EVALUATION OF LOW EXTERNAL INPUT, SUSTAINABLE FARMING PRACTICES FOR LIVESTOCK FARMS IN CUMBERLAND COUNTY.

A Project of REAP-Cumberland

Supported by

Canada/Nova Scotia Livestock Feed Initiative Agreement
Technology Transfer Program

Final Report

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Final Report, prepared by
D. Patriquin, S. Hubbard and J. Scott.

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[d] Project funding covered 1.5 field workers for 5 months. N. Boone and O. Maass were employed by the project in 1990, and S. Hubbard and N. Van Thielen in 1991, J. Scott is a graduate student in the School of Resource and Environmental Studies, Dalhousie University, supported by a Killam Scholarship; she conducted some of her thesis research on REAP-Cumberland farms while participating in the project in 1990 and 1991.

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ABSTRACT

Existing livestock systems in Cumberland Co. rely mainly on grass, clover and spring cereals for home grown forage and grain. There are well known limitations to these systems on the fragipan or basil till soils which predominate in the county and which often suffer from early season wetness and mid-summer drought. Together with the high costs of fertilizers or of purchased feed in comparison to farm gate prices, these limitations contribute to the poor economic status of many of the farms in the county.

In April, 1990, REAP-Cumberland was awarded a 2 year grant from the Canada/Nova Scotia Livestock Feed Initiative Agreement to evaluate a number of low input/sustainable practices for their applicability to livestock farms in Cumberland County. The practices were ones that had been researched initially elsewhere, but either have not been widely adopted by farmers or had not been tested locally. They were identified by REAP-Cumberland farmers in consultation with researchers as ones that could help overcome specific limitations to feed production, reduce input costs and protect the environment.

Five sets of experiments or trials were set up in 1990 on one or more of four livestock farms (sheep and beef/sheep/dairy/hogs and beef). The first four experiments were examined in relation to a model rotation, which was developed through discussion between the researchers and farmers:

Year **1: GRAIN LEGUME/HAY**
Year **2: HAY,**
Year **3: HAY**
Year **4: HAY/WINTER CEREAL,**
Year **5: WINTER CEREAL/CATCH CROP.**

In Year 1, the grain legume is harvested for silage and functions as a nurse crop for hay. Some benefits of this rotation (compared to spring cereals and longer term hay) are (i) a large legume component which reduces need for fertilizer; (ii) almost continuous cover; (iii) a short sequence under hay which should maintain high quality; also ploughing in of legumes in Year 4 should reduce need for N fertilizer for the winter cereal; (iv) less need for spring tillage.

The five sets of experiments, and some of the highlights of the results were:
(1) Use of grain legumes for silage and as nurse crops: Fababeans and lupins, and mixtures of the two were compared with barley and a barley-pea mix for silage production, and suitability as nurse crops, in a replicated plot experiment set up at two sites. Lupins and fababeans yielded well, made acceptable silage, and allowed good establishment of undersown triple mix.

(2) Improvement of hay quality by fertilization and by use of improved mixes. Effects of NPK, composted manure and fresh manure on first and second production year hay were examined in replicated plot experiments at two sites. Grass components of hay, but not legume components, responded to the amendments. Data on nutrient contents of manures and composts suggest that large losses of K are occurring in the composting process as presently managed (i.e. not covered).

Four hay mixes including 2,3 or 6 components were compared over the establishment and first production year, with traditional, common Triple Mix, in replicated plot experiments at 2 sites, and in large, unreplicated strips at one site. Grass predominated in the mixes on the site where there was a history of heavy N loading from manures, and at this site there appeared to be no particular advantage to improving the legume component. At the other sites, the 3 and 6 component mixes were most consistently high yielding. An alfalfa/timothy mix did well at one site, but not at a second; the same was true for a red clover/timothy mix. At one site, large difference in the legume component between replicate blocks appeared to be related to differences in soil calcium. The data indicate that that hay productivity can be improved at sites not receiving high N loadings by use of improved mixes containing alternatives to Alsike clover; that more complex mixes on average will perform most predictably, and that a medium or higher level of Ca is necessary to realize the full potential of the improved mixes.

