hoe is used to cultivate the interrow space, digging out, cutting and burying weeds, thus leaving the crop field clean. In large scale commercial farms it is used as supplement in combination with other control techniques. As with hand weeding, success with hoeing

depends on the proper timing for removal, size of the weeds, size of the field and the thoroughness of the people doing the weeding. It is also most effective when the weeds are small and not well-established.

Mouldboard ploughing, chisel ploughing, discing or harrowing are commonly used before planting to eliminate emerged annual weeds and to suppress perennial weeds. Ploughing can bring the rhizomes of perennial weeds to the soil surface where they are killed by desiccation and freezing depending on the season and location.

Row cultivators are widely used in the production of crops established in rows. Cultivators dislodge or cover many weed seedlings and they work best when weeds are small, before they reach the 3 to 4 leaf stage. A layer of dry soil placed in the crop row by cultivation can also assist in weed control by preventing germination.

However, large weeds with extensive root systems require deep tillage for adequate kill, a practice that is now discouraged for its damaging effect on soil structure. Deep tillage also increases the potential for damaging crop root systems. Effective mechanical control requires precise row spacing, a practice which most farmers are failing to achieve due to shortage of equipment. Weather conditions influence the effectiveness of tillage, with wet conditions causing delays and allowing weeds to proliferate. Rainfall or irrigation soon after mechanical control allows weeds to re-root.

Chemical methods

Herbicides destroy weeds by inhibiting biochemical processes necessary for growth and development. Herbicides should be selected based on certain factors such as; crop being grown, crop rotations being used, weed species present, costs, and ease of application and farmers should work closely with extension staff for specific details on herbicide compatibility with their crops. The chemical management of weeds should be minimal as a result of the high costs of herbicides and dangerous impact of chemicals to the environment. Farmers should only resort to this method in dealing with spot problems.

Herbicides can be divided into classes that are well detailed in standard crop protection textbook. For example, selective herbicides like atrazine can be directly applied to maize and other crops listed on their labels without causing injury, while nonselective herbicides such as glyphosate must be applied without coming into contact with the crop. Other classes include preemergence and postemergence. Farmers should always read instructions and understand the class of the chemicals before they use these.

Calibrating crop protection equipment correctly does not only save money, but also helps the farmer to reduce environmental damage and harm to the person applying the herbicide. Herbicides can alter soil chemical properties and affect microbial life in the soil, therefore proper amount of herbicide should be applied evenly on target areas.

Integrated Pest Management (Other categories of pests)

Crop life (2014) described IPM as the best combination of cultural, biological and chemical measures to manage diseases, insects, weeds and other pests. It takes into account all relevant control tactics and methods that are locally available, evaluating their potential cost-effectiveness. IPM does not, however, consist of any absolute or rigid criteria. It is a flexible system that makes good use of local resources and the latest research, technology, knowledge and experience. By bringing technology to farmers, IPM has been instrumental in increasing agricultural productivity and sustainability and reducing pesticide misuse in the developing world. For example, new methods for propagating virus-free seed roots and vines for sweet potato in Shangdong Province, China, augmented annual sweet potato production by 30%, a productivity increase valued at US$145 million annually (Fuglie et al. 1999). Meanwhile in Africa, the introduction and release of the exotic wasp Anagyrus Lopezi succeeded in controlling the exotic and invasive cassava mealy bug Phenacoccus Manihoti. This project showed internal rates of return of US$200-500 for each dollar invested by donor organizations (Neuenschwander, 2003). Without this and other interventions to control cassava pests and diseases, it is likely that cassava would have all but ceased to exist in Africa years ago, and with it would have gone the food security of millions of Africans (IITA, 2010). IPM in potato and sweet potato in Latin America has shown an internal rate of return on investment of 27-49%, a very high level when compared with other types of investment in agricultural research; moreover, the adoption of IPM brought additional net benefits to farmers ranging from US$100 to 536/ha (Ortiz et al. 2009). Pretty et al. (2006) have also shown that IPM technologies have effected a decline of 71% in pesticide use, while yields increased by 42%. Different approaches based on IPM have been developed in the French West Indies in banana cultivation and have led to a 65% decrease in pesticide use over the last 10 years (Côte et al. 2009).

