THE DEVELOPMENT OF AN ORGANIC FARMING SYSTEM (OFS) BASED ON BEST PRACTICES WITH AN ORGANIC FARMER PILOT GROUP

END OF PROJECT REPORT

ARMIS 3898

Authors

F.S. MacNaeidhe, W. Murphy, M. Lynch, F. Codd

Johnstown Castle Research Centre
Wexford

Teagasc acknowledges with gratitude the support of the European Union in financing this research project.

September 1998

ISBN 1 901138 90 9

Teagasc
The Science of Farming and Food

EUROPEAN UNION
European Agricultural
Guidance and Guarantee Fund

Teagasc, 19 Sandymount Avenue, Ballsbridge, Dublin 4

CONTENTS

SUMMARY 1

SELECTION OF THE PILOT FARMS 3

PARAMETERS 3

DEVELOPMENT OF THE THREE HUSBANDRY PRACTICES 4

Development of a multifunctional grassland management system (MGM) 4

Development of an ecological nutrient management system (ENM) 6

Development of an ecological infrastructural management (EIM) system 9

RESULTS AND DISCUSSION 10

Multifunctional Grassland Management (MGM) 11

Ecological Nutrient Management (ENM) 13

Ecological Infrastructural Management (EIM) 16

CONCLUSIONS 19

REFERENCES 20

SUMMARY

The farming system was developed with the assistance and co-operation of ten pilot farmers during the period March 1993 to March 1997. The purpose of the project was to develop a method which would enable farmers to practice a system of farming which was sustainable and friendly towards the environment. This was achieved by way of three major objectives. These were:

(A) The production of high quality and healthy pasture and livestock.
(B) Development of a fertile soil and a clean environment.
(C) Production of a diverse flora and attractive landscape.

These objectives were achieved by the application of three basic husbandry practices which were combined in a complementary way into a single farming system.

These were:

(a) Multifunctional Grassland Management (MGM) to achieve objective A
(b) Ecological Nutrient Management (ENM) to achieve objective B
(c) Ecological Infrastructural Management (EIM) to achieve objective C.

Four criteria were used to evaluate the applicability of the husbandry practices and their success.
These were:

(1) Is it ready for use.
(2) Is it acceptable to the farmer.
(3) Is it manageable for the farmer.
(4) Is it effective.

The investigation showed that

- The use of pilot farmers is an effective method of developing practical organic farming systems and disseminating information on these systems among farmers.
- Application of multifunctional grassland management (MGM) gave better health in sheep and cattle through better pasture hygiene.
- Of the three basic husbandry practices which were used the advantages of ecological nutrient management (ENM) was the most easily understood and most readily applied by the farmers.
- Grassland fertility was maintained by grazing and cutting in alternate years and by recycling measured amounts of farmyard manure on to silage land.
- There is little or no risk of environmental pollution with the application of the farming system which was developed during the investigation.
- The advantages of ecological infrastructural management (EIM) was least readily understood and applied by the pilot farmers.
- The application of EIM was slower to yield positive results compared with MGM and ENM.
- The presence of good hedgerow networks on most of the farms reduced the need for a strong programme of EIM.

SELECTION OF THE PILOT FARMS

Ten organic pilot farmers were selected with the help of the main organic farming organisation (IOFGA) during 1993. The pilot farmers were selected on the basis of their ability to keep farm records, on their innovative nature and on the previous experience of the project operators with the individual farmers. Each farm was surveyed to check on the type of rotational and grassland management system which was operated, the type of nutrient management system which was practised and on the environmental infrastructural management system which was in place on each farm. The ten pilot farmers who were selected were highly regarded opinion leaders within their respective groups. These were the farmers which were rated by their peers to be successful and knowledgeable and who could influence other farmers to follow their example. The experimental organic farm operated by Teagasc was also included in the group. Much of the basic design for the prototype was done at this farm. The farms which were selected were mainly grassland farmers with suckler cows, dry stock and sheep. There were two dairy farmers in the pilot group. Farm size was typical of the size found in Ireland and varied from 20 to 98 ha in area.

