# CONSERVATION AGRICULTURE,
## A WORLDWIDE CHALLENGE

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# Adaptation of sowing techniques to maintain important lumbricid biomasses in the hydromorphic soils of Normandy

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## Introduction

Permanent pastures are occupying 10.5 million hectares (IFEN, 1996) and are only moderately productive. Sustained fertilization and judicious exploitation methods will allow to increase their output. In the Vieux Pin INRA domain (Le Pin-au-Haras, Orne), the production of a pastured prairie which had been monitored for fifteen years increased from 4.5 t DM/ha to 8 t DM/ha after they had been moderately fertilized.

Resowing a degraded prairie or destroying one, or even establishing a maize crop, means that the soil must be ploughed to make a good seedbed. If the ploughing works of the soil have a negative effect on the lumbricid populations, is it possible to conceive sowing techniques which would preserve this food source which is so important to the fauna? Is it possible to obtain a high forage production without degradation of the soils while maintaining the soils' bearing capacity and their feeding potential for game species in winter? What are the environmental impacts of the various technical crop management sequences on nitrate losses, on erosion and on the risks of diffuse pollutions? What is the influence of intensive forage practices on lumbricid populations?

Another resowing technique of the meadows, which is more respectful of the lumbricid populations and the properties of meadow soils, was tested in the Vieux Pin estate; it consisted in weeding in autumn and resowing in the next spring (Laissus, 1985; Leconte et al., 1998). The lumbricids which are very active in the period of the year when the days are short (autumn, winter) will take the organs of the plants which are destroyed by the herbicides, take them underground and then feed on them; thus they have an important role as «cleaners» of the soil surface before sowing. They use the energy of the plant litters of dead vegetation to do a tilling job which creates porosity, aggregates of stable soils and and anti-erosives; they are recycling the fertilizing elements which are contained in the organic matter.

**Key words:** Hydromorphic soils, leached soils, plowing, direct seeding, autumn weeding, spring sowing, lumbricid biomass, *Lumbricidae*.

## Methods

*Presentation of the experiment carried out in the Vieux-Pin estate*

The objective of the tests which were carried out on the experimental domain of Vieux Pin, was to improve quantatively as well as qualitatively the production of the permanent pasture *and notably to obtain:* (besides quality and quantity):

- a greater durability of the resown prairie,
- a longer grazing period (earlier putting at pasture, later stalling which, a priori, is possible because of the improved bearing capacity of the soil),
- lesser number of hours worked and energy savings at the moment of resowing,
- a greater *soil bearing capacity* in the year following sowing,
- the possibility to finish sowing in one day with ordinary seeders.

*Comparison of sowing techniques*

Three sowing techniques (tables 1 et 2) were compared to those applied in permanent-meadow control plots:

- «Ploughing» process: mechanical shredding of the sward followed by ploughing, the run of a rotary harrow and sowing with a cereal seeder.
- «Simplified» process: destruction with herbicides in autumn (Aminotriazole + ammonium Thiocyanate at 3,600 g + 3,225 g AI/ha or Glyphosate at 1,000 g AI/ha, according to the vegetation that should be destroyed) then, in spring, rotary hoe before sowing, followed by sowing with a classical seeder, rolling after sowing.
- «Direct drillingprocess»: destruction by herbicides in autumn (Glyphosate at 1,000 g AI/ha) direct drilling with a special sowing drill *next spring.*

*Measurements taken*

The following parameters were compared:

- the cost of planting of the crop,
- the yields of two fodder crops (grass and maize),
- lumbricid biomasses,
- nitrogen mineralization,
- soil bearing capacity.

The expenditures for planting included the costs of pesticides, a reserve for the depreciation and maintenance of farm equipment at CUMA rates (Cran, *2000*), and the costs of labour for which the payment of the hours of work was charged to another account.