(3) Winter Cereals. Traditionally, few farmers grow winter cereals in Cumberland Co. Unreplicated strip trials of Trtiicale (OAC Trillium), rye (Kustro), and wheat (Borden) and 2 component mixtures of the same were established on two farms, using only manures as fertilizers. The rye-wheat mixture gave the best yields on both farms.

(4) Catch crops after winter cereals. Four brassicas, ryegrass, oats, and *Phacelia tanecifolia* were grown after winter cereals in unreplicated strips, with and without manure, at two sites. The best cover achieved by late fall was 80%, which was by oil radish; it accumulated 20-30 kg N above that in weeds in control plots. It is suggested that better cover and conservation of N might be achieved by sowing cover crops into cereals in spring.

(5) Ryegrass/legume, and winter cereal/legume mixtures as lower cost alternatives to ryegrass for summer pasture. Ryegrass, winter rye, and winter Triticale were grown with and without Persian clover and vetch in replicated plot experiments at 3 sites. Only vetch contributed significantly to biomass, and only at one site. Cereals did not yield well compared to ryegrass. Nitrate in ryegrass reached levels of 1-3% at the two more heavily fertilized sites, which is in the potentially toxic range.

A variety of informal research was conducted during the course of the project. Trials of different rye varieties and of spelt, fertilized with only manure, were conducted at two farms over two years. Schmidt rye, which had been selected on an organic farm in Ontario, produced high grain yield and an exceptionally high straw yield; the straw component is of particular value on these livestock farms. Spelt (potential cash crop for the organic market) also yielded well, and with the Schmidt rye, was multiplied on larger acreages.

A system for managing residues and controlling weeds in organic vegetable production was tested. It involves incorporation of residues in the fall in raised beds, and growing winter-kill cover crops. It provided excellent control of weeds in the following year with no cultivation.

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INTRODUCTION, SUMMARY OF RESULTS & CONCLUSIONS

The north shore of Nova Scotia - mainly Cumberland and Pictou Counties - has one of the largest underdeveloped and underutilized land bases on the eastern seaboard of North America. The family farm structure in this region, already weak, is in serious jeopardy due to the chronically low prices fetched for products, the relatively high costs of production, and in dairy farming, to the progressive dismantling of supply management systems. Thus the future of family based, livestock farms is seen as being dependent on indigenous crop production, with legume based forage as the main component grown in rotation with cash crops for on-farm feeding or sale. Legume based forage systems have significant ecological benefits because of their relatively low requirements for fertilizers and pesticides, and because they give more continuous cover than do grain based systems.

REAP-Cumberland is a farmers' group formed in 1989 with the goal of researching and promoting practices that can enhance the economic and ecological sustainability of family farms in Cumberland County. Through a series of meetings in 1989 and early 1990, including discussions with researchers at the Agriculture Canada Research Station at Nappan and from REAP-Canada (based at Macdonald College, Montreal), farmers of the REAP-Cumberland group identified some of the major agronomic limitations in their system, and some approaches or practices for relieving them. The practices were ones that had been researched initially elsewhere, but either have not been widely adopted by farmers or have not been tested locally.

<u>Agronomic limitations to existing systems.</u>

Existing livestock systems in Cumberland County rely mainly on grass, clover and spring cereals for home grown forage and grain. Freight assistance programs that have subsidized farmers' purchases of feed from the west, are being phased out. Thus in the future, farmers will be even more dependent on home-grown feed. There are well known limitations to production of forage and grain on the fragipan or basil till soils which predominate in the county. The soils tend to be slow draining in spring, are easily saturated by heavy rains, and effective water storage capacity is restricted; consequently they often suffer from early season wetness and mid-summer drought.

