

# Guidance on weed issues and assessment of noxious weeds in a context of harmonized legislation for production of certified seed



# **GUIDANCE ON WEED ISSUES AND ASSESSMENT OF NOXIOUS WEEDS IN A CONTEXT OF HARMONIZED LEGISLATION FOR PRODUCTION OF CERTIFIED SEEDS**

Gualbert Gbèhounou  
Weed Officer - AGPME  
Plant Production and Protection Division

Edited and illustrated by C. F. Reinhardt, Extraordinary Professor of  
Weed Science (University of Pretoria) and Adviser on Weed Control  
and Plant Production

**Plant Production and Protection Division  
Food and Agriculture Organization of the United Nations  
Rome, 2013**

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations (FAO) concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by FAO in preference to others of a similar nature that are not mentioned.

The views expressed in this information product are those of the author(s) and do not necessarily reflect the views or policies of FAO.

ISBN 978-92-5-107996-6 (print)  
E-ISBN 978-92-5-107997-3 (PDF)

© FAO, 2013

FAO encourages the use, reproduction and dissemination of material in this information product. Except where otherwise indicated, material may be copied, downloaded and printed for private study, research and teaching purposes, or for use in non-commercial products or services, provided that appropriate acknowledgement of FAO as the source and copyright holder is given and that FAO's endorsement of users' views, products or services is not implied in any way.

All requests for translation and adaptation rights, and for resale and other commercial use rights should be made via [www.fao.org/contact-us/licence-request](http://www.fao.org/contact-us/licence-request) or addressed to [copyright@fao.org](mailto:copyright@fao.org).

FAO information products are available on the FAO website ([www.fao.org/publications](http://www.fao.org/publications)) and can be purchased through [publications-sales@fao.org](mailto:publications-sales@fao.org).



## **FOREWORD**

Food security and nutrition can only be assured if it is based on sustainable production practices and crop seeds of good quality and purity. Good quality seeds are needed on farm as a major asset to boost crop yields. However, availability of good quality seeds largely depends on investment by the private sector, which depends on availability of a significant market to ensure profit. But, enforcement of different national seed legislations, which is the case in many countries, for example in Africa, does not provide a seed market large enough to attract investment from the private sector. In this context, the Food and Agriculture Organization of the United Nations (FAO) encourages and supports regional harmonization of rules governing quality control, certification and marketing of crop seeds. While regional harmonization enlarges the seed market and makes it attractive for investment by the private sector, care must be taken to upgrade the seed standards by insertion of the list of dangerous seed borne pests, pathogens and weeds, to anticipate on their possible spread over entire regions.

With regard to weeds, contamination of crop seeds by weed propagules is an important issue in several countries in Africa, Asia and Latin America. Contamination of crop seeds by weed propagules contributes to spreading of weeds to places where they were not encountered before, which increases weed management cost incurred by the farmer, may take land out of production and may become an impediment to sustainable crop production intensification.

Sustainable crop production intensification can be considered the best choice to deal with the actual degraded and shrinking natural resource base for agricultural production imposing to produce more from less to feed an increasing human population expected to reach 9.2 billion in 2050. Produce more with less inputs, while preserving and improving the natural resource base, prompted a shift of paradigm published by FAO in its book “Save and Grow”. The new paradigm is

translated into a new strategic objective formulated as “Increase and Improve provision of goods and services from agriculture, forestry and fisheries in a sustainable manner”. In this context, any potential threat to sustainable agricultural production intensification should be anticipated and addressed.

Noxious weeds are a threat to sustainable crop production intensification. For this reason, crop seeds in general, and certified seeds in particular, should be free of weed propagules. Nearly zero tolerance is the rule for noxious weeds, which are weeds specified by law as being especially undesirable, troublesome and difficult to control.

This manual is a technical support to regional harmonization of seed regulations and provides information to crop protectionists, seed specialists and policy makers on noxious weeds not acceptable in certified seed lots. Noxious weeds in production of certified seeds should be anticipated and avoided in a context where globalization of trade has favored spread of many invasive alien plants, displacing native species and taking land out of production in many countries.

**Clayton Campanhola**  
**Director AGP**

## **ACKNOWLEDGEMENTS**

The content of this manual has been reviewed by several colleagues from FAO Headquarters. Thomas Osborn and Josiah Wobil from the seed group are acknowledged for their inputs. Special thanks to Barbara Herren and Theodor Friedrich from our group (Ecosystem Approach to Sustainable Crop Production Intensification) for their comments. Ms. Hannah Clarendon, Crop Protection Officer at the Regional Office in Accra has devoted much of her time to the review of the manuscript and organization of the workshop on noxious weeds in production of certified seeds. Sincere gratitude goes to all participants to the workshop on noxious weeds in production of certified seeds for their valuable inputs. Support received from Linda Collette and Caterina Batello for the production of this manual is fully acknowledged. Gratitude goes to former and current senior managements of the Plant Production and Protection Division for their support.