PARAMETERS

A set of parameters was selected to measure the progress made in introducing the OFS to the pilot farms. A parameter is a running indicator used to evaluate the level of achievement of the various objectives. Each parameter is evaluated with an experimental norm. It was necessary to apply parameters to measure the degree of success of the application of the husbandry practices on the farms. These were:

1) Area in line with the Multifunctional Grassland Management (MGM) model: Frequency of cutting, 1 year in 3, frequency of grazing of animal groups, 1 year in 3, frequency of use of grassland in rotation 5 years in 7.
2) Quality production index (QPI): i.e. achieved price/top quality price on market yield/achieved yield.
3) P, K and N annual balances i.e. achieved input/estimated output in each case (PAB, KAB, NAB).

4) P, K and N available soil reserves as established by soil analysis (PAR, KAR, NAR).
5) Nitrogen available soil reserve (NAR) as established by NO3 analysis of soil.
6) Nitrate-N in drainage water as established by water analysis in drains (NDW).
7) Ecological Infrastructural index (EII) - percent of production area managed as nature habitat or corridor.
8) Side element numbers (SED), i.e. field margins, hedgerows, ponds, woodland, woodstack, nest boxes, stream sides, wet meadows.
9) Plant species diversity (PSD) - number per farm of target plant species in ditchbanks and hedgerows.
10) Hedgerow management targets - improvements in management and care of hedgerows.

DEVELOPMENT OF THE THREE HUSBANDRY PRACTICES

The three husbandry practices which were used to achieve the objectives of the project were designed in consultation with the farmers during the first year of the project. It was necessary to design the husbandry practices in this way so that the acceptability and manageability of each of the practices could be discussed and tested by both farmer and researcher.

Development of a Multifunctional Grassland Management System (MGM)

The objective of the multifunctional grassland management system was 1) to provide sufficient good quality food on the farm to support the livestock (2) to achieve a high degree of animal health and welfare through the control of pests and diseases among the animals. This objective was achieved in a series of steps as follows:

Steps in the Multifunctional Grassland Management

Step 1.	The farms were classified as low rainfall (<1000mm/annum) and high rainfall (>10000mm/annum) farms. The low rainfall farms were located in the south-east of Ireland. The high rainfall farms were located in the north midlands.
Step 2.	Herd size adjustment was made on each farm within a stock density range of 1.1 to 1.5 LSU/ha depending on forage yields.
Step 3.	The areas which could not be mown (due to slope, rock outcrops) and which could not be grazed (due to poor drainage, soil physical conditions) were calculated.
Step 4.	The grassland areas were divided into three categories; i.e. mixed grasslands (Category A), grazed grassland (Category B) and mown grasslands (Category C). Category A was mown and grazed in alternate years, Category B was grazed but not mown, Category C mown but not grazed.
Step 5.	The grassland was subdivided into paddocks which gave 7-11 days of grazing with a rest period of 22-35 days. Cows and calves were grazed ahead of yearlings. Weaned calves were not let out on pasture grazed by weanlings or yearlings in the same season. A grazing calendar was used to achieve this plan successfully.
Step 6.	The grass height was 12 to 15cm when stock was let out on the paddock. The grass height was 5-7.5cm when stock was withdrawn. Dung was recycled on mown paddocks only.

Development of an Ecological Nutrient Management System (ENM)

The objective of the ecological nutrient management approach was to achieve a stable and sustainable nutrient balance on the farm and between fields on the farm. This was done by application of measured amounts of farmyard manure (FYM) or by applications of permissible fertilisers on silage land. A second objective was to achieve a level of nutrients particularly of nitrates and phosphates which was agronomically and environmentally desirable so that the risk of environmental pollution was minimal (Table 1).