Because of soil and climatic limitations, the range of crops that can be grown for grain is restricted, and hay and pasture provide most of the home grown feed. Major problems with existing management of hay (typically red clover, alsike, timothy) identified by the farmers were:

i) poor persistence of clover resulting in requirement for more fertilizer, and a decline in forage quality (and thereby, greater dependence on expensive, imported protein);

(ii) palatability of timothy drops off after a few years;

(iii) with loss of clovers, timothy by itself does not provide goodgrazing after hay.

A model rotation

In group discussions, farmers and researchers came up with the following "model rotation" for Cumberland County, which in theory, would relieve or reduce the limitations identified above:

Year 1. **ANNUAL LEGUME FOR SILAGE, UNDERSOWN**
Year 2. **HAY**
Year 3. **HAY**
Year 4. **HAY/WINTER CEREAL**
Year 5. **WINTER CEREAL/CATCH CROP**

The rotation is considered to have the following system level benefits in comparison to existing systems consisting mostly of longer term hay and summer cereals:

(1) There is a large legume component (including legumes in the hay), which reduces the need for N fertilizer to the system as a whole. Placing the annual legume at the low end of the rotation should stimulate N_2 fixation. (Legume N_2 fixation is suppressed in N-rich soils)

(2) There is a short sequence under hay which should result in more consistent and better hay quality; it may also reduce fertilizer requirement for the winter cereal because the hay has a large legume component when it is turned into the soil in year 3.

(3) There is almost continuous cover which should reduce erosion, increase soil organic matter and conserve nutrients.

(4) There is increased species diversity, with associated benefits (e.g. reduced disease, and reduced susceptibility to climatic change)

(5) There is a more even seasonal distribution of productivity and use of farm labor and machinery and spring tillage is required only one year in five.

Ideally, the 5 year model rotation would be evaluated over at least a 5 year period and on the same sites. However, this process can be accelerated by evaluating as many as possible of the variables in each stage of the rotation separately and simultaneously.[1] Four sets of experiments, were designed to test/develop each phase of the rotation:

Experiment Set I, to test use of grain legumes for silage and as nurse crops for establishing hay for forage establishment.

Experiment Set II, to test use of manure or compost & of improved hay mixes and species for better maintenance of hay quality.

Experiment Set III, to test new varieties and mixes of winter cereals.

Experiment Set IV to test use of different catch crops after harvest of winter cereals to cover soil and conserve nutrients.

Conceptualizing a model rotation served primarily to help participants think about interactions between successive crops, about properties of the whole system, and to identify specific limitations which could be researched, rather than as an end in itself. Farmers might adopt the whole rotation, modify it, or adopt only certain components.

A fifth set of experiments- on use of winter cereals and legumes in annual pastures - addressed a limitation of pasture production in the region, which is low mid-summer production or high seed and fertilizer costs involved in use of annual ryegrass to improve forage production during the low period. This set of experiments was designed to evaluate spring planted winter cereals with and without annual legumes, or ryegrass with annual legumes, as alternatives to intensively fertilized annual ryegrass.

In April of 1990, REAP-Cumberland was awarded a 2 year grant from the Canada/Nova Scotia Livestock Feed Initiative Agreement [a] to conduct the experiments. Specific details (design of experiments, cultivars tested, seeding rates) were modified as suggested by personnel from the Nova Scotia Agricultural College, Nova Scotia Department of Agriculture and Marketing, and Agriculture Canada.

The research was conducted on four family farms, these being respectively mixed livestock (Ferguson), sheep (Firth), dairy (Hubbard) and hog and beef (Van Thielen) farms.

A participatory approach[b]

Farmers were involved in the identification of problems to be researched, the planning of the research, in the research itself using existing equipment and in evaluation and dissemination of results. It was attempted as much as possible to integrate the experiments into the normal routine of the farms. To do so, members of farm families

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[a]Funding was sought for a 3 year research program. In response to requests to reduce costs, it was deemed more appropriate to restrict the program to two years, than to eliminate large parts of the project or otherwise reduce its intensity; it was anticipated that additional funding would be sought in the second year for aspects for which further research was most appropriate. The two year, grant ($72,149 in total) funded employment of 1.5 research technicians for 5 months (or equivalent person-days) and 1 month of professional researcher input each year, costs of materials and soil and plant analyses, travel, and small annual honoraria to cover part of the costs incurred by participating farmers. Some additional funding was obtained from the Cumberland Development Authority to bring in other researchers or farmers for short consultation visits.