# 1. Introduction

Weeds, in general, precede crops through the presence of dormant seeds in the soil seed bank and by germinating earlier. This, plus vigorous growth, gives weeds a distinct competitive advantage over the crop, which explains why they are major yield reducing factors. Weed seed can remain dormant for many years in the soil seed bank, whence they emerge sporadically before, together with, or after the crop. Annual species dominate the weed spectrum in annual cropping systems because this type of habitat (one that is regularly disturbed) suits them at least as well, if not better, than the crop. In ecological terms, most annual weeds are ‘*r*-strategists’, i.e. plant species that, following disturbances of the environment, will recolonize most rapidly due to a high intrinsic rate (*r*) of population growth (Booth *et al.*, 2003). Typically, annual weeds reproduce early and produce high numbers of seed, and hence, their populations quickly build up, in an exponential pattern. Sheer numbers of seeds produced and subsequent wide dissemination are important avoidance stratagems that provide protection against predation (herbivory and pathogens). The ultimate benefit of producing many seeds is that it increases opportunities for successful establishment or colonization of a species in a variety of environments (Booth *et al.*, 2003). Plants with relatively fewer but larger seeds have a different strategy; they often depend on restricted seed dissemination and quick germination to dominate locally for long periods. Larger seeds have more nutrients which allow rapid seedling establishment and strong competition. Plants that prefer less disturbed areas tend to have traits such as large size, longevity, and delayed reproduction; they are ‘*K*-strategists’ because the populations are maintained at or near the carrying capacity (*K*). Many plants do not fit neatly into any of these two classes. For example, *Echinochloa crus-galli* var. *crus-galli* (barnyardgrass) in California has numerous, small dormant seeds which promote its cosmopolitan distribution, thus making it an *r*-strategist. In contrast, the more *K*-selected *E. crus-galli* var. *oryzicola* has large seeds that germinate with the rice crop, and it

competes strongly due to vigorous seedlings. The latter variety is the more noxious one in rice but due to its restricted habitat (rice paddies) it is less of a problem worldwide than is *E. crus-galli* var. *crus-galli*. Two other cases in point are *Sorghum halepense* (johnsongrass) and *Xanthium strumarium* (cocklebur). They are considered two of the world's worst agronomic weeds but cocklebur is *r*-selected and johnsongrass is *K*-selected. Despite being *r*-selected, cocklebur has large seeds, can germinate early and late, and is a strong competitor; these traits are not usually associated with classical *r*-strategists.

Seed dispersal away from the maternal plant is an important strategy for avoidance of competition with parents or siblings, inbreeding, and predation (Booth *et al.*, 2003). Dispersal also allows colonization of new habitats or expansion of a species' range. Seed dispersal agents are of two basic types: biotic (animal, human, insect) and abiotic (wind, water). Humans are an important dispersal agent not only because of deliberate transport of seeds over long distances (e.g. for personal interest or horticultural trade), but also because of passive or accidental transport of seeds on our bodies, vehicles and various implements. Other passive ways in which seed distribution is promoted by humans are through contamination of crop products, such as fruit and grain, and its packaging. Seed dormancy, a key characteristic of many noxious weeds, will promote the risk of viable seed being spread by the trading of crop products. Dormancy of vegetative material, e.g. tubers, poses a similar risk. Seeds of many weeds are shed in a dormant state (primary dormancy) and are activated for germination with the loss of internal restraints over time, in others the seeds are immediately germinable as soon as suitable habitat is available, whereas some types can reacquire dormancy after it has been broken (secondary dormancy). If the seed of a noxious weed possess dormancy, it is unlikely to be affected negatively by the time crop products spend in storage, even cold storage.

Weeds compete with crops for the same resources, basically water, nutrients, light and carbon dioxide (van Andel, 2005). Many weeds have been found to produce and exude chemicals that can impede

the germination and growth of other species (weeds and crops) – the phenomenon is called ‘allelopathy’, and the combined effects of competition and allelopathy is referred to as ‘plant-plant interference’. Furthermore, weeds are alternate hosts for crop pests and pathogens. Moreover, some weeds lack autotrophy and fully develop only by parasitizing crops or wild hosts. This is the case with several species of *Striga* (**Photo 1**), *Orobanche*, *Cuscuta* (**Photo 2**), *Cassytha*, etc. Several weed species are toxic to livestock, and certain weeds taint animal products such as milk and meat with bad odors or unpleasant taste. Crop seed contaminated with weed seeds containing poisonous substances can cause toxicity when it is consumed as food by humans or animals.

It has been estimated that farmers in developing countries devote 20 to 50% of their time to weed management. A study by Vissoh *et al.* (2004) found that weeds are an important agricultural constraint to farmers in general, and that weed impact is an important contributing factor to keeping smallholders in a vicious circle of poverty. According to Labrada (2009), almost 40% of the activities on African crop fields are dedicated to weed control, which is often done at family level, at the expense of women and children whom, instead, should be spending time and energy on family care and education. Weeds have been adapting for millennia to ever changing environments, and it is conceivable that their adaptive ability has been heightened and accelerated by man’s agrarian activities. In all probability the earliest growers of crops learnt the hard way which weeds were the most harmful, and consequently, these were likely singled out for control and even eradication. Thus, from the earliest times of crop husbandry, man has exerted selection pressure which shaped weed communities. The general trend in the evolution of weed communities under pressure from even the most primitive forms of human control would have been for survival and spread of those species with the highest tolerance to the practices employed – this remains the case today, despite control practices having increased in efficiency and complexity. In early times it was the human hand and the hoe which did the selection, whereas these days essentially the same discrimination is done by herbicides – in

all instances those individuals within a weed population, or populations within a community, that have the highest tolerance to the practice(s) employed have the best chance of reproducing and spreading. This simply means that the weeds that farmers have to deal with these days have developed from the toughest individuals of a species, in terms of adaptation to both environmental and control pressures. This gives credence to the theory that the current genetic stock in weed populations and communities are probably more resilient and difficult to manage than ever before.

