SOIL SEED BANKS

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ABSTRACT: The goal of this literature review is to discuss some of the major aspects of the soil seed bank, from its characteristics down to methodological aspects of its determination. Soil seed bank is the reservoir of viable seeds or of vegetative propagules that are present in the soil and that are able to recompose a natural vegetation. In the agroecossystems the soil seed bank is related to weeds, and the knowledge of its size and composition in terms of species can be used in the prediction of future infestations, to built simulation models of population establishment through time and also the definition of soil and cultural management programs, in order to have a rational use of herbicides.
Key Words: weed, soil seed bank, population dynamics

BANCO DE SEMENTES DO SOLO

RESUMO: O objetivo desta revisão é discorrer sobre alguns pontos importantes no estudo do banco de sementes no solo, desde as sua características até aspectos metodológicos para sua determinação. Denomina-se de banco de sementes a reserva destas ou de propágulos vegetativos viáveis presentes no solo e que são capazes de recompor uma vegetação. Nos sistemas agrícolas o banco está relacionado com o estudo das plantas daninhas; o conhecimento do seu tamanho e das espécies que o compõem poderá ser utilizado na previsão de infestações futuras, na construção de modelos de estabelecimentos populacionais no tempo e consequentemente na definição de programas de manejo de solo e culturais, visando racionalizar a utilização de herbicidas.
Descritores: planta daninha, banco de sementes, dinâmica de populações

INTRODUCTION

According to Roberts (1981) the term soil seed bank has been used to designate the viable seed reservoir present in a soil. For Baker (1989) this reservoir coresponds to the seeds not germinated but, potentially capable of replacing the annual adult plants, which had dessapeared by natural death or not, and perennial plants that are susceptible to plant diseases, disturbance and animal consumption, including man. All the viable seeds present in the soil or mixed to soil debris constitute the soil seed bank (Simpson et al., 1989).

The soil seed bank is the life cycle origin for the annual species, being fundamentally the cause of its persistence; in perennials, besides the seed bank, there is abank of vegetative propagules like tubers, rhizomes and stolons (Fernández-Quintanilla et al., 1991).

The earlier studies of soil seed banks started in 1859 with Darwin, when he observed the emergency of seedlings, using soil samples from the bottom of a lake.However, the first paper published as a scientific research report was written by Putersen in 1882 studying the occurrence of seeds at different soil depths (Roberts, 1981). The weed seed banks have been studied more intensely than the others because of its economical importance.

In the agroecossystems, the soil seed bank is closely related to weed studies. Its determination allows to built models of population establishment through time, makingpossible the definition of weed control programs (Martins & Silva, 1994). The knowledge of the emergence rate of the different species from a soil seed bank in these areas can be used for the adequacy of soil and crop management programs, which can result in a rational use of herbicides (Voll et al., 1996).

CHARACTERISTICS OF THE SOIL SEED BANKS

The weed species have survived throughout time, because of their ability to resist to several adverse climatic conditions, tolerating high and low temperatures, dry and humid environments and variations in oxygen supply. The fundamental point in the success of weed survival is their persistence capacity in certain areas. This capacity is a consequence of a great number of seeds produced, long term viability, continuous germination, phenotypic and genetic plasticity (Hafliges & Scholz, cited by Freitas, 1990; Fernández-Quintanilla & Saavedra, 1989).

The composition of seed banks is variable, and is classified as temporary or persistent, when modifying the regeneration of the vegetation during different time of the year. Temporary banks are composed of seeds of short life, which do not present dormancy and are dispersed in time for short periods during the year (Garwood, 1989). Species like *Avenua fatua, Alopecus myosuroides, Galium aparine, Lapsana communis, Matricaria perforata, Centaurea cyanus*, are classified as temporary, having a rate of decrease around 80%. Persistent seed banks are composed of seeds that have more than one year of age and reserves of seeds remain in the soil year after year,generally buried into the soil. *Chenopodium album, Sinapis arvensis, Aethusa cynapium, Papaver rhoeas, Viola arvensis, Kickia spuria, Capsela bursa pastoris* and *Amaranthus retroflexus* are examples of persistent soil seed banks (Barralis et al., 1988).

According to Humprey cited by Carvalho & Favoretto (1995), the success of a seed bank depends on the seed density ready to germinate, when replacement of a plant is necessary and when the environmental conditions for establishment are favorable. The longevity of seeds represents a major mechanism of survival of certain weed species, and this leads to a continuous source of emergency.

The seed longevity in the soil varies among species, characteristics of the seeds, burial depth, and climatic conditions (Carmona, 1992). Freitas (1990) presents a study with weed species, buried and placed to germinate in different times of the year. After 40 years, the species, *Amaranthus retroflexus, Ambrosia eliator, Lepidium virginucu, Plantago major, Portulaca oleracea* and *Rumex crispus* originated seedlings.

The seed dormancy is another characteristic that affects the seed bank reservoir. The seed populations of several vegetable species behave in different ways with respect to germination; the weeds produce polimorfic seeds, with a certain proportion that is dormant and another not (Silvertown cited by Freitas 1990).

Several internal and external factors prevent seeds of germination. Among the internal factors, some important are: the presence of a seed coat, which is a barrier to the penetration of water and oxygen; presence of a biochemical inhibitor in the seed; and immature embryo. Among the external factors, the most common are soil water content and temperature (Fernández-Quintanilla et al., 1991).