[b]See: G. Youngberg and R.J. Sauer (1991). "Learning from each other: new models for sustainable agriculture and information" (editorial) in American Journal of Alternative Agriculture Vol 5 No. 1. The initiative for developing this research was the farmers'. In 1989, D. Patriquin and R. Samson were invited to a series of meetings with farmers, held at Shinimicas farm,

were employed as research assistants, and other researchers and assistants assisted, as time permitted, with farm chores. In principle, this approach should help to keep costs down, deal to some extent with site to site variability[c], promote two-way communication between researchers and the prospective beneficiaries of their research, and allow quick adoption of successful practices by farmers.

Two field days were held, and tours of experiments were given at other times informally.

Other research in 1990 and 1991

Researchers attempted to respond as much as possible to requests of the farmers to make observations on existing systems or to set up other experiments or trials in response to their queries. Some this "informal research" is integrated into the body of this report (trials of new ryes, spelt). Other informal research is being documented in a Masters thesis by Jennifer Scott (School of Resource & Environmental Studies, Dalhousie University), who participated in this project as a research assistant. This includes research in 1991 on:

i) perennial pastures, including studies of the botanical composition of native and seeded pastures, and of the response of pastures to compost;

(ii) annual pastures, including response of kale, and ryegrass pastures to synthetic fertilizers, compost, and intersown legumes;

Cumberland Co. to discuss ways of increasing self sufficiency in feed and fertilizer for livestock based farms. In the summer of 1989, several experiments were set up on Shinimicas farm by the Hubbard family, with occasional assistance from D. Patriquin and students who were at the time involved in work with a farmers' group in Prince Edward Island. Discussions in the fall led to the formation of "REAP-Cumberland", and the formulation of the research program which is the subject of this report.

[c] Reduced chemical input practices are more sensitive to site specific factors than are chemically intensive practices. The latter tend to saturate or circumvent natural processes, whereas the former are dependent on biological processes- e.g. decomposition to release N from manure - which vary in nature and intensity according to site and management conditions.

(iii) a preliminary survey of crops and weeds for selenium levels (investigated in relation to white muscle disease in lambs).

In 1990, Chengzhi Yang of Dalhousie University conducted an experiment on one of the farms as part of his PhD studies on "Influence of soil. fertility on fababean yields, crop-weed interactions, pests and symbioses". The experiment involved fertilization of febabeans with N, P, K and Ca fertilizers.

In 1990, D. Patriquin was contracted by Acadian Seaplant Ltd., Dartmouth to conduct laboratory and field studies on use of seaweed extracts on vegetables.[d] Establishment of an experimental vegetable production system for this purpose afforded an opportunity to investigate some new approaches to weed control and maintenance of fertility in organic vegetable production (Appendix E).

In the spring of 1991, Dr. R. Preston, a well known ruminant nutritionist who has researched use of alternative feeds for livestock, held a day of discussions with the REAP-Cumberland while in Nova Scotia to attend a symposium on Sustainable Agriculture at NSAC. In the fall of the same year, two of the REAP-Cumberland farmers participated in a trip to Colombia, S.A. to examine some of Dr. Preston's on farm research there. and other "ecofarming" activities in Colombia. [e]

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[d] Patriquin, D.G., Craigie, K., Hubbard, S., Hicks, G., Boone, N., Maass, O., & Scott, J. Determining and improving the beneficial effects of seaweed extract on vegetable crops. Report to Acadian Seaplants Ltd., Submitted January 10, 1991. 32 pp + appendices.

[e] Farming on Top of a Mountain: Ecofarming in Colombia. A resource kit (video, audio tapes, booklet) Distributed by CUSO-Atlantic, Halifax.