A survey conducted by the Food and Agriculture Organization of the United Nations (FAO) in 2010 in several countries in Africa, Asia and Latin America indicated that contamination of crop seeds by weed propagules (seeds and vegetative propagation organs) is an important issue. Contamination of crop seeds by weed propagules contributes to the spreading of weeds to places where they were not encountered before, which increases the weed management cost incurred by the farmer on the receiving end. Moreover, invasive weed species can disperse from crop field to natural ecosystem where indigenous flora and fauna might be transformed and even displaced by alien vegetation. The spreading of weeds through contaminated crop seeds represents the human factor in dispersal of weed seed. Humans are an important seed dispersal agent mainly because of our technology and mobility across the planet. For the afore-mentioned reasons crop seeds in general, and certified seeds in particular, should generally be free of weed propagules. Zero tolerance should be the rule for noxious weeds, which are weeds specified by law as being especially undesirable, troublesome and difficult to control. Based on growing knowledge about the problem status of certain weed species, current tolerance levels that apply to weed seeds occurring in crop seed may have to be adjusted downward in the case of specific weed types. Moreover, it is likely that tolerances ought to be instituted for those species that warrant scrutiny but thus far have escaped attention.

For easy access to good quality seed the FAO encourages and supports regional harmonization, between several countries, of rules governing quality control, certification and marketing of plant seeds. In

this context, guidance is needed and actions must be taken, at national and regional levels, to keep under control the contamination of certified seeds by weeds. If this is not done, seed marketing may be a pathway for dissemination of noxious weeds over entire regions and continents, thus jeopardizing food security.

**Photo 1:** *Striga asiatica* parasitizing rice



**Photo 2:** *Cuscuta* sp parasitizes a legume crop to such an extent that the latter is completely inundated by the weed. *Cuscuta* spp have a wide range of hosts and are likely to attack crop and weed species with equal alacrity



## 2. Weed concerns in production of certified seeds

As stipulated in most of certified seed production standards, the field must be as clean as possible of weeds to facilitate inspection of the field and to reduce the likelihood of weed seeds being present in the harvested seed for sale. In fact, crop seed containing excessive propagule numbers of any weed may be rejected from certification. To keep their fields clean, seed growers achieve weeding by several means. Although methods for weed control in annual crops have for the past four to five decades been centred on chemical (herbicide), mechanical and cultural practices, since the late 1940s the mainstay weed management tool on commercial farms has been herbicides. In contrast, herbicide use on small-scale farms lags far behind that of commercial enterprises, and often this mostly effective

method of weed control does not feature at all in subsistence and small-scale crop production. For example, in Africa, herbicides are used on 90% of land area on large commercial farms, whereas only 5% of small-scale farmer fields are treated with herbicides (Gianessi & Williams, 2011). Regardless of their popularity, herbicides should not be regarded as the “silver bullet” option in weed management. Herbicides are from time to time implicated in crop damage, inadequate weed control, and contamination of the environment, notably water resources. Another area of concern related to herbicide use is the development of weed resistance towards particular herbicides, whole families of herbicides, and even across certain families. Despite the challenges associated with herbicide use, the superior weed control efficacy they provide is generally considered to be an essential input for economic weed control. It is generally accepted that herbicides can make a significant contribution towards alleviation of the socio-economic burdens associated with weed control at small-scale farmer level (Labrada, 2009; Gianessi & Williams, 2011). Unfortunately, at smallholder level in developing countries, lack of access to herbicides is often the major limiting factor in weed management (**Photo 3**). Problems associated with herbicide use give emphasis to the need to consider, wherever appropriate, the practising of Integrated Weed Management (IWM). In the context of Integrated Pest Management (IPM), the concept of IWM demands that all weed control methods (chemical, cultural, mechanical, biological) should be considered in a particular situation, and it promises that the rational use of two or more control methods in combination is likely to promote efficient weed management beyond that which can be achieved with any method applied in isolation. Weed spectrum, cropping system, economics, access to technology, farmer knowledge and management skills are key factors determining whether IWM can be practiced successfully or not. There is no reason why IWM should be restricted to commercial farms; in fact, there should be no excuse for it not becoming standard practice at small-scale farm level.

**Photo 3:** Hand weeding of an area infested by the noxious weed *Scenecio madagascariensis* (in background, plants with yellow flowers). The plants with mauve-coloured flowers (visible close to the ground behind the man in picture) are the noxious weed *Ageratum conyzoides* (invading ageratum).



Since crop rotation, which is one of the cultural weed control practices, is required by most standards or protocols on production of certified seeds, it should be part of the farmer's weed management strategy. This practice not only disrupts life cycles of pests (including weeds) and diseases; it also is an important tool in strategies for avoidance of evolution of weed resistance towards herbicides because it makes possible the use of diverse chemistry, i.e. herbicides with different mechanisms of action, as well as alternative weed control methods dictated by the particular crop. Crop rotation, if appropriate and properly implemented, will likely improve seed quantity and quality, limits weed infestation, and consequently, weed management cost. But since none of the weed control methods described above are perfect in the sense that they singly or combined can keep the crop free of weeds

for the duration of the growing season, it makes sense to consider the type and number of weeds that can be tolerated without the occurrence of unacceptable losses in crop yield quantity and quality. Prediction of the outcomes of relations between weeds and crops is the subject of numerous modelling efforts aimed at predicting economic threshold levels for weeds in a particular cropping system. Basically, all models attempt to identify the ideal timing of weed control in order to avoid economic yield loss, in other words, they predict the period for which weeds can be tolerated in a crop. The accuracy of model predictions is subject to user skills, the vagaries of climate and soil factors, and a multitude of weed-crop permutations. This probably explains why the employment of models for weed management is mainly restricted to developed countries where the concept of precision farming is well established. As it is neither cost-effective nor environmentally friendly to make concerted efforts for keeping a field free of weeds throughout the cropping season, there will always be weeds in a field and surroundings. The critical stages of weed occurrence in the crop, from a risk for crop seed contamination point of view, are reached when weeds and crop reach maturity and set seed together. At that juncture the risk is highest for seeds from many agricultural weeds being harvested or combined along with the crop. Avoidance of this problem requires fairly high levels of weed and crop management. Farmers, quite often, for one reason or another, may fail to check establishment and development of weeds whose propagules are unacceptable in certified crop seeds.