Table 1: Agronomically and environmentally desirable levels of P and K on pilot farms

Available Soil Reserves of P and K (mg/kg)[1]					
Agronomically Unwanted		< Optimum Range >		Ecologically Unwanted	
P	K	P	K	P	K
>9	>150	4-9	70-150	<4	<70

[1]Assessment carried out using Morgans extract (Byrne 1979).

Ecological nutrient management was achieved as follows:

Steps in Ecological Nutrient Management

Step 1.	The PAR and KAR was calculated for each pilot farm.
Step 2.	When the soil fertility was within the environmentally acceptable/agronomically desirable range as indicated by the PAR and KAR the annual inputs were designed to achieve a PAB and KAB of 1 (Inputs = Outputs).
Step 3.	When the soil fertility was too low the inputs were increased to achieve a PAB and KAB of >1. This was achieved by increasing FYM inputs, using more unweathered FYM to achieve an increased KAB or using basic slag to achieve an increased PAB.
Step 4.	When the soil fertility was too high the target KAB was lowered to <1. This was achieved by reducing inputs of FYM to achieve a reduced KAB. The PAR was not above the desired level on any of the farms and a reduction in the PAB was unnecessary.
Step 5.	NAR was used to assess the risk of leaching on the pilot farms and to assess the annual needs of the grassland. NAR was increased by introducing clover in the sward up to a level of 40 per cent dry matter. As the NAR did not exceed the environmentally acceptable range on any farm it was unnecessary to reduce the N inputs on any of the pilot farms.

Table 2: Management of Ecological Infrastructure for the Pilot Group		
Type of Ecological Infrastructure	Minimum and Additional Management	Area of Farm (ha) (Mean)
Field Margins	Width: 1.5m minimum. 8m maximum (Headland). No pesticide or fertiliser. One cut between mid-July and late September. No access for animals.	0.0744
Ditches, Riverbanks (not main Rivers)	Width: 2m minimum, 8m maximum. No access for animals.	0.1928
Hedges	Width: 3m minimum, 11m maximum. Minimum: 1.5m unutilized strips on each side, cut after mid-July. All established hedges with a minimum of 4 indigenous hedgerow species/100m including 3 berried species Trimming regimes: – trimming every two years to minimum of 2m after July 1st – untrimmed hedges cut back every eight years for exploitation of wood Additional species: – these are added within the hedgerow as trees or added within existing open gaps as hedging plants.	0.0600
Slopes and Farm Road Borders	Width: Minimum of 1.5m. No pesticides or fertilizers. One cut after 30 August. No access for animals until 30 August.	0.0163
Forest Skirts	Width: 7m minimum from base of trees to opposite side of skirt. Minimum indigenous tree species/100m=6 including one berried species and two species with nuts. Management: Thinning of trees after 7-9 years. Exploitation after 30 years + depending on species.	
Total	Minimum 5% of farm area.	

Development of an Ecological Infrastructural Management (EIM) System

The objective of the Ecological Infrastructural Management system was (1) to convert a minimum of five per cent of the land area of each farm to environmental infrastructure, i.e. hedgerows, shelterbelts, fields margins or items of environmental value, (2) to improve the management of infrastructural elements so as to encourage or increase the biodiversity. This was achieved as follows:

Steps in Ecological Infrastructural Management

Step 1.	An assessment of the ecological infrastructure on each pilot farm was carried out. A botanical survey was carried out to measure PSD and a list of target species for hedgerows and field margins was drafted. The side elements on each farm were listed.
Step 2.	The percentage hedgerows exceeded the target in many cases and ecological improvement was made by filling hedgerow gaps and increasing the plant species diversity.
Step 3.	Ecological infrastructure was enlarged mainly by introducing field margins on all the pilot farms.
Step 4.	Ecological infrastructure was also increased by increasing woodlots and the number of side elements.
Step 5.	Improvements in ecological infrastructure were assessed by area measurements, botanical surveys and side element counts.