Background to the Experiments and Highlights of Results:

I. Use of Grain Legumes for Silage and as Nurse Crops for Forage

The objective of this experiment was to test the suitability of grain legumes (fababeans and lupins) as silage crops, and as nurse crops for forage establishment, a system that has been researched in England.[2] These legumes tend to be slow growing during early vegetative growth when they are forming nodules, but once those are formed, the legumes quickly establish a closed canopy.[3] The early slow-growing phase should allow for good initial establishment of undersown forage. Fababeans provide good lodging resistance compared to cereals (lodging of cereals suppresses the undersown crop), and the silage harvest provides an early removal of the nurse crop. No nitrogen fertilizers or herbicides are required in this method of establishment. Fababeans are reported to have excellent silage quality that provide milk yields equivalent to high quality alfalfa.[4]

One reason to try this scheme in Cumberland Co. was that we observed good vegetative growth of lupins and fabas grown in a farmer trial (C. Hubbard) in 1989, but they did not reach maturity. These legumes also rank highly in nitrogen fixation potential.[5]

In this experiment, we compared silage production potential of 5 crops:

<u>**Experiment I Treatments**</u>

1. fababeans,
2. lupins,
3. fababean/lupin mixture
4. pea-cereal mixture
5. cereals (barley/oats)

All were undersown with an improved triple mix.

We also examined the fall cover by the undersown crop after harvest of the nurse crop, and the cover and production of the undersown crop in its first production year. At one farm, fababeans and lupins, undersown with improved triple mix, were grown and used to make silage.

The 5 treatments were set up in plots replicated 3 times at each of two sites (Hubbard, Van Thielen farms). For silage tests (limited to one trial) C. Hubbard planted 1/2 acre each of fababeans and lupins undersown with hay.

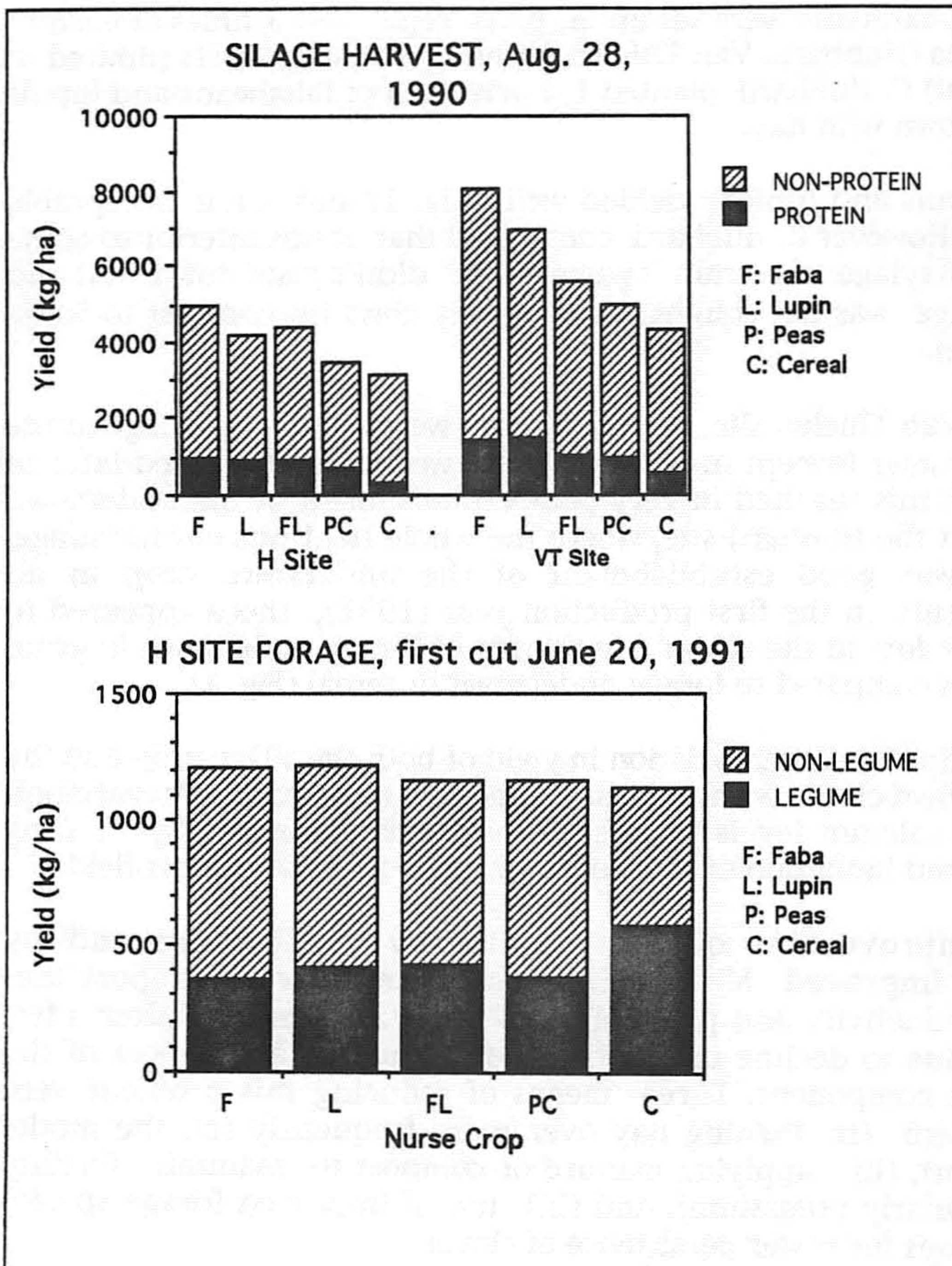
Fababeans and lupins yielded well (Fig. 1) and made acceptable silage. However C. Hubbard considered that it was inferior to Sonja clover haylage: the grain legume silage didn't pack down well and the silage was not sought out by Jersey cows (in contrast to Sonja haylage).

