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

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1. Introduction

Weeds, in general, precede crops on farming lands and are major yield reducing factors. In ecological terms, most annual weeds are r-strategists, establishing populations with high relative growth rate (r). Thus, they produce numerous viable seeds and their populations quickly build up, in an exponential pattern. Weeds compete with crops for the same resources, basically water, nutrients, light and carbon dioxide. Furthermore, they are alternate hosts for crop pests and pathogens. Moreover, some of them lack autotrophy and fully develop only by parasitizing crops or wild hosts. This is the case of several species of Striga, Orobanche, Cuscuta, Cassytha, etc. Several weed species are toxic to livestock. Farmers devote 20 to 50% of their time to weed management. A study published by Vissoh *et al*. (2004) indicates that weeds are an important agricultural constraint to farmers and keep smallholders in a vicious circle of poverty.

Contamination of crop seeds by weed propagules (seeds and vegetative propagation organs) brings weeds at places where they were not encountered before, which will increase the weed management cost incurred by the farmer. This is the reason why crop seeds in general, and certified seeds in particular, should be in general free of weed propagules. Zero tolerance is the rule for noxious weeds, which are weeds specified by law as being especially undesirable, troublesome and difficult to control.

For easy access to good quality seed the Food and Agriculture Organization of the United Nations (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 contamination of certified seeds by weeds. If this is not done, seed marketing may be a vector for dissemination of noxious weeds over entire regions, thus jeopardizing food security.

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 reduce likelihood of weeds being present in the seed for sale. In fact, crops containing excessive numbers of any weed may be rejected from certification. To keep their fields clean seed growers achieve weeding by several means. Since crop rotation is required by most standards or protocols on production of certified seeds, it should be part of the farmer's weed management strategy. Crop rotation, if appropriate, improves seed quality and limits weed infestation and subsequently weed management cost. As it is not cost effective to keep a field free of weeds throughout the cropping season, there will always be weeds in a field and surroundings. Moreover, a farmer, quite often, for one reason or another, may fail to check development and establishment of weeds unacceptable in certified crop seeds. In production of certified seeds noxious weeds are prohibited both in the field and in the seed lots because of their peculiar biological characteristics. 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 are not yet assessed.

2.1. On farm criteria

- **Weed seed and crop seed are of the same size.** When a weed produces seeds of the same size with the certified seed, this weed is prohibited and if encountered during field inspection bearing seeds the field must be disqualified. For example *Rottboellia cochinchinensis* (itchgrass) produces seeds of the same size with rice and therefore 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. Several vegetables like *Amaranthus caudatus* have close wild relatives (for example *Amaranthus spinosus*) producing visually similar seeds, that can hardly be separated during the conditioning process. These wild relatives must be prohibited from certified seed production sites along with other weeds producing seeds of the same size.
- **Parasitic weeds.** Parasitic weeds are systematically prohibited from sites of production of certified seed. For example *Striga hermonthica* is a parasitic weed of cereal crops like maize, sorghum, millet and upland rice. A single Striga seed is hardly visible to a naked eye (0.2mm) and can easily contaminate crop seeds. As shown in the demographic model presented in the annex, few viable seeds of Striga can quickly induce build up of a large population.
- **Invasive species.** Weed species recognized as invasive are not tolerated on certified seed production farms. For example *Solanum elaeagnifolium* (silverleaf nightshade) currently colonizing agricultural lands in the Near-East is an invasive plant not acceptable on sites where certifiable seeds are being produced. In the State of Virginia in the Unites States of America Johnsongrass (*Sorghum halepense*) and Kudzu vine (*Pueraria montana*), Canada thistle (*Cirsium arvense*), Cogon grass (*Imperata cylindrica*), among others, are considered as highly invasive species.
- **Weeds with peculiar biological characteristics.** Several weed species have peculiar biological characteristics that make them highly reproductive and difficult to control. The weed species *Commelina benghalensis* (tropical spiderwort) can be cited as an example for its highly reproductive ability. It produces seeds above and below ground and quickly reproduces from stem cuttings. This weed tolerates a wide range of environmental conditions and establishes monospecific stands.
- **Weeds toxic to livestock.** Several weed species are toxic to livestock. These weeds are not accepted on production sites of certified forage seeds.

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 discussed above. The tolerance of ordinary weed seeds depends on the purity level requirement indicated in the legislation. Scientists of the International Institute of Tropical Agriculture (IITA) 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 discussed above must be assigned zero tolerance. A case study on Striga illustrated in the demographic model below clearly shows

why zero tolerance must be the rule for noxious weeds. A 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 far below the 0.05% acceptable contamination indicated by Dugjie *et al*. (2008). Yet, this contamination may lead to the production of 2,400,040 new Striga seeds! 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. A list of common weeds poisonous to grazing livestock has been established by the Government of Ontario (Canada). This list includes *Equisetum arvense* (Horsetail), *Ranunculus acris* (Tall Buttercup), *Solanum sp.* (Nightshade), etc.

2.3. List of noxious weeds in regions of harmonized regulations on certification of seeds

As stated above, a noxious weed is a weed specified 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, Bermudagrass (*Cynodon dactylon*), Dodder (*Cuscuta spp.*), Johnsongrass (*Sorghum halepense*), Nightshade Silverleaf (*Solanum elaeagnifolium*), Purple Nutsedge (*Cyperus rotundus*) and Red Rice (*Oryza rufipogon*).