RESULTS AND DISCUSSION

The pilot farmers who were selected to participate in the pilot farm project were regarded among the organic farmers of the country as the most efficient and most knowledgeable. For this reason they were the most likely to be approached by colleagues for advice and guidance in future. In this way any improvements which were brought about by participation in the project are more likely to be disseminated among colleagues involved in organic farming to the benefit of more rapid development of organic farming in Ireland as a whole.

The pilot farmers who were selected were most co-operative with regard to any changes which were necessary within their system of farming. Being opinion leaders among their peers they had a high level of interest in the project and showed great enthusiasm for additional knowledge and improved farming know how. The exchange of contacts was a two way process. Contact from the farmer to the researcher occurred almost as frequently as contact from researcher to the farmer.

Table 3: Results of the application of OFS on pilot farms.

Parameters	Mean of all farms (kg ha^{-1})			
	1993	1994	1995	1996
Area in line with MGM	0.83	0.88	0.90	0.93
Quality Production Index				
Beef	0.83	0.82	0.85	0.90
Sheep	0.90	0.93	0.91	0.95
Cereals	0.78	0.78	0.84	0.92
Beans	0.47	0.80	0.87	0.93
Nitrogen annual balance (NAB)	0.81	0.74	0.84	1.0
Phosphorus annual balance (PAB)	0.80	0.80	0.81	1.16
Potassium annual balance (KAB)	1.31	1.21	1.32	1.51
Nitrogen annual reserve (NAR)	18.2	15.8	20.4	17.6
Phosphorus annual reserve (PAR)	3.33	3.52	4.11	4.33
Potassium annual reserve (KAR)	92	106	102	135
Nitrate in drainage water (NDW)	0.84	0.80	1.10	0.80
Ecological Infrastructure Index (EII)	4.4	5.4	5.6	5.6
Side element numbers (SED)	2.1	2.6	4.6	5.6
Plant species diversity (PSD)	40	41	41	44
Plant species numbers per m^2 (PSDN)	3.0	3.1	4.1	5.3
Hedgerow targets	35.6	36.3	38.4	39.8
Hedgerow area (% of farm area)	4.4	5.4	5.6	5.6

The setting up of the pilot group had many advantages for the research group. Firstly, because the pilot group was representative of a wider farming spectrum it was possible to design and set up a prototype to suit a more representative sector of organic farmers and to achieve wider uptake for the model.

Secondly, due to the close contact and high level of consultation difficulties and problems of application were more easily recognised and solved.

The results of the application of OFS over the four year period are shown in Table 3.

Multifunctional Grassland Management (MGM)

During the first interviews which were held with the farmers the importance of crop rotation was emphasised. But following a survey of the farms it became clear that grassland and animal production was the major enterprise on Irish organic farms and that improvement in the method of grassland management was essential for the success of the model. The emphasis was moved from multifunctional crop rotation (MCR) to multifunctional grassland management (MGM) but the desirable elements of MCR were retained within the model. MGM is a new concept which was previously unknown to farmers and initially adaptation of this method was slow. It is based on a rotational system of grassland grazing and conservation. One or more animal species are divided into groups with varying degrees of resistance to animal parasite infection and these are rotated on the pasture. A grazing calendar is kept to enable the farmer to turn out various animal groups to pasture at the stage when it is most unlikely that these groups will be infected by animal parasites. Initially the principles upon which this system is based is more difficult to understand and to operate than MCR which is based on a simple annual rotation. The two parameters (1) area is line with the MGM model and (2) the Quality Production Index were used to test the success of the application of MGM. Over the four year period of the project there was an overall increase in the area in line with the model of 6 per cent. The greatest progress in the last year was made by the two dairy farms within the group of eleven because only one animal species was present on these farms and it was necessary to divide the herd into two groups to reduce susceptibility to stomach parasites. This was most effectively achieved in the final year of the project. It was necessary for some of the farms with a high proportion of arable crops to reduce the area of these and such farms also achieved higher efficiency and a better average "in line" value as a result.

