A study on the effects of agricultural practices on earthworms and their predators in hydromorphic soils

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In one of its study areas, INRA (National Institute for Agronomic Research) has shown that grassland flora can be improved with fertilisers and adapted farming methods. Such improvement, however, is slow and has its limits if the cultivated plant species give low-quality fodder. Re-sowing permanent grasslands with selected cultivars would be the best solution, but most soils of permanent grasslands cannot be treated by classic tillage. It is less expensive to weed the grassland at the end of autumn and to re-sow it in spring. Then herbicides of average persistence and normal seeders can be used. Moreover, the lumbricids which are present in great numbers in permanent grasslands are very active in winter and will consume the mass of destroyed vegetation. Their activity will create a seedbed of excellent quality. The application of this technique and the intensification of fodder productions will yield an important earthworm biomass (on average 2.37 t/ha) that will be used by numerous earthworm predators (Woodcock, Snipe, Lapwing and Thrush) in winter. Hunting opportunities may be increased by the introduction of cereal crops and the creation of refuge areas.

Introduction

About 11 million ha of France are covered with permanent grasslands that are not very productive. Productivity could be increased up to three-fold by fertilisers and certain agricultural practices (Laissus 1985).

On the other hand, hydromorphic soils of permanent grasslands are characterised by dense vegetation and high biomasses of earthworms or lumbricids (Bouché 1972, Lee 1985). Traditional agricultural methods to increase the economic yield include deep ploughing and cutting the grassmat into pieces with a rotavator in order to prepare seedbeds i.e. for growing maize. These practices, however, are detrimental to earthworm populations (Edwards and Lofty 1982) and consequently to the quality of soil in several aspects (i.e. porosity, stability of soil aggregates).

These drawbacks led us to test techniques of "sowing without ploughing" and preventing undesirable weed flora by application of non-persistent herbicides harmless to the soil fauna. The objective of this study was to find compromises between agricultural yield without soil degradation and conservation of earthworm biomasses as a main food resource for certain wildlife species.

Study area

The studies were carried out in the "Vieux Pin", situated in the eastern region of Lower Normandy (western France). The soils are rich in thin clay and clayey subsoils, which makes them more or less impermeable to water. They are often stony and not very productive. They are covered with original permanent grass vegetation. There are 720mm rain-fall per year, with no pronounced peaks.

The study area therefore represents the category of marginal agricultural areas, which comprises about one third of all areas used for agriculture in France.

Methods

During two consecutive years, several agricultural techniques to increase the production of either grass or maize have been tested, and the costs and benefits for the years 1985 and 1990 calculated.

Both alternatives (grass and maize), were tested by different methods:

1. Traditional practices, namely mechanical harrowing of the sward of natural grass cover, ploughing, then seeding, rolling and treating the field with a rotary harrow.
2. No tillage (ploughing), but seeding by direct drilling after undesirable weeds had been removed in autumn by treatment with various herbicides that are not, however, harmful to earthworms.

For each category of study area, species and biomasses of lumbricids were investigated.

Earthworm predators were monitored the during day, but also at night with a spotlight mounted on the motor vehicle, as described by Gossmann *et al.* (1988).

The results were compared with those of control plots of natural grassland.

Results

Production of grass

On traditionally treated areas (1) fodder production was much higher in the first year. In the second year, no

differences to areas (2) were found. If areas (2) are weeded properly in autumn, costs for planting in the following spring are lower than those on areas (1) with traditional ploughing. Savings for not ploughing increased from 388 FF/ha in 1985 to 702 FF/ha in 1990.

Production of maize

There was no significant difference in productivity between the study plots and methods applied in the first year. There was, however, a reduced productivity in the second year on areas ploughed traditionally (1). This may have been caused by a slower process of mineralisation of the organic matter ploughed under the year before.

Species composition and biomasses of lumbricids

Due to the impact of fertiliers and lime, as well as favourable grazing techniques, grasslands with hydromorphic soils are rich in earthworms. Ploughing, followed by other traditional farming practices, however, caused considerable drops in lumbricid biomasses. Superficial practices, i.e. harrowing, are less harmful, while just drilling the seeds caused only little impact.

Predators of earthworms

Several species of potential earthworm consumers were monitored during day and night. In particular, numbers of Common Snipe (*Gallinago gallinago*) and various species of Thrush (*Turdidae*) varied considerably according to the biomasses of earthworms found in the various study plots.