General benefits of Integrated Weed /Pest Management

Advantages of IWM

- It shifts the crop-weed competition in favour of crop
- Prevents weed shift towards perennial nature
- Prevents resistance in weeds to herbicides
- No danger of herbicide residue in soil or plant
- No environmental pollution
- Gives higher net return
- Suitable for high cropping intensity

Constraints to Integrated Weed / Pest Management

Ehi-Eromosele (2013) reported the following as the major constraints facing integrated weed / pest management:

- An IPM program requires a higher degree of management. Making the decision not to use pesticides on a routine or regular basis require advanced planning and therefore, a

higher degree of management. This planning includes attention to field histories to anticipate what the pest problems might be, selecting crop varieties which are resistant or tolerant to pest damage, choosing tillage systems that will suppress anticipated pest damage while giving the crop the greatest yield potential.

- ❖ IPM can be more labor intensive. Consistent, timely and accurate field scouting takes time. However, it is this information that is necessary and is the corner stone of IPM programs. Without this information you cannot make intelligent management decision.
- ❖ Success can be weather-dependant. Weather can complicate IPM planning. For example, you might want to lower herbicide rates and use row cultivation to manage weed pressure. However an extended wet period may reduce (or eliminate) the effectiveness of row cultivation. Therefore, good IPM planners will have an alternate plan for when these problems arise.

Conclusion

It is obvious that herbicides / pesticides contamination is on the increase in the country as a result of its usage for different activities. Therefore, there is need for a more sustainable agricultural production system that has higher potential of improving crop yield, boosting food safety with less negative effect on the environment. That system is Integrated Weed / Pest Management and good Agricultural Practices.

Recommendation

- Agricultural extension workers should train farmers on integrated weed /pest control to reduce over reliance on chemicals.
- Safety precaution must be strictly observed by farmers before, during and after applying herbicides and other pesticides.
- Government should establish task force to ensure that only trained and licenced pest control officers are operating, especially in major cities of Nigeria where quack pest control officers are multiplying every day.
- Manufacturers should develop less toxic or hazardous pesticides and increase the awareness on pesticides usage.
- Herbicide residues in spraying tank should not be emptied in streams and rivers.
- Recommended dose of herbicides/ pesticides should be used and re-entry period strictly followed.
- Herbicides / pesticides should not be stored in bed room or near food stuff.

References

Ali, S. and Muhammed, K. I.(2016). Acute toxicity of herbicides (glyphosate) in Clariasgariepinus juveniles. Elsevier Island LtD.Vol 3 page 513- 515

Anonymous (2014).Global pesticide usage. www.epa.gov

Babalola, O. (2002). Nigerian Agriculture: Basis for Hope, Hurdles against Hope, Hope for Tomorrow. University of Ibadan, Ibadan, Nigeria. Lecture Series (2000 / 2001). P. 76.

Blackshaw, R. E. J. T. O'donovan, k. N. Harker, G. W. Clayton and R.N. Stougaard,(2004). Reduced herbicide doses in field crops: A review.Weed Biology and Management.Vol 6 (1) page 10.

Côte FX, C.Abadie, R.Achard, P.Cattan, C.Chabrier, M. Dorel, L. de Lapeyre de Bellaire, J.M.Risède, F. Salmon, and P.Tixier (2009). Integrated Pest Management approaches developed in the French West Indies to reduce pesticide use in banana production systems. ActaHorti 828: 375-382.

Cralle, H. T.(1986). AGRONOMY: The Science and Technology of Crop Growth, Breedingand Production. Harry T. Cralle. US.