The quality production index for sheep and beef remained steady over the four year period of the project with a small improvement in the beef produced over the last two years of the project. This was due to the fact that good quality meat was produced at the farms during the early stages of the project and the high standard made large improvements difficult. The improvements in the quality production indices for beans and cereals were due to better management practices which were introduced during the course of the project. The introduction of a longer rotation and changing from spring to winter cereals improved the quality and yield of the cereals.

MGM is more easy to operate and is more effective when more than one animal species is present on the farm and a higher level of animal health and welfare is achieved when cattle are used in rotation with sheep on pasture. With suckler cows three groups are used, (I) the highly susceptible sheep with lambs, (2) the less susceptible cows with calves and (3) the partially resistant yearlings from the suckler herd. The operation of this system results in earlier finishing, better quality lambs and better weight gains in calves. This is reflected in the achievement of a slightly better QPI in both sheep and cattle at market. The largest benefit is in the achievement of better health in the sheep flock and the cattle herd through better pasture hygiene. After mid-July susceptible animals such as young calves and lambs are grazed on silage or hay aftermath and must not be grazed on pasture used by the same animal species within the previous calendar year. On the other hand suckler cows, yearling cattle and non-pregnant ewes are more resistant to parasite infection and can be grazed on parasite infected pasture with relatively little ill-effects. This system of grassland rotation also contributes to the nutrient balance on the farm. Under this system crops are grown in two years out of five at a maximum and are used to provide winter fodder and straw bedding for livestock. Beans are used to provide a high protein diet for young cattle. Clover is introduced by sod seeding and at reseeding after crops to increase the protein in the diet and to provide sufficient grazing and winter feed for livestock.

Ecological Nutrient Management (ENM)

Of the three farming methods which were proposed, the pilot farmer group were the most interested in the ecological nutrient management method (ENM) and found it more easy to adapt and operate this system. This was because previously none were intensive farmers and all had received some formal training in conventional agriculture and the importance of crop and grassland nutrition was highlighted during the course of this training. All had availed of the soil and plant analytical services which were available within the state and most had received reports stating that the nutritional status of at least some of the farm fields was below optimum for conventional grassland and crop production in the past. Despite the high levels of interest and the rapid adoption of this method some improvements especially in the method of recycling of organic waste were still being made at the conclusion of the project.

Progress parameters: The parameters used to assess progress with ENM were P, K and N annual reserves (PAR, KAR, NAR), P, K and N annual balances (PAB, KAB, NAB) and nitrate-N in drainage water. The PAR, KAR and NAR were used to evaluate the environmentally and agronomical desirable levels of these nutrients in the soil. In the first two years PAR was generally low and increased on average to within the acceptable range in the final two years of the project but although all farms increased over the period of the project four of the eleven farms were below acceptable range. None of the farms were close to the upper limit of the acceptable range. All of the farms were within the acceptable KAR range during the course of the project. During the first three years there was a fall-off in the level of soil K reserves but the level increased during the last year of the project due to improved methods of recycling of nutrients. One farm increased the soil K reserves to above the acceptable range in the last year of the project and a reduction in the rate of recycling of K per hectare will be necessary in future on this farm. This farm was located on a K releasing soil and a very strict regime of nutrient conservation in manure was observed so that K loss from the manure was reduced to a minimum. Seven of the other farms were in the upper part of the acceptable K range. The NAR was generally low in the soil, not exceeding 30 mg/kg on any farm in October. The reserves were highest on farms with good clover swards. NAR was below 10 mg/kg on three of the farms and an increase is necessary in these cases to maintain productivity. On most of the farms a good balance between nutrient inputs and needs were maintained especially with P. The largest deficit of N was below 20 kg/ha and the largest excess was slightly over 20 kg/ha. On three of the farms the excess of K over needs was high. On two of these farms soil reserves of K were also high. The input/output ratio of P was high on only three of the eleven farms. The input/output ratios of K was high on only two of the farms.