Lumbricids were collected by the etho-physical sampling method defined by Bouché and Beugnot (1972) whereby: the ground is wetted with formol, then soil samples are digged up with a spade at a depth of 20 cm, washed and sieved.

Net nitrogen mineralization was estimated by determining the amounts of nitrates in the soil (measurements of nitrates within a 0-30 cm horizon in the laboratory) and in crops in the field in late winter.

The penetrometer used was an artisanal device. It consisted of a 150-cm long rod, with a 3.0-kg weight sliding along the rod and a 4-cm diameter cap at the extreme end of a tube with a check at 12 cm from the cap.

## Results

*Case of a resown prairie*

During the first year, a significantly greater amount of grass will grow in plowed plots (table 1) because of the important mineralizable flux of a great amount of dead tissue (necromasses), obtained after soil aeration and tillage. In the second year, there is no longer any difference in productivity between the ploughed plot and those left without ploughing.

The classical technique of sowing after minimum tillage allows to plant very evenly at a lesser cost (1.711 F *all taxes included in 2000*) than with the traditional method of ploughing (2.554 F/ha in *2000*), i.e. at a lesser cost of 843 F/ha (33%). Total weed control before the winter followed by resowing in the following one is a reliable and cheap technique, which has been applied at a regular basis for more than 15 years in the Vieux Pin estate. The lower costs of this technique may in the first place be explained by the lesser time invested in farm labour (Leconte et al. 1998, table 1) .

The technique of direct drilling of seedlings is even less costly (a 43% reduction in the cost of sowing after ploughing). However, the results obtained by this method of total weed control followed by resowing later on in the season are very dependent of the preservation of the soil's humidity in the first two months after sowing and of the presence of bent grasses the exsudats of which are hindring the sown seedlings' growth (phenomenon of allelopathy described by Delabays et al., 1998).

*Destruction of permanent pastures to plant maize*

Thanks to the perfection of this technique of sowing without plouging through the adoption of simpler soil cultivation techniques, it has been possible to introduce the cultivation of maize in the Vieux Pin domain (table 2). No significant difference in yield has been observed whatever the adopted technical method. However, in the second year an (unsignificant) drop in yield has been noted for the plot that had been ploughed.

With regard to the method of direct drilling, the planting expenses of the crop had gone down by 30% in 1999 when direct drilling was applied; and moreover, the improved soil bearing capacity makes harvesting easier when it is raining in autumn, like in 1999 et

2000, the year when the many maize seedlings which had been planted after ploughing had incurred a great deal of additional expenses at the moment of harvesting (and to restore the state of the soil after harvesting), or had even been lost.

*Effect of habitat and various sowing techniques on lumbricid populations*

Meadows with hydromorphic soils, contain very large lumbicid populations (on average 2.8 t/ha), which is higher than than in leached brown soils (2.0 t/ha).

Earthworm populations are best preserved when meadows are weeded in autumn and are seeded directly in spring (74 à 83% of the control meadows with permanent grass, table 3); the effect of runs with a machine for superficial tillage with a rotary hoe, or of plowing, is that the lumbricid biomass will greatly be destroyed: respectivement 66-74% et 57% of the biomass when the direct drilling technique is applied.

*Reduction of nitrate losses in the absence of deep soil ploughing*

When soils which are rich in organic matter are cultivated, the risks are great that nitrates will be released. On the contrary, after weeding in autumn, there is only limited mineralizaton of the organic matter because no oxigenation of the soil takes place (table 4). In these cold soils, nitrate winter losses in the first 30 cm beneath ground level are very low compared to those which are deeply ploughed before autumn (between depths of 30 to 60 cm, no analyses were made of the clayey subsoil with glauconites which is very impermeable).

*Improvement of the soil's bearing capacity and the absence of deep-soil tilling*

The soil's bearing capacity before the meadows are grazed for the first time, is reduced by half when the «ploughing», option is applied, by 30% with superficial ploughing, and by 10% (NS) after after direct drilling of seeds (tableau 5). The effect is even more pronounced at the end of the winter. The greater resistance to trampling may contribute to the lengthening of the grazing season, while the pastures' perennity also increases.