In production of certified seeds, noxious weeds are prohibited both in the field and in the crop seed lots because of their peculiar biological characteristics, which may comprise the following traits: toxic compounds, difficult to control, highly invasive, etc. Summarized below are criteria that can be used by farmers and seed inspectors to determine which weeds to prohibit from fields where certified seeds are being produced, especially in a context where noxious weeds in many instances are not yet included in assessments. The noxious weeds that are mentioned below represent a small snapshot of the bigger picture. Although some noxious weeds are highly ubiquitous in that

they occur on many continents around the world, others are important on a regional basis only. Despite many types of noxious weeds being widely distributed in the world, and in many instances having become naturalized, their management ought to be stepped up because of their prevalence and obvious ability to spread and dominate even more than is currently the case. Similarly, those which are important only in certain regions on a particular continent ought to be monitored and managed. Localized problems associated with noxious weeds would be similar the world over, irrespective of the species involved, and besides, the invasive types do not respect political boundaries and sooner or later they are likely to spread.

## 2.1. On-farm criteria

- **Weed seed and crop seed of similar size and weight.** When a weed produces seeds of more or less the same size as the certified seed, this weed is prohibited and if field inspection encounters such a weed bearing seeds the field must be disqualified. For example, *Rottboellia cochinchinensis* (itchgrass) produces seeds of about the same size as that of rice, and therefore, this weed must not be allowed in fields where production of certified rice seed is undertaken. The same is true of wild rice. Wild rice is a major constraint to the production of rice all over the world. It is particularly difficult to control and prohibited from certified seed production areas. In wheat and other small grains grown the world over the weed spectra tend to be similar, not only because certain weeds prefer the same environmental conditions as small grains, but likely also because of the difficulty to separate crop and weed seeds due to similar seed morphology or mimicry. In this respect, prime examples are grass weeds such as *Avena fatua* (wild oats – **PHOTO 4**), *Lolium* spp, *Bromus* spp, etc. Similarly, seeds of the noxious weeds *Argemone mexicana* (yellow-flowered Mexican poppy), *A. ochroleuca* (white-flowered Mexican poppy), *Datura stramonium* (common thorn-apple or jimsonweed) and *D. ferox* (large thorn-apple) can contaminate the seeds of grain crops such as sorghum and maize (**PHOTO 5**). Probably such distinctive weed-

crop associations were established decades ago when regulatory scrutiny and methods for cleaning of traded crop seed were less effective than is currently the case. The situation will be similar for most of the world's major grain crops. Several vegetables like *Amaranthus caudatus* have close wild relatives (e.g. *Amaranthus spinosus*, *A. hybridus*) that produce visually similar seeds that, for practical reasons, cannot be separated during the conditioning process. Wild relatives must be prohibited from certified seed production sites along with other weeds producing seeds of the same size. Because seed size is not only genetically controlled but also environmentally influenced, selection pressures could change seed size (Booth *et al.*, 2003). In cases where weed and crop seeds would both pass through the winnowing machine at the same time, season after season, weed seeds can become similar to crop seeds. For example, seed morphology of the weed *Camelina sativa* (gold-of-pleasure) has changed over time depending on the type of flax (*Linum* spp) it grows in. In flax for oil this weed's seeds are relatively small and plump, whereas in fibre flax they are larger and flat. In both cases the weed seed has taken on morphological traits similar to that of the respective crop seed types. In cases where sieving is used to separate weed and crop seeds, size of seeds will determine whether separation is done successfully or not – same size seeds will be difficult to separate. When blown air (wind) is used for winnowing, the relative weight of seeds will determine the extent to which they can be separated – same weight seeds will not be separated.

**Photo 4:** *Avena fatua* seed (left) in relation to wheat seed (right)



**Photo 5:** *Argemone sp* (left) and *Datura stramonium* (right) seed in relation to sorghum seed (middle)



- **Parasitic weeds.** Parasitic weeds are systematically prohibited from sites of production of certified seed. For example, *Striga hermonthica* and *S. asiatica* (Photo 1) are serious parasitic weeds of cereal crops like maize, sorghum, millet and upland rice. A single *Striga* seed is hardly visible to the naked eye (0.2 mm) and these dust-sized seeds can easily contaminate crop seeds. As shown in the demographic model presented in Annex 1 and 2, few viable seeds of *Striga* can quickly induce build-up of a large population. Similarly, in the case *Cuscuta* spp (dodder) (Photo 2), one seed can infest 25 m<sup>2</sup> of legume crop in a single season; 1 kg dodder seed contains 1.2 to 1.8 million dodder seeds. This means that 0.001% contamination of legume crop seed, at a crop seeding rate of 22 kg ha<sup>-1</sup>, gives 395 dodder seeds ha<sup>-1</sup> which can infest 0.99 ha in a single season.
- **Invasive species.** Weed species recognized as invasive are not tolerated on certified seed production farms. For example, *Solanum elaeagnifolium* (silverleaf nightshade), which currently colonizes agricultural lands in many countries in the sub-tropics, is an invasive plant that is not acceptable on sites where certifiable seeds are being produced (**PHOTO 6**). In parts of the State of Virginia in the United States of America, the following among others, are considered as highly invasive species: *Sorghum halepense* (johnsongrass), *Pueraria montana* (kudzu vine), *Cirsium arvense* (Canada thistle), and *Imperata cylindrica* (cogon grass). All these noxious weeds are listed as “declared” weeds in South Africa. This demonstrates the supreme ability of the highly successful invader species to adapt successfully to diverse environments. Another particularly noxious weed deserving mention is *Parthenium hysterophorus* (parthenium) that is considered highly competitive and invasive of both crop fields and natural areas in India, Australia and many regions of Africa (**PHOTOS 7.1, 7.2, 7.3**).