Critical nutrient values: During the period when the ENM method was being designed the acceptable levels of N, P and K reserves in the soil were set out. The critical upper and lower limits were based on the most recent research results and particular attention was paid to the environmentally unwanted and agronomically desirable levels. The acceptable range for P in Irish soils was set at from 4.0 mg/kg to 9.0 mg/kg extractable P (Morgan's solution). The lower limit was based on a limited survey which showed that grassland yields did not increase on organic farms at soil concentrations above this level. The upper limit was based on data which indicated that the P loss from medium loam soils at this value was low and not damaging to the environment. It was necessary to apply permissible P fertiliser, mainly basic slag to increase the soil P concentrations. On P absorbing soils such as the "brown earth" types the increase in the P concentrations was only temporary and the P concentrations remained low during the course of the project. The P level is likely to remain low on these soils until sufficient P has been applied to reach saturation. Continual application of P to soil saturation is not acceptable to the organic certification body and in any case is an undesirable and wasteful practice. At the low soil P concentrations recorded at the pilot farm environmental pollution due to excess P is unlikely to occur.

The acceptable range for K in Irish soils was set at from 70 mg/kg to 150 mg/kg of extractable K (Morgan's solution). The lower limit was based on data which showed that grassland yields did not increase significantly at soil concentrations above this level. The upper limit was based on data which showed that K loss from a medium loam was low and did not cause environmental damage.

The nitrate levels in drainage water at entry and exit points at the beginning of drain flow in October did not exceed 3 mg/kg in any case and the mean value for nitrate in drainage water overall was less than 1.0 mg/kg. These values indicate a low risk from nitrate pollution from the ENM which was put in place during the four years of the project.

Nutrient balances: The nutrient balance (PAB, KAB, NAB) is an indication of the sustainability of the ENM which is in operation on the farms. The P, K and N inputs and needs are calculated for each farm. The inputs and needs values are calculated from data recorded on each farm in each year. The surplus or deficit is calculated by subtracting the inputs from the needs. The needs of P were generally low being less than 10 kg/ha on all except two farms. The needs of K (54 and 64 kg/ha) and N (58 and 65 kg/ha) were high on two of the farms which had dairy herds due to the high offtakes on these farms as a result of milk production. P and K needs were also high on two other farms which were slightly more intensive than the others. Inputs of K were also high on these soils. All of these farms were established on K releasing "brown earth" soils which contributed from 40 to 80 kg/ha of K each year to the nutrient level. Inputs of N were high (87 kg/ha) on one farm which had a good density of clover in the sward. It is clear from the above that special models of EMN were required for each individual farm due to the variable nature of the inputs and needs but in general the ENM model was sustainable in practice on all but one farm which had consistent deficits of K and N over the period of the project. This farm had a low K status and was established on a K absorbing soil. High annual rainfall in combination with poor drainage did not allow good clover establishment. Better storage facilities for compost resulted in better K conservation in the compost but the improvement in the K supply was not reflected fully in the K balance in the final year of the project. On the other farms the K was generally in balance. The

K supply especially on the K releasing soils was very often in excess of the offtakes. This was particularly true on two of the farms which had excellent storage facilities for compost. The N balance varied from year to year on most farms but N supply is less important from the point of view of long-term sustainability as measures such as clover establishment or manure application can quickly correct any shortfall in supply of this nutrient. The degree of balance which has been achieved for P, K and N on the pilot farms during the course of this project clearly show that a sustainable model for ENM can be designed for these types of farms and that the risk of environmental pollution as a result of the application of this model is minimal.