Table 1. Cost-benefit analysis of the establishment of a prairie according to its technical specifications.

| | *Cost (F)* 2000 | *Number of* interventions | *Hours of work* (hour/ha) | *Production*(t DM/ha)* Year 1 | Year 2 |
|---|---|---|---|---|---|
| Classical sowing after plowing | 2 554 | 5 – 6 | 10 - 11 | 13.1 a | 10.9 b |
| Classical sowing after simplified till | 1711 | 4 | 4-5 | 11.5 b | 10.9 b |
| Direct drilling | 1460 | 2 | 2-3 | 10.4 b | 11.0 b |
| Reference plot (permanent pasture) | | | | 10.1 b | 10.6 b |

* Test T: the different vertical letters indicate the significant differences between treatments at the threshold of P = 0.05%

Table 2. Cost-benefit analysis of maize after prairie plantations according to their technical specifications.

| | 1st year | | 2nd year | |
|---|---|---|---|---|
| | Cost (F) 2000 | Yield (t DM/ha)* | Cost (F) 2000 | Yield (t DM/ha)* |
| Classical sowing after ploughing | 2 136 | 14.00 a | 1 962** | 11.72 a |
| Classical sowing after simplified till | 1962 | 14.12 a | 1 962** | 13.2 a |
| Direct drilling | 1570 | 13.29 a | 1 962** | 13.32 a |

* Test T: no significant differences between treatments at the threshold of P=0,05%

** For the 2e *year, same tilling method: 2 alternating passages of the cultivator in spring at 15-20 cm, 1 passage of rotary hoe and conventional sowing with a precision seeder.*

Table 3. Influence of tilling on lumbricid biomasses (in t/ha)

| | Plot1 (hydromorphic soil) | Plot 2 (brown leached soil) | Plot 3 (hydromorphic soil) |
|---|---|---|---|
| | | 1.32 ± 0.40 D | |
| Classical sowing after simplified till | 1.43 ± 0.29 D | 1.72 ± 0.40 CD | |
| Direct drilling | 2.15 ± 0.48 B | 2.33 ± 0.30 BC | 2.73 ± 0.30 AB |
| Reference plot «permanent pasture» | 2.91 ± 0.62 B | | 3.28 ± 0.62 A |

A, B, C, D: 5% Newman-Keuls range test

Table 4. Effect of ploughing on the liberation of nitrogen during winter (kg N/ha, March 1990)

| | Use of soil in winter | Nitric nitrogen in late winter (kg N/ha) | Nitrogen exported by the crop (kg N/ha) | Liberated nitrogen (kg N/ha) |
|---|---|---|---|---|
| Glyphosate in autumn | Bare soil | 21 | 0 | 21 |
| Glyphosate in autumn and direct drilling | Triticale | 7 | 20 | 27 |
| Glyphosate in summer, ploughing and sowing | Triticale | 69 | 81 | 150 |

Table 5. Incidence of ploughing on the soils' penetrometry.

| Penetrometry* | **Classical sowing after ploughing** | **Classical sowing after superficial ploughing** | **Direct drilling** | **Control: permanent pasture** |
|---|---|---|---|---|
| end of winter | 1.8 (± 0.37) | 4.0 (± 0.69) | 6.6 (± 0.62) | 7.5 (± 0.93) |
| before 1st grazing | 4.5 (± 0.62) | 6.9 (± 0.92) | 8.9 (± 0.89) | 9.8(± 1.06) |

* Reference specifications : 1 to 2: soil with low bearing capacity on which very large low-pressure tires should be used
5 to 6 : from this level on grazing is possible without degradation of the prairie
8 to 10: soil with a good bearing capacity for grazing as well as for cropping
12 to 16 : norm at the end of spring, beginning of summer