**Photo 6:** *Solanum elaeagnifolium* is a serious invader of both crop fields and natural vegetation.



**Photo 7.1:** *Parthenium hysterophorus* at the onset of serious invasion of a natural area (note hundreds of seedlings recently emerged on a relatively small area).



**Photo 7.2:** *Parthenium hysterophorus* near crop fields. Field borders and roadsides serve as reserves from which parthenium can spread to natural areas.



**Photo 7.3:** *Parthenium hysterophorus* - flowering plants dominating an area in a nature reserve in South Africa



- **Weeds with peculiar biological characteristics.** Several weed species have peculiar biological characteristics that make them highly reproductive and difficult to control. For example, *Commelina benghalensis* (tropical spiderwort) can be cited for its unique, highly reproductive ability. It produces seeds from flowers carried above and below ground (**PHOTO 8**) and quickly reproduces from stem cuttings. The two types of seed differ morphologically and also have different temperature requirements for germination. *Chenopodium album* (white goosefoot) produces two distinct types of seed on a particular plant; one type is thin-walled brown seeds that germinate immediately, and the other is thick-walled black seeds that have dormancy. *Xanthium strumarium* (large cocklebur) has two seeds per fruit, of which one is smaller than the other. The one germinates quickly, and the other remains dormant in order to germinate later than the other type.

**Photo 8:** *Commelina benghalensis* with blue-coloured flowers above-ground and beige to white coloured flowers on underground stems. Seeds from the two flower types differ morphologically and have different germination requirements.



- **Weeds toxic to livestock and to humans.** Several weed species are toxic to livestock and to humans, but the same weeds are not necessarily involved because food sources of livestock and humans differ. Such weeds are not accepted on production sites of certified forage seeds. Examples of plants that are poisonous for livestock when ingested: *Lantana camara* (lantana – **PHOTOS 9.1 and 9.2**), *Dichapetalum cymosum* (poison leaf), *Equisetum arvense* (horsetail), *Ranunculus acris* (tall buttercup), *Solanum* spp (e.g. nightshade), etc. Several weeds are known to be toxic to humans when ingested (e.g. *Datura* spp, *Senecio* spp, etc). Different plant parts can vary in toxicity depending on the type and concentration of poisonous compounds involved. Examples of weed seeds for which zero tolerance applies on the basis of their known toxicity to humans are *Datura* spp (jimsonweed), *Ipomoea purpurea* (morning glory), *Crotalaria sphaerocarpa* (wild lucerne), and *Senecio* spp (ragwort). In relation to the latter weed, the following rule was issued in 2006 by the Animal and Plant Health Inspection Service (APHIS) of the USDA: “The noxious weed and imported seed regulations are amended by adding South African ragwort (*Senecio inaequidens*) and Madagascar ragwort (*Senecio madagascariensis*) to the list of terrestrial noxious weeds and to the list of seeds with no tolerances applicable to their introduction. This action is necessary to prevent the artificial spread of these noxious weeds into the United States”.

**Photo 9.1** *Lantana camara*



**Photo 9.2** *Lantana camara* flowers and fruits



## **2.2. In certified seed batches ready for sale**

- In addition to control measures undertaken in the field to keep away noxious weeds, certified seed lots ready for sale must be clean. All certified seed lots must be free of propagules of noxious weeds for which just some examples were discussed above. The tolerance of ordinary weed seeds depends on the purity level requirement indicated in the legislation. Scientists developed a guide to certified seed production in Borno State in Nigeria where they indicate on a weight basis a minimum of 97% pure seeds and a maximum contamination of 0.05% weed and other crop seeds (Dugje *et al.*, 2008). However, noxious weeds must be assigned zero tolerance. A case study on *Striga* illustrated in the demographic model in Annex 1 and 2 clearly shows why zero tolerance must be the rule for noxious weeds. A single *Striga* seed has a maximum weight of 7 micrograms. Hence, hundred seeds of *Striga* would weigh a maximum of 700 micrograms and represent in a certified seed packet of 500 grams a contamination percentage (0.00014%) on a weight basis, which is far below the 0.05% acceptable contamination indicated by Dugje *et al.* (2008). Yet, this contamination level may lead to the production of 2,400,040 new *Striga* plants! This shows why noxious weeds are not acceptable on certified seed production farms.
- Seeds of weeds toxic to livestock are not acceptable in certified forage seed lots. As an example, a list of weeds poisonous to grazing livestock published by the Government of Ontario (Canada) contains the following species: *Equisetum arvense* (horsetail), *Ranunculus acris* (tall buttercup), and *Solanum spp* (nightshade).

## **2.3. Lists of noxious weeds in regions of harmonized regulations on certification of seeds**

As stated above, a noxious weed is a weed specified or declared by law as being especially undesirable, troublesome and difficult to control. Most of the regulations on production of certified seeds worldwide have a list of noxious weeds neither accepted on-farm nor in certified seed lots. For example, the list of noxious weeds not permitted in certified seeds

in the State of Georgia in the United States of America includes, among others: *Cynodon dactylon* (Bermudagrass), *Cuscuta* spp (dodder), *Sorghum halepense* (johnsongrass), *Solanum elaeagnifolium* (silverleaf nightshade), *Cyperus rotundus* (purple nutsedge – **PHOTO 10.1**) and *Cyperus esculentus* (yellow nutsedge – **PHOTO 10.2**), and *Oryza rufipogon* (red rice). On the African continent, all the foregoing species are considered noxious weeds. As pointed out earlier, this phenomenon of commonality in weed spectra across continents bears witness to the supreme adaptability of the really successful weeds, a trait which no doubt earns them noxious weed status wherever they exist!

