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Foundations of the cover crop technique and potential use in afforestation

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Introduction

In many circumstances in afforestation, by tree plantation or by direct tree seeding, the quick development of very competitive herbaceous and shrubby species can compromise tree establishment (Balandier et al. 2006). At present, this vegetation is often controlled by chemical and mechanical operations, whereas they are criticized from environmental points of view; some alternatives are under study (Willoughby et al. 2009). The cover crop technique (or cover plant), i.e. sowing in place of the spontaneous competitive vegetation (mainly perennial grasses) a cover plant mixture assumed to be less competitive, is an example of potential ecological engineering (Balandier et al., 2009). In addition with the control of potential weeds and reduction of competition for resources, the cover plants are thought to offer protection against frost and scorching temperatures to the young trees, or to avoid the water run-off encountered on bare soil.

Despite promising results obtained in some experiments, there are also a lot of negative data. The reasons of success or conversely failure of the cover plants to control weeds and establish young trees are not fully known or analysed. Actually the fundamental bases of the technique are not fully established.

Monoculture or mixture?

In many circumstances using a single species to establish the cover was reported as a failure, either because the plant did not established well, or because conversely it developed too much and competed strongly with the young trees. Sowing a mixture of plants is a way of both securing the establishment of some species while avoiding a too large development of other species. In some experiments more than 20 species were used, annuals and perennials, with complementary phenologies and functional traits. The aim is to rapidly and permanently cover the soil in order to limit the development of weeds, often very light-requiring species, in addition with other functions such as the N fertilisation of soil with legume species, prevention of erosion with dense rooted species, etc. The reason of designing a mixture of species rather than using a single species is also that in a species community, species using different resources, or collecting resources at different places or at different periods can coexist (niche theory). This principle was largely exploited to select species grown in association, and particularly crop and tree in agroforestry (Batish et al., 2008).

The choice of species

However a huge work remains to do in the context of afforestation to select a sufficient number of species, not too competitive relative to young trees, well adapted for different site

conditions and coexisting as a community. If we add also the principle of using only species present in the local flora to avoid pollution by exotic species, the work becomes excessive. We know some species to avoid, and particularly those that are undesirable such as perennial grasses. For instance the Ray grass (*Lolium perenne*) is often used in different contexts as slope stabilisation, prevention of erosion, etc., whereas it is a strong competitor relative to most young trees. We obviously need a referential frame of plant functional traits that would allow to select species for a low competitiveness relative to tree, and having complementary features. This work has been done, at least partially, for some communities as pasture or meadow but still needs development in forest.

What is the good technique to correctly sow different species?

The rapid development of cover plants is fundamental to avoid those of weeds at the moment of tree sowing or plantation. If in agriculture efficient guidelines have been available for a long time to sow most crop species, little is known for more uncommon or wild species. In many experiments, the failure of the cover plant technique is due to a very low emergence and development rate of the sown plants, or too late to play a significant role. We identified that the sowing technique itself is often inappropriate to correctly sow a mixture of seeds with different sizes. Soil preparation must also be adapted to the chosen species, to the cultural antecedents of the site (Provendier et al. 2005). Again a large amount of work should be done on some aspects to improve the cover plant technique.

The fundamental impact of predation

Seed predation by rodents and birds and damages on young trees by browsing animals are often reported in the literature as adverse factors for the success of afforestation, either by tree plantation or by direct tree seeding. Rodents and birds can obviously raise a non negligible amount of seeds of the cover plants, reducing the emergence rate accordingly. The role of insects such as ants is probably underestimated in that predation. In a controlled experiment in central France (Charensat) where cover plant seeds of different species were protected from birds and rodents by a wire netting, we observed an intense harvest of seeds by different insects. The role of other animals such as slugs is probably underestimated as well (observations at Claye-Souilly, Paris, France).

There are also interactions between the mixture composition and damages on young tree made by rodents and wild ungulates such as roe deer. Of course if some palatable plants make up the mixture, damages on trees strongly increase. For instance legume species are known to attract rodents. Conversely some plants with spines or toxic compounds like alkaloids could keep away the predators; to our knowledge this track is not explored.

Why using cover plants?

Despite this long list of drawbacks, cover plants proved in some cases that they can improve tree establishment, mostly in unfertile sites, at least in comparison with doing nothing, the use of herbicides still giving the best results (Balandier et al., 2009). They can also bring an added value, such as an increase of biodiversity, an improvement of the landscape if flower species are used, or bring other productions as honey if melliferous plants are used. Again these different aspects have not been really investigated to actually assess the ecological footprint of the technique.

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