Crop life (2014).Integrated Pest Management.croplife@croplife.org, www.croplife.org

Daniel,M., Duniya, N. and Idris, G.A. (2013). Effect of continous application of herbicides on soil and environment with crop protection machinery in southern Adamawa state. International Refered journal of Engineering and science.Vol.2, issue 6, pp 04 - 09

Ehi-Eromosele, C. O., Nwinyi, O. C.andAjani,O.O.(2012). Integrated Pest management.http://dx.doi.org/10.5772/54476

Ehsas, J. Desai, L. J. , Ahir, N. B. and Joshi, J.R.(2016). Effect of integrated weed management on growth, yield, yield attributes and weed parameters on summer maize (zea mays l.) under south Gujarat. International Journal of Science, Environment and Technology, Vol. 5, No 4, 2050 – 2056

Erhunmwunse, N. O., Dirisu, A. and Olomukoro, J. O. (2012). Implications of pesticide usage in Nigeria.Tropical Freshwater Biology, 21 (1) 15- 25. http://www.ajol.info/index.php/tfb

Fuglie K, L Zhang, LF Salazar, and T Walker (1999).Economic impact of virus-free sweetpotato seed in Shandong Province, China.In International Potato Center Program Report 1997-1998. International Potato Center, Lima, Peru..

Gardner, F. P., R. B. Pearce and R. L. Mitchell, (1985).Physiology of Crop Plants.Iowa State University Press. AMES.

IITA (2010).Integrated Pest Management and Crop Health — bringing together sustainable agroecosystems and people's health. White Paper.SP-IPM Secretariat, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.17 pp.

Iyagba, A. G.(2013). Assessing the safety use of Herbicides by farmers in Rivers state, Nigeria.European scientific Journal. Vol.9, No. 15

Kelner, D. and D. Derksen, 1996.IntegratedPest Management.*Making It Work on Your Farm*.Saskatchewan Agriculture and Food.

Kolo, M.G.M. (2004). Herbicide utilization in Niger State, Nigeria.Nigerian Journal of Weed Science. 17:21-28.

Liphadzi, K. B. and Dille, J. A.(2005). Annual weed competitiveness as affected by preemergence herbicide in corn. Weed Science*:* Vol. 54, No. 1, pp. 156–165.

Orhii, P.(2010). Sensitization Workshop on Safe and Responsible use of Agro chemical. National Agency for food and Drug Administration and Control Abuja, Nigeria

Ortiz, O, J.Kroschel, J.Alcázar, R.Orrego, and W.Pradel(20090.Evaluating dissemination and impact of IPM: lessons from case studies of potato and sweetpotato IPM in Peru and other Latin American countries. In Peshin R, AK Dhawan (Eds.) Integrated Pest Management: Dissemination and Impact. Springer, Dordrecht, The Netherlands. pp. 419-434.

PAN, Germany (2012). Pesticides and health hazard : facts and figure. www.pan-germany.org

Pretty, J.N., Noble, A. D., Bossio, D. Dixon, J. Hine, R.E. Penningdevries, F.W.T. and MorisonJ.I.L. (2006). ResourceConserving Agriculture Increases Yields in Developing Countries. Environ Sci& Tech 40 (4): 11141119

Rell, M.J. and Galvin, J.R. (2011). Safe application of pesticides and herbicides

Tjorhorm, J. D. Norton, G. W. and Gapud, V. (1988). Impacts of price and exchange rate policies on pesticide use in the Philippines. Agricultural Economics. 18:167-175.

Waheed, U., Muhammad, A. K., Muhammad, S. H., Anwar, N. and Muhammad, A. S. (2008).Inpact of integrated weed management on weeds and yield of maize.Pakistan weed sc. Res. 14 (3-4); 141- 151.

Wopereiset al. (2009).Safe and correct use of herbicides.PLARn IRMCurriculum:TechnicalManual.www.afticarice.org/publications/PLAR/Technical/referenc e 20.pdf.