**Photo 10.1:** *Cyperus rotundus* occurring as a heavy infestation in a grain crop



**Photo 10.2:** *Cyperus esculentus* (flowering in foreground) in a potato crop. Tubers of this weed and its close relative *Cyperus rotundus* can contaminate the produce of tuberous crops



Lists of noxious weeds have not yet been defined in most African countries. There is an urgent need to compile lists of noxious weeds on a regional basis for Africa, and elsewhere where FAO is assisting in promoting harmonization of the rules governing quality control, certification and marketing of plant seeds. To achieve that, a survey should be conducted which will come up with perceived top priority noxious weeds per country. Subsequently, regional workshops should be organized that bring together weed scientists, seed growers, seed inspectors, crop protection officers, extension officers, etc. The output of these workshops will be consensus lists of noxious weeds not acceptable in production of certified seeds. Once the consensus lists of noxious weeds have been established the appropriate procedure will be followed to mainstream them in the technical regulations of harmonized regional regulations on production of certified seeds. One such workshop on noxious weeds in production of certified seeds was held in Accra, Ghana, 11-12 July 2011. It was organized for Sub-Saharan African countries where harmonization of certified seed legislations has made progress in recent years. The main objective of the workshop was to

compile a list of weeds (see table below), which could be considered as noxious weeds in the production of certified seeds in Sub-Saharan Africa, and to decide on follow-up actions.

Table: List of noxious weeds in production of certified seeds in Sub-Saharan Africa (SSA)

| Weed species                       | Criteria used         |                |                              |                    |                |                         | Major crops  |
|------------------------------------|-----------------------|----------------|------------------------------|--------------------|----------------|-------------------------|--|
|                                    | Difficulty to control | Ease of spread | Geographical Coverage        | Climatic tolerance | Aggressiveness | Seed contamination risk |  |
| 1. <i>Striga</i> spp               | Yes                   | Yes            | Sub-Saharan Africa (SSA)     | +++                | +++            | +++                     | Cereals, cowpea  |
| 2. <i>Orobanch</i> spp             | Yes                   | Yes            | East Africa, Southern Africa | ++                 | +++            | +++                     | Legume crops   |
| 3. <i>Alectra</i> spp              | Yes                   | Yes            | SSA                          | +++                | +++            | +++                     | Groundnut, cowpea  |
| 4. <i>Parthenium hysterophorus</i> | Yes                   | Yes            | Eastern and Southern Africa  | ++                 | +++            | +++                     | All crops  |
| 5. <i>Ischaemum rugosum</i>        | Yes                   | Yes            | West Africa                  | +                  | +              | +++                     | Rice   |
| 6. <i>Solanum elaeagnifolium</i>   | Yes                   | Yes            | Southern Africa              | +                  | +++            | ++                      | Cotton, sunflower, soya, cowpea                              |
| 7. <i>Cyperus rotundus</i>         | Yes                   | Yes            | SSA                          | +++                | +++            | +                       | Tuber crops (tubers in crop vegetative propagation material) |
| 8. <i>Cuscuta</i> spp              | Yes                   | Yes            | SSA                          | +++                | +++            | ++                      | Alfalfa, oil seed crops                                      |
| 9. <i>Oryza longistaminata</i>     | Yes                   | Yes            | SSA                          | +++                | ++             | +++                     | Rice   |

Continued...

| Weed species                          | Criteria used         |                |                             |                    |                |                         |  |
|---------------------------------------|-----------------------|----------------|-----------------------------|--------------------|----------------|-------------------------|--|
|                                       | Difficulty to control | Ease of spread | Geographical Coverage       | Climatic tolerance | Aggressiveness | Seed contamination risk | Major crops  |
| <i>10. Oryza barthii</i>              | Yes                   | Yes            | SSA                         | +++                | ++             | +++                     | Rice   |
| <i>11. Rotboellia cochinchinensis</i> | Yes                   | Yes            | SSA                         | +++                | ++             | +++                     | Maize, sugar cane, rice  |
| <i>12. Ageratum conyzoides</i>        | Yes                   | Yes            | SSA                         | +++                | ++             | +                       | Cereals, soya  |
| <i>13. Argemone mexicana</i>          | Yes                   | Yes            | Eastern and Southern Africa | ++                 | ++             | +                       | All crops  |
| <i>14. Avena fatua</i>                | Yes                   | Yes            | Southern and Eastern Africa | ++                 | ++             | +++                     | Wheat and other small grains                                   |
| <i>15. Imperata cylindrica</i>        | Yes                   | Yes            | SSA                         | +++                | +++            | +                       | Tuber crops (rhizomes in crop vegetative propagation material) |
| <i>16. Lolium species</i>             | Yes                   | Yes            | Southern and Eastern Africa | ++                 | ++             | +++                     | Wheat and other small grains                                   |
| <i>17. Echinochloa colona</i>         | Yes                   | Yes            | SSA                         | +++                | +++            | +++                     | Rice   |

+++; high; ++; moderate; +; low

"Aggressiveness" encompasses high fecundity, weed-crop interference, invasiveness, toxicity, difficulty to control.

"Contamination risk" takes into account seed size/weight, mimicry (close external resemblance between crop and weed seed).

