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**Original Article**

# Germination of Buried Weed Seeds: Potential Threat to Agricultural Systems

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**ABSTRACT:** There is a very rich weed flora under the soil. This is in the form of buried weed seeds. This paper aims to identify the threats of buried weed seeds and address how to prevent or minimize these threats. Literature from scientific journals related to buried weed seeds were reviewed. The search was generally done by means of a structured keyword search. Literatures were analyzed and synthesis was done. Results showed several threats of buried weed seeds such as the following: weed propagules can germinate anytime with favorable environmental conditions and farm managers can be confused of their sudden occurrences; tillage methods can either bury weed seeds deeper or expose these to light breaking dormancy; farm fertilization rates and methods can trigger buried weed seed germination; reckless pesticide application will trigger buried weed seed germination; unsuitable cropping system and inappropriate weed management methods can intensify buried weed seed germination and improve weed proliferation; and poor understanding of the concept of seasonality and shifts of weed flora will lead farmers into confusion and surprise with rapid and unexpected weed seedling emergence in various geographic locations. Several strategies were identified to address these threats. A framework for a sustained buried weed seed study for a holistic weed flora management was also developed. Knowledge of the ecology, systematics and biology of the buried weed seeds and other propagules help assess the threat they pose in weed management. The proposed framework for future buried weed seed studies highlighted the needed scientific inquiry into several aspects of weed biology to come up with a sustainable holistic weed flora management.

**KEY WORDS:** Weeds, buried seeds, threats, framework, weed flora and holistic weed management.

## INTRODUCTION

There are weed seeds under the soil with prolonged dormancy. Terrestrial plants presumably evolved their length of dormancy to approximately 30 million years (Mapes *et al.*, 1989) thereby minimizing the chances of germination under unfavorable environmental conditions hindering seedling establishment. A complex interaction of environmental, physiological, genetic and edaphic factors regulates the dormancy and germination of weed seeds (Dyer, 1995). Weed population dynamics and species composition are influenced by different farming practices affecting the amounts of seeds returned to

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and removed from the soil (Wilson, 1988), enabling seed germination even several years after or whenever favorable conditions are available. This will bring farmers and farm managers to a surprise whenever unexpected weed population arise. However, with proven knowledge about buried weed seeds they can be better prepared and won't be caught unaware, hence, be critical with their appropriate weed management program.

Seeds can be regarded as the longest living propagules of higher plants, because of their ability to persist in soils. A Canadian botanist reported that he was able to grow normal plants from 10,000-year-old seeds of Arctic Lupin (*Lupinus arcticus* S. Wats) that were found frozen in silt 3 to 6 m below the soil surface in Yukon Territory, Canada (Burmside, 1985). The seeds of *Galium anglicum* which were buried 3000 years ago in the valley of Doubs were able to germinate (Brenchley, 1918). Sacred lotus (*Nelumbo* spp.) seeds, recovered from a canoe in a peat bog near Tokyo, Japan in 1951, were found viable and estimated to be 2000 years old based on radiocarbon dating. *Glaudum Serpieri* seeds gathered from land covered by excavated scoriae, 1500 years ago were found to be viable. However, doubts are still existing, regarding the authenticity of the recovered seeds. Nevertheless, the ability of seeds buried for a long period to germinate have been proven by many studies (Brenchley, 1918; Egley and Chandler, 1978, 1983; Burmside, 1985; Conn and Deck, 1995; Burnside *et al.*, 1996).

Numerous studies dealing with population of viable buried weed seeds in the soil's surface layers were conducted through the years (Darlington and Steinbauer, 1961; Kivilaan and Bandurski, 1981). Other pioneering studies on viable buried weed seeds include that of Brenchley (1918), Brenchley and Warington (1930, 1933, 1936, 1945), Chippindale Milton (1934) and that of Milton (1936, 1939, 1943). These studies focused on the viable weed seeds in soils of underlying pastures.