Harper, cited by Carmona (1992) used the term innate dormancy (primary) andinduced dormancy (secondary) to characterize the development of the dormancy in the mother plant and after the dissemination in space, respectively. The term enforced dormancy, has been used for the inability of the seeds to germinate due to an environmental restriction, like water deficit, low temperature and poor aeration. However, some seed physiologists do not consider the induced dormancy as an actual dormancy since the seed does not germinate because of the absence of environmental conditions and characteristics of the seed, since the seed does not need break dormancy but responds only favorable conditions for germination. This situation is more conveniently refereed as a case of quiescent seeds.

The dormancy represents a main mechanism of species preservation in the seed bank, distributing the germination through the year. It can guarantee the species survival in the form of seeds, under adverse conditions, even when the population of plants is completely eliminated (Carmona, 1992).

DYNAMICS OF SOIL SEED BANKS

The studies on population dynamics have the objective to determine their sizethroughout time and factors that influence their size (Saavedra, 1994). In agroecossystems,where the soil is disturbed frequently, the soil seed bank acts to stabilize and ensure species survival (Roberts, 1981).

The dynamics of a seed bank envolves a series of events of and of seeds from the bank, in relation to time (Simpson et al., 1989). The input is determined by the seed “rain”. This way of dispersion includes passive forms, mechanical ejection of seeds, fire, wind, water and animals. The result from physiological answer of plants to environmental factors, that induces the germination, seed burial or redispersion of the seeds, and predation of the seeds by insects, pathogens, and other animals (Carvalho & Favoretto,1995).

Land preparation and crop rotation are the two primary agricultural practices that generate impacts on weed seed banks (Ball, 1992). The land preparation practices are used in order to control weeds, break soil surface hardness, and increase aeration; the seed germination is stimulated because of the seed dormancy break by light, alternated temperature, water and nitrate ions (Cavers & Benoit, 1989).

The type of land preparation influences the seed dispersion in the soil profile; themanagement at same depth, favor an uniform distribution of the seeds in the soil profile,finding lower seed populations deeper in the soil (Dessaint et al. 1990).

Ball (1992) comparing land preparation systems, disc plow versus disc harrow, observed the predominance of weed seeds closer to the surface after disc harrowing.Clements et al. (1996) studied the influence of land preparation types over the seed bank and found that more than 70% of the seeds were present in the layer of 0-5 cm in plots where no mechanical method was used, and 30% for plots mechanically managed.

Some weed species may present higher intensity of emergence in the no till planting than in the conventional till. Carmona (1992) stated that no till and superficial tillage tend to reduce the amount of seeds at the soil surface shed by plants, since there is induction in the germination or loss of viability. The presence of seeds at thesuperficial layer of the soil and frequent cultivation, are factors that reduce the seed bank rapidly. This situation can facilitate seed predation by exposure of seeds to variations in temperature and humidity, and breaking their dormancy. However, the speed of soil seed bank depletion depends on the seed production of the species (Yenish et al., 1992; Fernández-Quintanilla, 1988).

For the seeds that are buried in the soil profile, where the conditions are more uniform, the action of external factors is less intense. The maintenance of viability will depend basically on the seed characteristics (Roberts & Dawkins cyted by Martins & Silva, 1994).

The use of herbicides can also influence the species composition of the seed bank,and may increase or decrease it, depending on the chemicals used (Ball, 1992), and they can also cause species shifting (Roberts, 1968). In general, it can be said that interaction among herbicides, land preparation and cultural practice have altered the size and nature of seed banks (Roberts, 1981).

Schweizer & Zimdahl (1984) reduced the seed bank in 98% after the application of atrazine in a corn field, during six years . The continuous use of triazines in this crop in Ontario/Canada altered the species composition and resulted in an increase in resistant plants to the products (Cavers & Benoit, 1989).

The development of integrated weed management systems is a hard and complex task, and can be efficient if there is a complete understanding of the weed population dynamics (Fernández-Quintanilla, 1988). The seed bank reflects the historical process of the plant life cycle, from its establishment in the environment to the distribution in time and space.

METHODOLOGY OF STUDYING SOIL SEED BANK

In order to development alternative weed systems, it is necessary to have information about the seed bank biology. However, in most agroecossystems little is known about weeds. The determination of seed banks of the soils is very difficult through the techniques that have been used lately, since they demand a lot of work and sometimes destruct seed viability (Buhler & Maxwell, 1993).

According to Roberts (1981), the best way to determine the presence and amount the seed in soil is to observe the seedlings emergence at the site. However, the most frequently used technique envolves the determination of the number of seeds placing soil samples for germination in appropriate places, or using physical separation of seeds from the soil particles, based in differences in size and density.

When the soil samples are collected the main problems are related to the heterogeneity present in the soil profile. If there is no previous information in relation to the seed distribution, it is recommended to take the soil samples in “W”, like it is normally used for soil chemical analyses (Roberts, 1981).

The method of emergence of seedlings is simple and has the advantage of the easy identification of the species; however, it requires space in the greenhouse or growth chamber and the results can be influenced by seed dormancy (Buhler & Maxwell, 1993).

The use of substances that promote the floatation is a good method for seed separation, but these substances can reduce the viability of the seeds. It is, therefore, desirable to reduce the seed exposition to the solution in order to reduce the losses in the seed viability (Buhler & Maxwell, 1993).

Several chemical substances have been used for seed separation, mainly cheap salts not highly toxic to. Potassium and sodium carbonate and zinc calcium chlorine are examples. For soils with high clay content it is necessary to use a dispersant, like sodium hexametaphosphate + sodium bicarbonate (Roberts 1981).

Buhler & Maxwell (1993) using a solution of potassium carbonate at 10,000 rpm centrifugation, recovered about 100% of the seeds of giant foxtail e *Abutilon theophrasti*. The germination of *Chenopodium album, giant foxtail* and *Abutilon theophrasti* was reduced by the exposition to carbonate.

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