### **3. Conclusion**

Contamination of certified crop seeds by weeds in general, and especially by noxious weeds, is an important issue. If certified seeds purchased by farmers are contaminated, noxious weeds will infest new localities and put pressure not only on producers of crops, but eventually, due to the weeds moving out from crop fields, also on livestock farmers when invasive types reduce the carrying capacity of natural pastures. Such infestations will increase the cost of weed management and likely will depress crop and livestock yields, thus putting food security at risk. In order to avoid contamination of certified crop seeds by seeds of noxious weeds, appropriate measures must be undertaken. Initial measures for preventing weed seeds from contaminating crop seed rely heavily on on-field weed management practices. Irrespective of the weed management programme followed by a crop producer, special care should be taken that individuals of noxious weeds do not survive, especially not until they are mature and shed seed. The longer a noxious plant is left to grow on a field, the greater is the risk that its seed will contaminate crop seed at harvest. This level of weed control intensity implies there should be nearly zero tolerance in the case of noxious weeds growing on crop fields. Implicit in this is a discriminatory approach to weed management – give the noxious weed species more attention than other less harmful weeds. Such an approach will require the naming (listing) of noxious weeds on a country and regional (country grouping) basis. Furthermore, farmers and others involved in weed management will need to be taught how to recognize noxious weeds during all phases of their life cycle. It will be of little value to be able to identify a noxious weed only once it flowers. Ideally, noxious weeds should be identified even if only seeds, seedlings, or non-flowering plants are available. In order for such an approach to be effective it must be adopted at country and regional levels. Close collaboration and harmonization of efforts by key stakeholders are required in order to discern the criteria used for declaring weeds as noxious, compiling lists of noxious weeds, establishing strategies for effective on-field management of noxious

weeds, and setting the rules governing quality control, certification and marketing of plant seeds. Lists of noxious weeds considered undesirable both on production sites and in seed lots ready for sale must be included in enabling technical regulations that complement seed legislations. As a first step, in order to define the list of noxious weeds for each region, weed scientists, seed growers, seed inspectors, crop protection and extension officials must come together to enable consensus to be reached.

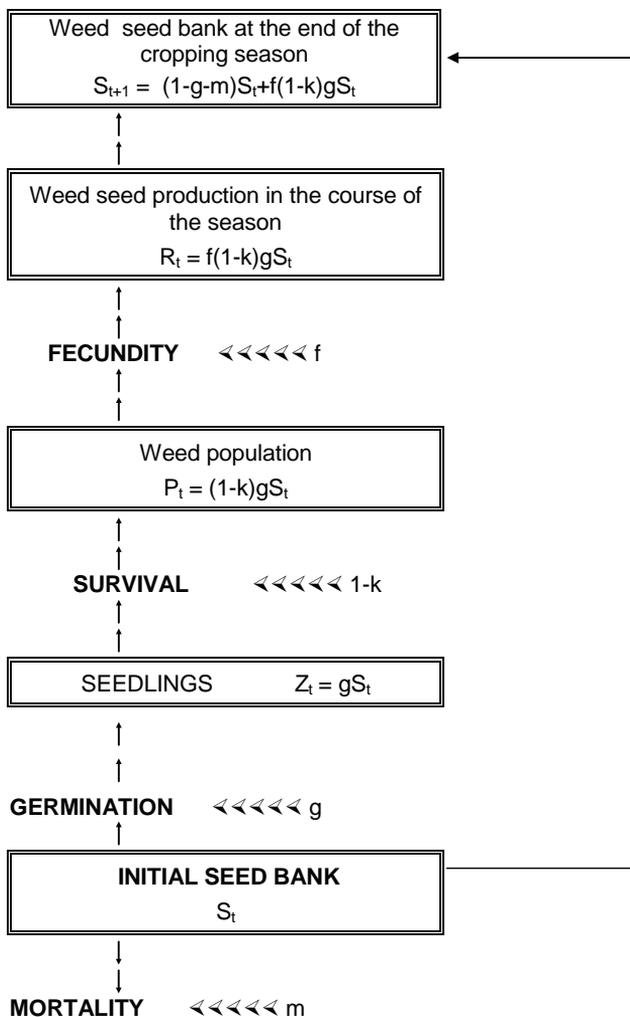
## **4. Bibliography**

- African Union Commission – Department of Rural economy and Agriculture- African Seed and Biotechnology Programme (ASBP). A flyer.
- Association of Official Seed Certifying Agencies. 1996. Genetic and Crop Standard of the Association of Official Seed Certifying Agencies.
- Booth, B.D., Murphy, S.D. and Swanton, C.J. 2003. Weed ecology in natural and agricultural systems. CABI Publishing, CAB International, Wallingford, UK.
- Canadian Centre for Biodiversity. 2006. Glossary. [http://nature.ca/plnt/glo/glo\\_e.cfm](http://nature.ca/plnt/glo/glo_e.cfm)
- Dugje, I.Y., Onyibe, J.E., Ekeleme, F., Kamara, A.Y., Tegbaru, A., Omoigui, L.O. and Bassi, S.A. 2008. Guide to certified seeds production in Borno State, Nigeria. [http://www.iita.org/cms/articlefiles/740-Guide\\_to\\_certified\\_seeds\\_production.pdf](http://www.iita.org/cms/articlefiles/740-Guide_to_certified_seeds_production.pdf)
- ECOWAS. 2008. Regulation C/REG.4/05/2008 on harmonization of the rules governing quality control, certification and marketing of plant seeds and seedlings in ECOWAS Region.
- Erker, B. and Brick, M.A. 2010. Producing certified seed [www.ext.colostate.edu/pubs/crops/00302.html](http://www.ext.colostate.edu/pubs/crops/00302.html)
- FAO. 2007. Système des semences de qualité déclarée. 271p.
- FAO. 2008. Harmonized seed legislation in West Africa. A flyer.
- Fernàndez-Quintanilla, C. 1998. Forecasting growth of weed*