Buried weed seeds pose threats to weed infestation, disturbing a lot of farmers and agriculturists as well. Germination of weed seeds is actually a real threat to agricultural production. Once germinated weeds will compete for nutrients, light and other requirements that will promote good crop growth and high yield. The dynamics of weed infestation is influenced by the quantity (Forcella, 1992), structure (Myers *et al.*, 2004) and horizontal distribution of the seed bank (Wiles and Brodahl, 2004), as well the distribution of as seed-bank in different soil layers (Grundy *et al.*, 1996). This paper aims to identify the threats of buried weed seeds and address how to prevent or minimize these threats through holistic weed flora management.

## MATERIALS AND METHODS

In this paper, literature review was done. Papers from scientific journals in English related to buried weed seeds were utilized. The search was generally done by means of a structured keyword search. Moreover, major databases were also utilized to search for related articles, such as those stored and made available by major publishers including, Elsevier (www.sciencedirect.com), Springer (www.springerlink.com), Wiley (www.wiley.com), as well as library services (e.g., Ebsco www.ebsco.com; Scopus www.scopus.com; Subito www.subito-doc.de). Literature were reviewed, critically analyzed and synthesis was made.

## RESULTS AND DISCUSSION

### Nature and Threats of Buried Weed Seeds

Several threats of buried weed seeds were identified. Table 1 presents the nature and the corresponding threats of buried weed seeds. Figure 1 shows some photos of buried weed seeds of certain species excavated under the soil. Further details about these threats are discussed hereunder.

Asexual structures and buried seeds have long longevity and viability under the soil (Table 1). In general, greater longevity and viability is achieved with increasing soil depth as they are well protected from harsh disturbances (Toole, 1946; Rampton and Ching, 1966; Dawson and Bruns, 1975). It is also achieved with acidic and water-logged soils (Champness and Morris, 1948; Lewis, 1961). On the other hand, seed longevity and