Ecological Infrastructural Management (EIM)

Of the three farming methods which were developed to design an advanced ecological farming system this was the most difficult method to put into operation. The concept of EIM was acceptable to the pilot farmers. All are interested in the conservation and preservation of flora and fauna and increased biodiversity. But the benefits of increased biodiversity are received indirectly, improvements in the ecological infrastructure take several seasons to show results and the effects are not immediately apparent to the farmer. For this reason improvements in the EIM were not carried out as enthusiastically as with MGM and ENM. Nevertheless following discussions with the group during which the benefits of stock proofing and the provision of shelter was also discussed good progress in this farming method was achieved by the end of the project. Hedgerows were present on all of the pilot farms. The average number of woody species was greater than ten. *Crategus, Fraxinus, Rubus, Hedera* and *Ulex* were the dominant species but *Lonicera periclynum, Euonymus europaeus, Fagus, Alnus, Viburnum opulus, Ligustrum ovalifolium, Prunus avium* and *Prunus spinosa* were also common. The hedgerows occupied slightly over four percent of the land area of the farms at the beginning of the project. However, in nearly all cases the hedgerows were poorly maintained. Lack of maintenance resulted in poor coppicing and the development of gaps. Improvements in maintenance over the four year period of the project resulted in better coppicing, improved cover for flora and fauna and better stock proofing of the hedgerows. The hedgerows also provided better shelter for the livestock which took shelter on the leeward side of the well furnished areas during wet and windy weather. Many of the farmers increased the number of species in the hedgerows by planting *Acer, Quercus, Betula, Sorbus, Populus* and other species in the hedgerows. Gaps were filled by planting *Crategus, Alnus, Fraxinus* and other species also. As a result of the improved maintenance a better basal spread due to coppicing was achieved and this resulted in an expansion of the areas cover by hedgerows by 26 per cent during the course of the project. On some of the farms large improvements were difficult to achieve due to the exposed nature of the landscape.

The target for EIM as a percentage of the farm area was five per cent. Three of the farms had achieved or exceeded this target at the beginning of the project. A further four had exceeded the target at the end of the project and only two were more than one per cent below target.

The targets for the improvement of hedgerows were based on the presence or absence of an earthbank, presence of gaps, level of maintenance, numbers of species and the presence of food source for birds and mammals. A target rating of 50 points was set during the first year of the project. Improvements in the numbers of hedgerow species was achieved due to the planting by the farmers of additional species during the project. Planting to fill in gaps was also carried out and hedgerow maintenance was also improved on each farm but these measures were slow to take effect and the achieved targets were not met in any case within the life of the project. However, the results indicate that the target will be met in nearly all cases over time. The development of side elements among the organic farmers was encouraged. These included the development of field strips and buffer strips, hedgerows, ponds,, haystacks, farm woodland, woodstacks and nest boxes. The largest improvements in EIM were made in the development of side elements with increases in the numbers of buffer strips, field margins, woodland, ponds, hedges and wet meadows. An average of 5 to 6 side elements per farm were installed during the course of the project. An average of one additional side element was achieved on each farm in the final year of the project.

Hedgerows are an important source of cover for birds and small animals and provide corridors for the movement of wild-life throughout the agricultural landscape. However, to achieve this objective successfully biodiversity within the hedgerow is important. The combination of earthbank and ditch provides an environment for wetland and dryland fauna. A season long supply of fruits and seeds as a source of food for animals and birds is also important An unbroken hedgerow provides a corridor for the dispersal of some insect species throughout the countryside. A set of targets based on these principles was set for the hedgerows on the pilot farms at the beginning of the project. An overall target of 40 per cent of full achievement was set for the hedgerows as that which would encourage the proliferation of fauna. This target was achieved at the conclusion of the project.

An increase in the flora as a means of achieving a higher population of flowering plants and greater numbers of insect species, small mammals and birds on the farm was achieved by the development and maintenance of field margins throughout the fields on the pilot farms. Due to the presence of hedgerows a large number of flower species were present already on the farm. Counts carried out at the beginning of the project showed a total number of 40 different flowering herbaceous species. This number had increased to 44 species by the end of the project. The increase which was achieved in the flower density as a result of the development of field margins was more spectacular. At the beginning of the project quadrat counts showed a flower density of 3 per square meter. At the end of the project this value had increased to 5 flowering plants per square meter, an increase of over 60 per cent.