- populations. Report of the expert consultation on weed ecology and management. FAO/AGP.*
- Gianessi L & Williams A, 2011. Overlooking the obvious: The opportunity for herbicides in Africa. *Outlooks in Pest Management*, Oct 2011, pp 211-215 ([www.pestoutlook.com](http://www.pestoutlook.com))
- <http://www.certifiedseed.org/PDF/UGAHosted/genstds.pdf>. General Seed Certification Standards. Revised 2008.
- [http://www.afriqueverte.org/r2\\_public/media/fck/File/Documentation/Outils\\_information/Fiche2\\_Techniques\\_de\\_productions\\_de\\_semences\\_ameliorees\\_OK.pdf](http://www.afriqueverte.org/r2_public/media/fck/File/Documentation/Outils_information/Fiche2_Techniques_de_productions_de_semences_ameliorees_OK.pdf). Afrique Verte. Techniques de production de semences améliorées certifiées.
- <http://www.extension.org/article/18331>. Seed quality testing and certification: resources useful in organic seed production. Last updated April 02, 2010.
- <http://www.agriculture.gov.sk.ca/Default.aspx?DN=e1011fbf-2859-4a51-96c5-e410c38bdcfc>. 2008. What producers are receiving when they buy certified seed – FAQs.
- Institut Sénégalais de Recherches Agricoles – Centre pour le Développement de l’Horticulture – FAO GCP/SEN/033/BEL. 1996. Techniques de production de semences d’oignon au Sénégal.
- Labrada, R. 2002. Major weed problems in rice – red/weedy rice and the Echinochloa complex. *In* FAO Rice Information, Vol 3.
- Labrada, R. 2009. Manejo mejorado de malezas para mitigar la crisis de alimentos. *XII Congreso SEMh/ XIX Congreso ALAM/ II Congreso IBCM*, Instituto Superior de Agronomia, Lisboa, 1: 319-323.
- Lacharme, M. 2001. La production de semences certifiées: règles à suivre à l’exploitation. Extrait du « Mémento technique de riziculture pour la vallée du fleuve Sénégal ». [http://www.arid-afrique.org/IMG/pdf/Production\\_des\\_semences\\_certifiees.pdf](http://www.arid-afrique.org/IMG/pdf/Production_des_semences_certifiees.pdf)
- Organic Seed Alliance. 2010. Principles and practices of organic bean seed production in the Pacific Northwest. <http://www.seedalliance.org/uploads/pdf/BeanSeedManual.pdf>
- Organization for Economic Co-Operation and Development. 2006. OECD seed schemes for the Varietal Certification or the Control of Seed Moving in International Trade.

- Primary Industries and Resources SA. 2002. South Australian Seed Certification Scheme - Procedures and Standards Manual.
- Seed production of Northern Wheatgrass. 1998. <http://www.saskforage.ca/publications/Northern%20WG%20Seed%20Production.pdf>
- UEMOA. 2009. Règlement N°03/2009/CM/UEMOA portant harmonisation des règles régissant le contrôle de qualité, la certification et la commercialisation des semences végétales et plants dans l'UEMOA.
- Van Andel, J. 2005. Species interactions structuring plant communities. In: E. van der Maarel (ed). *Vegetation ecology*. Blackwell Science Ltd., Oxford, UK.
- Vissoh, V.P., Gbèhounou, G., Ahanchédé, A., Kuyper, T.W., Roling, N.G., 2004. Weeds as agricultural constraints to farmers in Benin: results of a diagnostic study. *NJAS Wageningen Journal of Life Sciences* 52: 209-448.

## Annex 1: Demographic model illustrating why contamination of certified seed lots by weed seeds is not acceptable - Simplified diagram of the population dynamic of an annual weed



In the demographic model above  $S_t$  is the initial weed seed bank and  $m$  is the percentage of dead seeds. A fraction  $g$  of the total seed bank will germinate giving  $Z_t$  ( $gS_t$ ) seedlings.  $K$  is the percentage of seedlings that will not survive to establish weed population. Thus, the weed population that will establish is  $(1-K)gS_t$ . Production of new seeds depends on the fecundity of the weed which has been given the value  $f$  in the model. Thus, the total number of new seeds which will be produced is  $f(1-k)gS_t$ . The seed bank at the end of the season is the sum of the newly produced seeds and the viable seeds that did not germinate. The total number of viable seeds that did not germinate is  $(1-g-m) S_t$ . Hence the seed bank  $S_{t+1}$  at the end of the season equals to  $[(1-g-m) S_t + f (1-k) gS_t]$ .

## **Annex 2: Application of the demographic model to a certified seed packet contaminated with 100 (hundred) viable seeds of *Striga hermonthica* a well known noxious parasitic weed on cereal crops in West Africa**

- It is assumed that the farm was not initially infested with *Striga*,
- $S_t = 100$  and  $m = 0$  (since all the seeds are viable the mortality value is zero) ;
- $g = 60\%$  and  $(1-k) = 80\%$ . When crop seeds are contaminated they will fall together with *Striga* seeds in the same seeding hole. This maximizes germination and survival likelihood of *Striga*. Therefore,  $g=60\%$  and  $(1-K) = 80\%$  are reasonable values.
- $f = 50,000$  is actually below potential fecundity of a single plant of *Striga hermonthica*. In fact fecundity is maximum when infestation is low, which will reduce competition among *Striga* plants.
- Based on rate and state variable values above, the seed bank at the end of the season is 2,400,040 seeds of *Striga hermonthica*  
 $[S_{t+1} = (1-g-m) S_t + f(1-k)gS_t = (1 - 0.6 - 0) \times 100 + 50.000 (0.8) 0.6 \times 100 = 2,400,040 \text{ seeds}]$

As shown by the calculation, based on realistic values, 100 *Striga hermonthica* seed contaminants (of a maximum weight of 0.7 milligram) in a certified cereal seed lot may lead to the production of more than 2 millions of seeds of *Striga hermonthica*. *Striga hermonthica* population will sharply increase the second season if a cereal crop is grown again. The third season, if a cereal crop is grown again it will be at loss if nothing has been done to control *Striga hermonthica* infestation in the second year.



ISBN 978-92-5-107996-6



9 789251 079966

I3493E/1/11.13