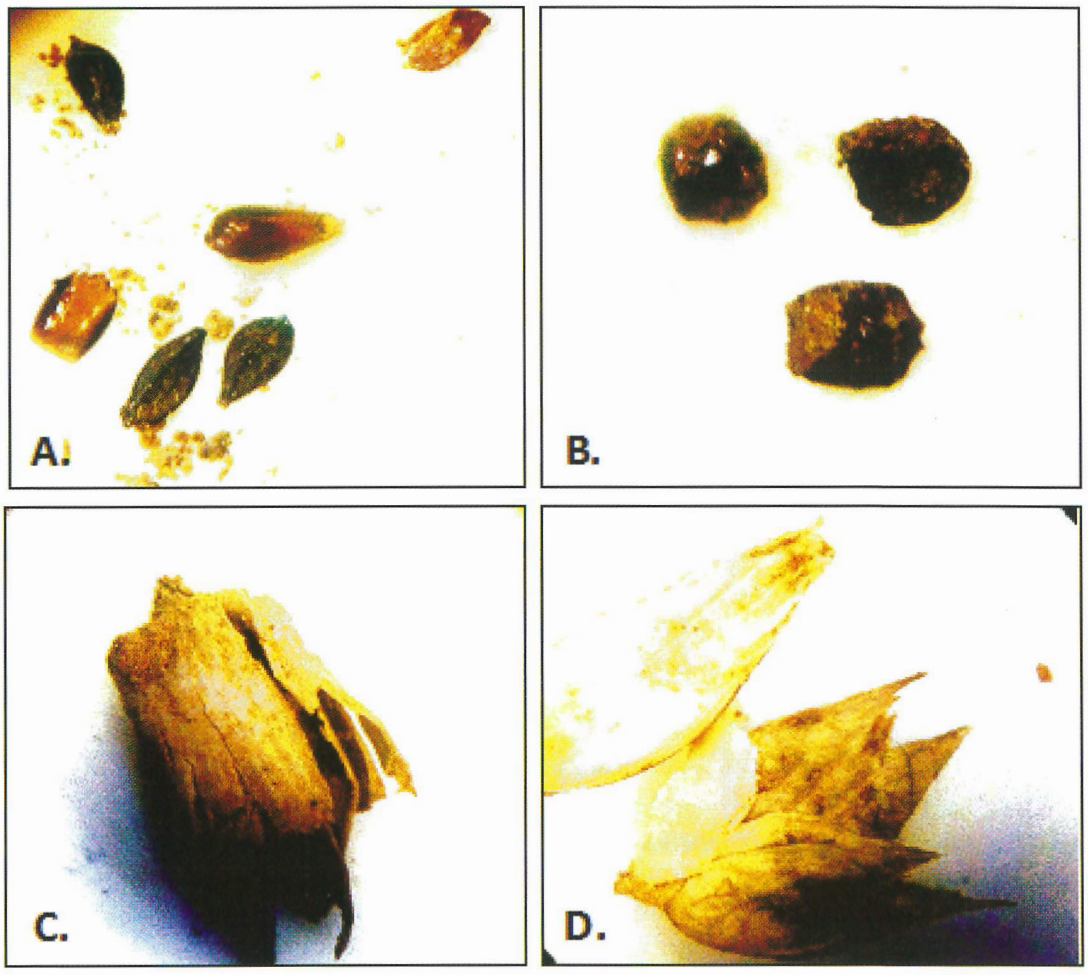



**Figure 1.** Buried weed seeds of some species excavated from the soil as viewed under a stereomicroscope. A.) *Cyperus iria*; B.) *Fimbristylis miliacea*; C.) *Rottboellia cochinchinensis*; D.) *Eleusine indica.* Photos by: J.T. Torrefiel

viability is reduced by cultivation because it increases soil aeration, exposure of seeds to light and improving the conditions making it favorable for germination (Roberts and Feast, 1973). As long as weed propagules remain viable in the soil, potential weed problems will always be present because these propagules can germinate anytime with favorable environmental conditions. Farm managers can be confused of their sudden occurrences.

Weed seed burial is influenced by different types of soil tillage (Table 1). The distribution of seed-bank is influenced by both the depth (Yenish *et al.*, 1992) and type (Cousens and Moss, 1990) of soil tillage. Higher accumulation of seeds at deeper portions is usually caused by plowing in comparison with other tillage systems (Yenish *et al.*, 1992, Mohler *et al.*, 2006). However, buried weed seed germination can also occur following a disturbance of the soil containing these seeds caused by tillage (Saur and Struick, 1964; Wesson and Wareing, 1967, 1969; Holm, 1972; Dyer, 1995). Tillage methods can either bury weed seeds deeper or expose these to light and other factors responsible for breaking dormancy and triggering germination.

Germination of dormant weed seeds can be stimulated by soil fertility levels, specifically because of the presence of nitrite and nitrate (Fawcett and Slife, 1978; Roberts, 1981) (Table 1). Increased weed seed germination can be stimulated with further applications of N fertilizer (Espeby, 1987). Thus, farm fertilization rates and methods as well, can aggravate seed germination. Germination can also be stimulated by a diverse group of chemicals (Table 1). Compounds including, sodium azide (Fay and Gorecki, 1978; Hurtt and Taylorson, 1986), cyanide (Taylorson and Hendricks, 1973), alcohols (Cohn, 1990), certain herbicides (Fawcett and Slife, 1975), and substituted phthalimides (Metzger, 1983) have been studied. In view of this phenomenon, reckless pesticide application should be avoided. Additionally, buried weed seed germination and population dynamics can be affected by the cropping system, and the weed management methods used (Table 1). Weed seeds buried under the soil, assures a continuous weed problem. Once there is a lack of attention on the weed control program and cropping system, weeds can rapidly increase and re-infest a field (Burnside, 1986). Considering this, unsuitable cropping system and inappropriate weed management methods can actually intensify buried weed seed germination and worsen weed proliferation. Moreover, weed seedling emergence is affected by different factors in the environment, seasonality, and location (Table 1). These factors determine seed numbers and species composition of seed banks (Thompson and Grime, 1979). Poor understanding of this concept will lead farmers into confusion and surprise with rapid and unexpected weed seedling emergence.

Thus, the weed seedbank assures continuity to the weed problem that will require more than eliminating weed seed production for several years.