The lists of noxious weeds have not been defined in most African countries. There is an urgent need to come out with the list of noxious weeds for regions in 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 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 the consensus lists of noxious weeds not acceptable in production of certified seeds. When the consensus lists of noxious weeds are established the appropriate procedure will be followed to mainstream them in the technical regulations of harmonized regional regulations on production of certified seeds.

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. Such an infestation will increase weed management cost or depress yield and put food security at risk. To avoid contamination of certified crop seeds by seeds of noxious weeds, appropriate measures must be undertaken. In a context where FAO is supporting regional harmonization of the rules governing quality control, certification and marketing of plant seeds, for example in Africa, there is a need to define for each country and each region the list of noxious weeds undesirable both on production sites and in seed lots ready for sale. The list of noxious weeds must be included in enabling technical regulations that complement seed legislations, to strengthen FAO supported efforts which are well underway. To define the list of noxious weeds for each region weed scientists, seed growers, seed

inspectors, crop protection and extension officials must come together. This process and capacity building should be facilitated by FAO for sustainable crop production intensification in and beyond regions where certified seed regulations are being harmonized.

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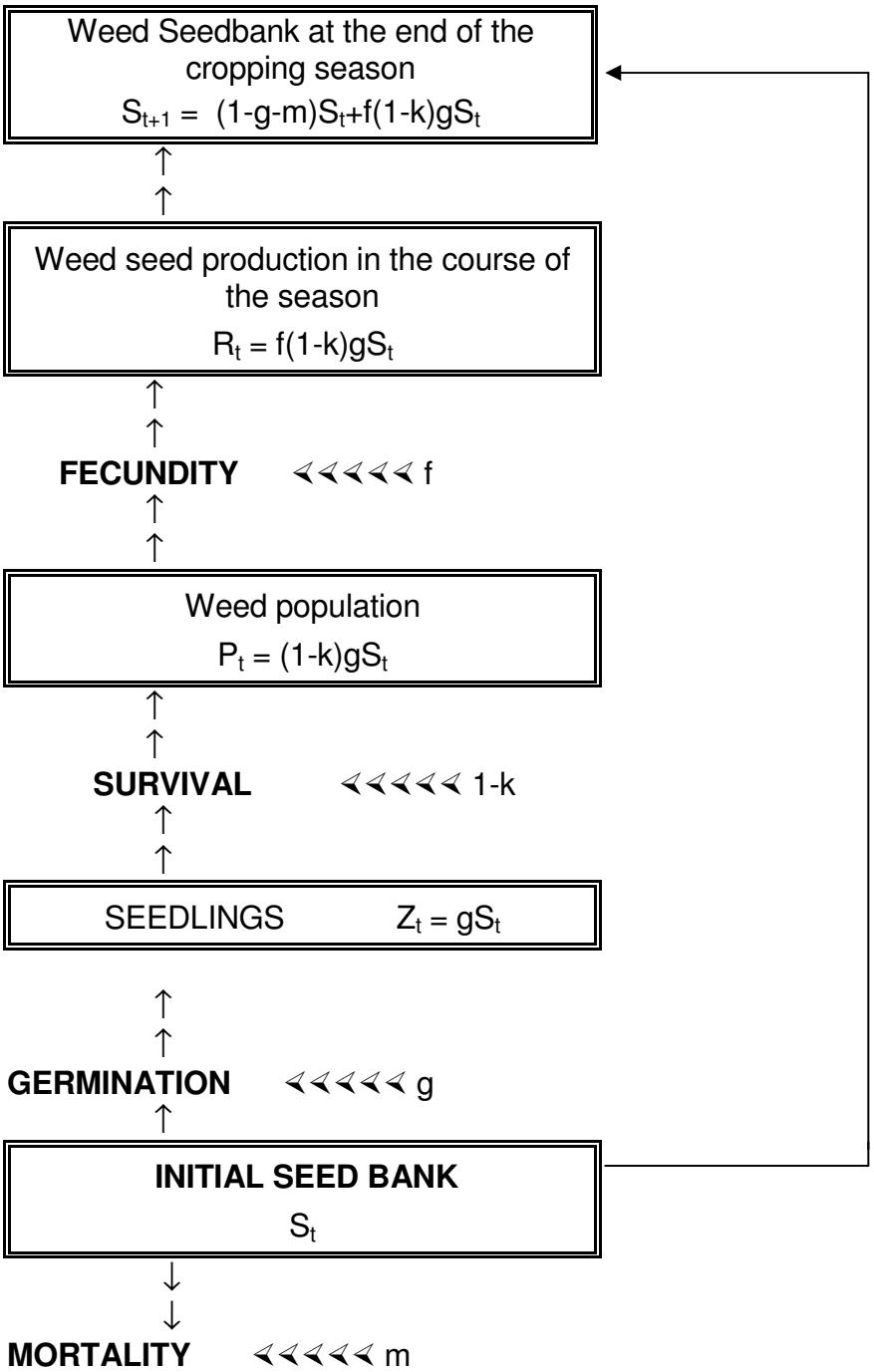
Annex 1

- **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 (gSt) 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) St. Hence the seed bank S_{t+1} at the end of the season equals to [(1-g-m) St + f (1-k) gSt].

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) St + f(1-k)gS_t = (1 - 0.6 - 0)x100 + 50.000(0.8)0.6 x100 = 2,400,040 seeds]

As shown by the calculation, based on realistic values, 100 *Striga hermonthica* seed contaminants (of a maximum weight of 0.7milligram) 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.