Discussion and conclusions

Both methods, traditional ploughing (1) and direct drilling of seeds (2), provided similar agricultural yields in grass and maize. Method (2) is, however, more conservative to lumbricid populations.

Method (2) is cheaper, since it takse less time: soil harrowing and seeding are conducted simultaneously by two associated machines. So the farmer is less dependent on the weather and can spare energy and equipment. Instead, lumbricids are tilling the soil for free. Not only organic matter, but also mineral elements pass the digestive tract of earthworms and are brought to the surface. So, leaching of the soils is considerably reduced. Drainage of the soils is also improved, as revealed by water discharge experiments with the munz-ring method. Soils rich in lumbricids held five times more water than comparable substrates without worms (Lopez-Assad 1987). There is almost no erosion in the study area – a result of the extensive grasslands, but also the excellent structure of the soil thanks to the activities of the lumbricids.

All three types of herbicides used in the area to remove weeds do not harm lumbricids (Lee 1985). We do not know, however, the effects on other members of the fauna.

Observations of species preying on earthworms like Woodcock (*Scolopax rusticola*), Common Snipe, Lapwing (*Vanellus vanellus*), Thrushes and Red Fox (*Vulpes vulpes*) in the Vieux Pin study area, with lumbricid biomasses ranking among the highest found in France, confirm the results of earlier studies. Foxes (MacDonald 1977), Badgers (*Meles meles*) (Kruuk and Parish 1982) and Woodcock (Granval 1988a, b) have been found to prefer short-grass habitats rich in lumbricids for feeding. By intensive grazing until November the vegetation has been kept at this stage in our study area.

In addition, non-tillage techniques experienced in this study not only improve pasture in areas where traditional techniques fail, i.e. because of too thin soil or because they are too expensive. The new techniques should be generally considered in a new economic context of agricultural policies in the European Union, aiming at lower productivity by quotes on milk or meat and therefore not allowing costly investments in manpower or equipment. The economic and social consequences of a change in agricultural techniques in favour of wildlife may even range further, namely in additional income from harvesting these renewable wildlife resources or leasing the areas to corresponding outdoor activities, such as hunting, fishing or bird watching.

References

Bouche, M.B. 1972. Les lombriciens de France. Ecologie et systématique. Ann. Zoo. Ecol. Anim., INRA, n° spécial, 72–2, 671 pp.

Edwards, C.A. and Lofty, J.R. 1982. The effect of direct drilling and minimal cultivation on earthworm populations. J. Appl. Ecol., 19: 723–734.

Gossmann, F., Ferrand, Y., Loidon, Y. and Sardet, G. 1988. Méthodes et résultats de baguages des bécasses des bois (*Scolopax rusticola*) en Bretagne. In: Havet, P. and Hinrons, G. (eds.) C.R. 3ème Symp. Européen sur la Bécasse et la Bécassine, ONC, 35–41.

Granval, Ph. 1988a. Influence de la l'accessibilité des lombriciens sur le baguages des bécasses des bois (*Scolopax rusticola*) en Bretagne. In: Havet, P. and Hinrons, G. (eds.) C. R. 3ème Symp. Européen sur la Bécasse et la Bécassine, ONC, 60–66.

Granval, Ph. 1988b. Approche écologique de la gestion de l'espace rural: des besoins de la Bécasse des bois (*Scopolax rusticola* L.) à la qualité des milieux. Thèse doct. 3ème cycle, spéc. Ecologie, Univ. Rennes I, 186 pp.

Kruuk, M. and Parish, T. 1982. Factors affecting population density, group size and territory size of the European badger, *Meles meles* L. J. Zool. Land., 196: 31–39.

Laissus, R. 1985. Resemis des prairies permanentes sans labour préalable, après emploi de désherbants à l'automne, favorisant l'action des lombrics pendant l'hiver, sur la structure du sol. C. R. Acad. Agtic. de France, 71, 3: 229–240.

Lee, K.E. 1985. Earthworms, their ecology and relationships with soils and land use. Academic Press London, 411 pp.

Lopez-Assad, M. 1987. Contribution à l'étude de la macroporosité lombricienne de différents types de sols de France. Thèse doct. 3ème cycle, spéc. Science du sol, USTL/ENSAM, Montpellier, 21/05/87, 40 pp.

MacDonald, D.W. 1977. The behavioural ecology of the red fox, *Vulpes vulpes*: a study of social organization and ressource exploitation. Phil D. Thesis, Oxford University.