**Table 1** Nature and threats of Buried weed seeds.

| Nature of Buried weed seeds | References | Threats |
|---|---|---|
| Asexual structures and buried seeds have long longevity and | Toole, 1946; Champness and Morris, 1948; Darlington | Weed propagules can germinate anytime with |

**Table 1** (Continued).

| Nature of Buried weed seeds | References | Threats |
|---|---|---|
| viability under the soil | and Steinbauer, 1961; Lewis, 1961; Rampton and Ching, 1966; Roberts and Feast, 1973; Lewis, 1973; Dawson and Bruns, 1975; Kivilaan and Bandurski, 1981; Baskin and Baskin, 1990; Pons, 1991; Bouwmeester and Karssen, 1992; Bouwmeester and Karssen, 1993; Dyer 1995; Conn and Deck, 1995; Burnside *et al.*, 1996 | favorable environmental conditions and farm managers can be confused of their sudden occurrences. |
| Weed seed burial is influenced by different types of soil tillage. | Saur and Struick, 1964; Wesson and Wareing, 1967; 1969; Feltner and Vesecky, 1968; Taylorson and Borthwick, 1969; Taylorson 1970; Holm, 1972; Bewley and Black, 1982; Taylorson, 1987 Egley, 1986; Cousens and Moss, 1990; Pons, 1991;Yenish *et al.*,1992; Vierstra, 1993; Mohler *et al.*, 2006 | Tillage methods can either bury weed seeds deeper or expose these to light breaking dormancy. |
| Buried weed seed germination can be stimulated by soil fertility levels. | Fawcett and Slife, 1978; Roberts, 1981; Espeby 1987; Buhler, 1991; Yenish *et al.*, 1992 | Farm fertilization rates and methods can trigger buried weed seed germination. |
| Buried weed seed germination can be stimulated by a diverse groups of chemicals. | Taylorson and Hendricks, 1973; Fay and Gorecki, 1978; Fawcett and Slife, 1975; Metzger, 1983; Hurtt and Taylorson, 1986; Cohn, 1990; | Reckless pesticide application will trigger buried weed seed germination. |
| Buried weed seed germination and population dynamics can be affected by the cropping system, and the weed management methods used. | Steinsiek *et al.*, 1982; Burnside, 1986; Derksen *et al.*, 1993; Thomas and Frick, 1993 | Unsuitable cropping system and inappropriate weed management methods can intensify buried weed seed germination and improve weed proliferation. |

**Table 1** (Continued).

| Nature of Buried weed seeds | References | Threats |
|---|---|---|
| Weed seedling emergence is affected by different factors in the environment, seasonality, and location. | Goloff and Bazzaz, 1975; Thompson and Grime, 1979; Benech *et al.*, 1990; Grundy *et al.*, 2003 | Poor understanding of the concept of seasonality and shifts of weed flora will lead farmers into confusion and surprise with rapid and unexpected weed seedling emergence in various geographic locations. |

**Addressing the Threats of Buried Weed Seeds:**

As discussed earlier, tillage methods can either bury weed seeds deeper or expose these to light triggering germination. Hence, tillage practices should be well planned and well thought to avoid the undesirable burial and germination of weed propagules that can cause damaging infestations (Table 2). Additionally, to avoid or minimize high germination rates of weed propagules, thus preventing weed infestation and proliferation the following should also be considered: farm management practices such as irrigation, fertilization and pest management should be well studied considering seasons, effect on plant and soil and impact on buried weed propagules; practicing ecologically friendly farming systems such as various multiple cropping schemes and biological pest control or integrated pest management; practicing fallowing to rest farm soil, hence, regaining normal soil fertility levels and breaking pest cycle (Table 2).

