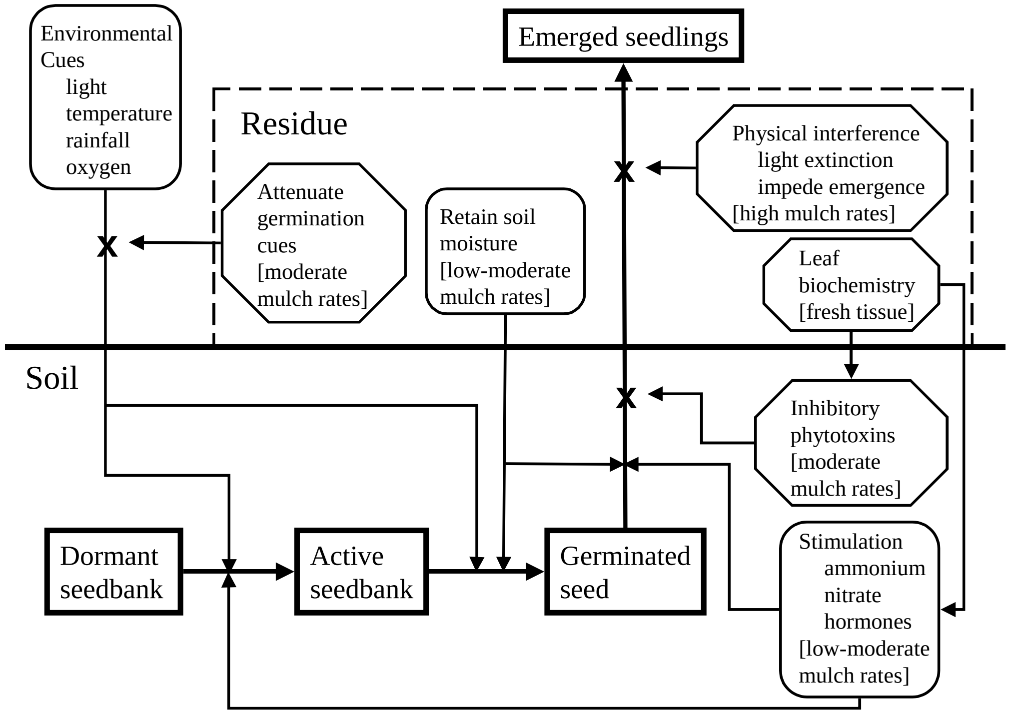
Understanding the Complexities of Cover Crop Residue Influences on Weed Emergence

This diagram shows factors influencing suppression or enhancement of weed emergence by cover crop residue. Rectangles connected by arrows represent weed states leading from dormant seed to emerged seedlings. Hexagons represent effects that inhibit emergence at the point marked with an “X”. Rounded rectangles represent effects that enhance emergence at the points designated by the attached arrow. Brackets indicate residue conditions where the effect is most likely to occur.



The important factors that control weed suppression by cover crop residue are shown in the accompanying diagram. The germination process begins when seed dormancy is broken and is initiated by environmental cues such as exposure to light, high alternating daily temperature amplitude, imbibed soil moisture, and dissolved oxygen. Residue can enhance emergence by retention of soil moisture or by release of nitrogenous compounds that interact with environmental cues to break dormancy. Residue can inhibit emergence by attenuating environmental cues, physically interfering with the emergence process, and releasing phytotoxic compounds. The residue conditions under which these processes are most likely to occur are discussed below.

Research has shown that residue from cover crops or other organic mulches must be present in very high amounts to provide a high level of physical suppression of annual weeds. For example, Teasdale and Mohler (2000) showed that greater than 75% inhibition of weed emergence is consistently achieved only when mulch biomass exceeds 8000 kg/ha and mulch thickness exceeds 10 cm. The mechanism for this is primarily physical interference with the upward movement of the emerging seedling and the downward penetration of light to seedlings. Such high levels of cover crops residue may be consistently achievable by cover crops in tropical and subtropical areas but are not typical of winter annual cover crops in temperate climates. Use of cover crop mixtures including legumes and grasses (e.g. rye and hairy vetch) can achieve such high biomass levels if grown to maturity (Teasdale and Abdul-Baki 1998).

Most cover crops such as rye and hairy vetch produce natural levels of approximately 3000 to 5000 kg/ha and, therefore, would not be sufficient to smother weed emergence as occurs at higher rates but, rather, can operate through effects on either germination cues or allelopathy. Teasdale and Mohler (1993) showed that these intermediate rates of residue can limit light and temperature fluctuation cues that weed seed may require for initiation of germination. Residue reduces the frequency of soil sites under residue that receive light, an important cue that triggers many weed seed to germinate. Live cover crop vegetation is more effective at inhibiting light-mediated germination because it lowers the red-to-far red ratio of light (higher ratios can trigger a phytochrome receptor in seeds to initiate germination, Teasdale and Daughtry 1993). Dead cover crop residue has little influence on the red-to-far red ratio, but only reduces the amount of light received at the soil surface. Also, residue reduces maximum soil temperature and may slightly increase minimum soil temperature. These effects in themselves are insufficient to influence germination but the net affect on daily maximum to minimum amplitude can affect seed behavior; lower temperature amplitudes are more typical at deeper levels in soil and essentially trick the seed into thinking it is positioned too deep to germinate.

In addition, release of phytotoxic compounds from cover crop residue can inhibit weed root and hypocotyl growth immediately following germination and prevent emergence of seedlings. Research suggests that this would most likely occur immediately following cover crop kill when residue is fresh and contains intact leaf material. A pulse of these compounds would be released when the first rains begin the degradation of fresh residue material. After the initial degradation process, residue would become decomposed and lose the leaf material where the highest activity resides. Phytotoxicity of cover crops can not be expected to persist more than 2 weeks in soil. Subsequent weed suppression beyond the initial 2 weeks following cover crop kill would probably result more from physical effects on germination cues and emerging seedlings than on allelopathic influences.

It is also important to recognize that release of inorganic nitrogenous compounds can stimulate germination of selected weed seeds under selected conditions when low or moderate levels of residue are present. For example, smooth pigweed germination was stimulated when a dormant seed lot was treated with hairy vetch extracts under moderate temperature and light conditions (Teasdale and Pillai 2005). The activity of hairy vetch extracts and ammonium ions on germination was highly correlated suggesting the role of inorganic nitrogen in this process. Also, cover crop residue can create a “safe site” under residue by maintaining more uniform soil moisture and moderate temperature under hot, dry conditions (Mohler and Teasdale 1993) and by intercepting soil active herbicides and reducing their soil concentration (Teasdale et al. 2003). As a result, it may be difficult to predict weed emergence at natural levels of cover crops, particularly leguminous cover crops such as hairy vetch because of these multiple effects. Effects of stimulatory and phytotoxic compounds as well as effects on germination cues and growth factors can be highly dependent on local conditions and environmental parameters. Clearly, more research is needed to understand the complex interactions between soil, residue, and environment as it influences the process of weed germination and emergence.

References

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