CONCLUSION

This project had a highly successful outcome and an advanced ecological farming system which is suitable for Irish conditions was developed. This has been reflected in better animal health and improved quality of production on the eleven pilot farms which were involved in the project. A grassland management system which has enabled organic farmers to provide organic products free of chemical inputs has been developed as a result of the research which was carried out during the project. Two standard booklets which are available to all organic farmers have now been published as a result of the development of MGM (Lynch and Mulcahy, 1996, MacNaeidhe et al. 1997). With ENM a system of nutrition which enables farmers to provide nutrients in a sustainable but non-polluting way has been developed. Some adjustment of the nutrient balance using permissible fertilisers is necessary initially in a small minority of cases (MacNaeidhe, 1996; MacNaeidhe, 1997).

Although the principles of EIM were less readily adopted by the farmers these have been put in operation in the last few years of the project and are working well. Observation clearly shows a larger number of birds and small mammals on the farms.

The project proved highly popular with the pilot farmers, the organic farmers throughout the country, with the Irish Department of Agriculture, Fisheries and Food and with the Organic Certification Bodies in the country. The improvements which have taken place will continue to be demonstrated on the farms for several years to come.

REFERENCES

Byrne, E. (1979). Chemical analysis of agricultural materials. An Foras Taluntais, Dublin 194 pp.

Lynch, M. and Mulcahy, G. (1996). Parasite control in organically-farmed animals. IOFGA, Dublin 28 pp.

MacNaeidhe, F.S. and Fingleton, W. (1997). Economics of Organic Beef and Sheep Production. Proc. RASE. Conference Organic Farming Science into Practice. Stoneleigh, U.K. In Press.

MacNaeidhe, F.S., Lynch, M. Murphy, W., Fingleton, W. and Codd, F. (1997). Production and Economics of an Organic Calf to Beef/Sheep Enterprise. Teagasc, Dublin.

MacNaeidhe, F.S. and Fingleton, W. (1997). Economic Investigations of Organic Calf to Beef and Sheep Production. Newsletter of the European Network for the Coordination of Research in Organic Farming (NENOF). No. 6. Pp 20-22.

MacNaeidhe, F.S. (1997). The Economics of Organic Beef and Sheep. In "Organic Farming, Cattle and Sheep Production". Teagasc, Johnstown Castle, Wexford. pp 4-20.

MacNaeidhe, F.S., Lynch, M., Murphy, W., Fingleton, W. and Codd, F. (1997). Organic calf to beef/sheep production; Research Investigation. Teagasc, Dublin, 21 pp.

MacNaeidhe, F.S., Lynch, M., Murphy, W., Fingleton, W. and Codd, F. (1996). A report on the Organic Farm, Johnstown Castle, Production and Economics. Teagasc, Johnstown Castle, Wexford, 85 pp.

MacNaeidhe, F.S. (1997). Nutrient budgeting for forage production using farmyard manure in an organic livestock system in Ireland. Proc. 3rd ENOF Workshop "Resource Use in Organic Farming", ANCONA, Italy. June 5-6, 1997.

MacNaeidhe, F.S. and Culleton, N. (1997). The evaluation of draft parameters as a means of measuring nature conservation and landscape development on Irish Farms. Proc. 3rd Plenary Meeting of the EU Concerted Action "The Nature and Landscape Production Capacity of Organic/Sustainable types of Agriculture". Wageningen, January 1996.

MacNaeidhe, F.S. (1997). Organic Beef Farming - Production and Economics. Proc. Conference of the Department of Agriculture, Food and Fisheries, Portlaoise. April, 1997.