**Table 2** Strategies in Addressing the threats of Buried weed seeds.

| Strategies |
|---|
| Tillage practices should be planned and well thought of as these can either further bury seed propagules or expose them to light triggering germination. |
| Farm management practices such as irrigation, fertilization and pest management should be well studied considering seasons, effect on plant and soil and impact on buried weed propagules. |
| Practice ecologically friendly farming systems such as various multiple cropping schemes and biological pest control or integrated pest management. |
| Practice fallowing to rest farm soil, hence, regaining normal soil fertility levels and breaking pest cycle. |
| Develop a framework for a sustained buried weed seed study for a holistic weed flora management. |

Moreover, a framework for a sustained buried weed seed study for a holistic weed flora management was developed as shown in Figure 2. The proposed framework for

future buried weed seed studies was developed to highlight the needed scientific inquiry into several aspects of weed biology to come up with a sustainable holistic weed flora management. Plain agronomic and crop protection studies are not enough. Ecology and systematics of weeds may be very important, along with other basic and applied studies (Figure 2) which are always ignored. Hence, this framework tells us that we have to examine not only the weed itself, which we think is always the problem, by conducting several physiological and herbicidal studies, but the different conditions of the physical, biological and even the social practices and economic conditions of the farmers and the interactions of these components. This is the essence of holistic weed flora management where all the possible contributing and interacting factors are considered.

## CONCLUSION

Knowledge of the ecology, systematics and biology of the buried weed seeds and other propagules will help assess the threat they pose in weed management. The proposed framework for future buried weed seed studies highlighted the needed scientific inquiry into several aspects of weed biology to come up with a sustainable holistic weed flora management.

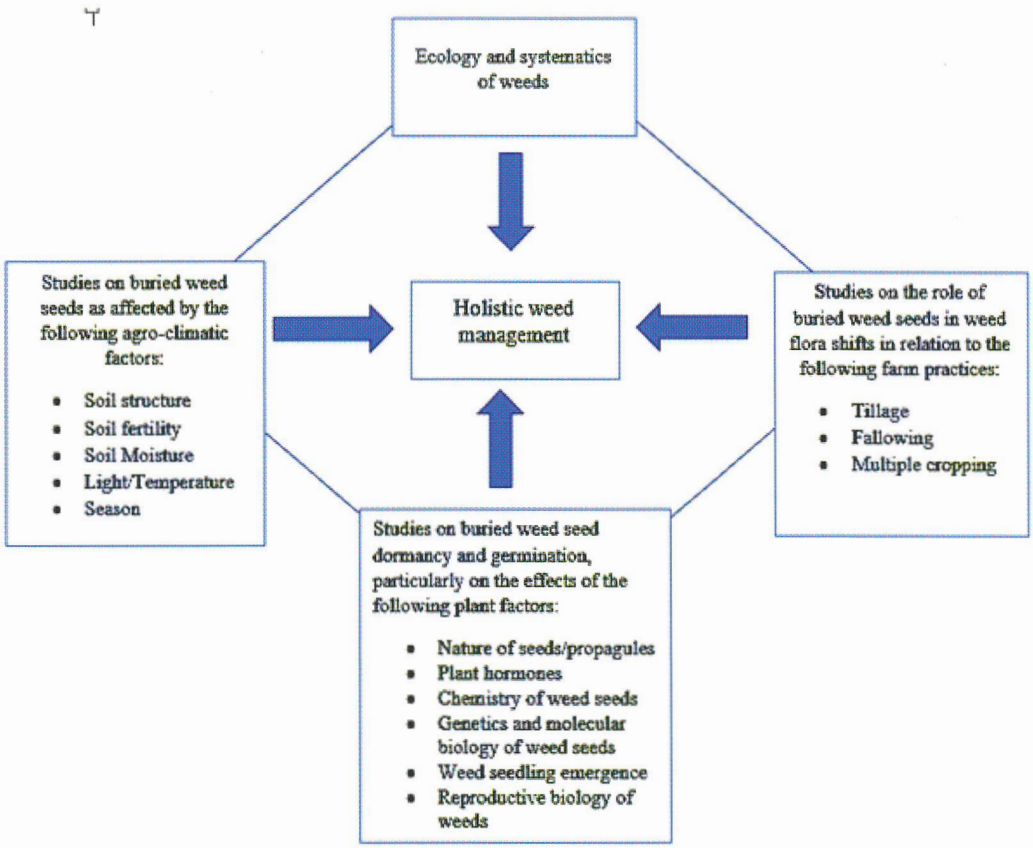



**Figure 2.** A framework for future buried weed seed studies.

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