At the Van Thielen site, the grain crops were not cut for silage in the late summer (except in quadrats), nor were they harvested later in the fall; this resulted in very poor establishment of the undersown crop. At the Hubbard site, where the whole field was cut for silage, there was good establishment of the undersown crop in all treatments. In the first production year (1991), there appeared to be some loss in the clover component of forage undersown in grain legumes compared to forage undersown in cereal (Fig. 1).

At the Hubbard site, variation in yield of both the silage crop and the undersown clover within the site appeared to be related to variation in soil calcium levels (range L to M-). Experiments by C. Yang confirmed limitation of fababeans by inadequate Ca on this field.

II. Improvement of Hay Quality by Fertilization and by Use of Improved Mixes. REAP-Cumberland farmers report that the productivity and palatability of triple mix declines after a few years due to decline in timothy and its quality, and to loss of the legume component. Three means of reducing this problem were proposed: (i) turning hay over more frequently (cf. the model rotation), (ii) applying manure or compost to maintain fertility (particularly potassium), and (iii) use of improved forage species and mixes for better persistence of clover.

Field experiments were set up in 1990 and 1991 to examine effects of fertilization of hay with manure, compost and NPK fertilizer, and of different hay mixes on yield, legume persistence and overall quality over several years.



Summary Figure 1. Yield of grain legumes cut for silage and yield of undersown hay the following year

(IIa) Fertilization of hay

In experiment IIA, we examined effects of adding manure, compost and fertilizer to hay on soil properties, and on hay or haylage yield, botanical composition and nutrient composition. Adding manure is a good way to replace potassium losses which appear to be one cause for loss of legumes in hay mixes over time.[7] Manure applications may also aid persistence of clover by reducing disease levels[7]. The treatments in this experiment were:

Experiment IIA Treatments

1. **Control #1**
2. **Manure applied 1st production year**
3. **Compost applied 1st production year**
4. **Synthetic Fertilizer applied 1st production year**

5. **Control #2**
6. **Manure applied 2nd production year**
7. **Compost applied 2nd production year**
8. **Synthetic Fertilizer applied 2nd production year**

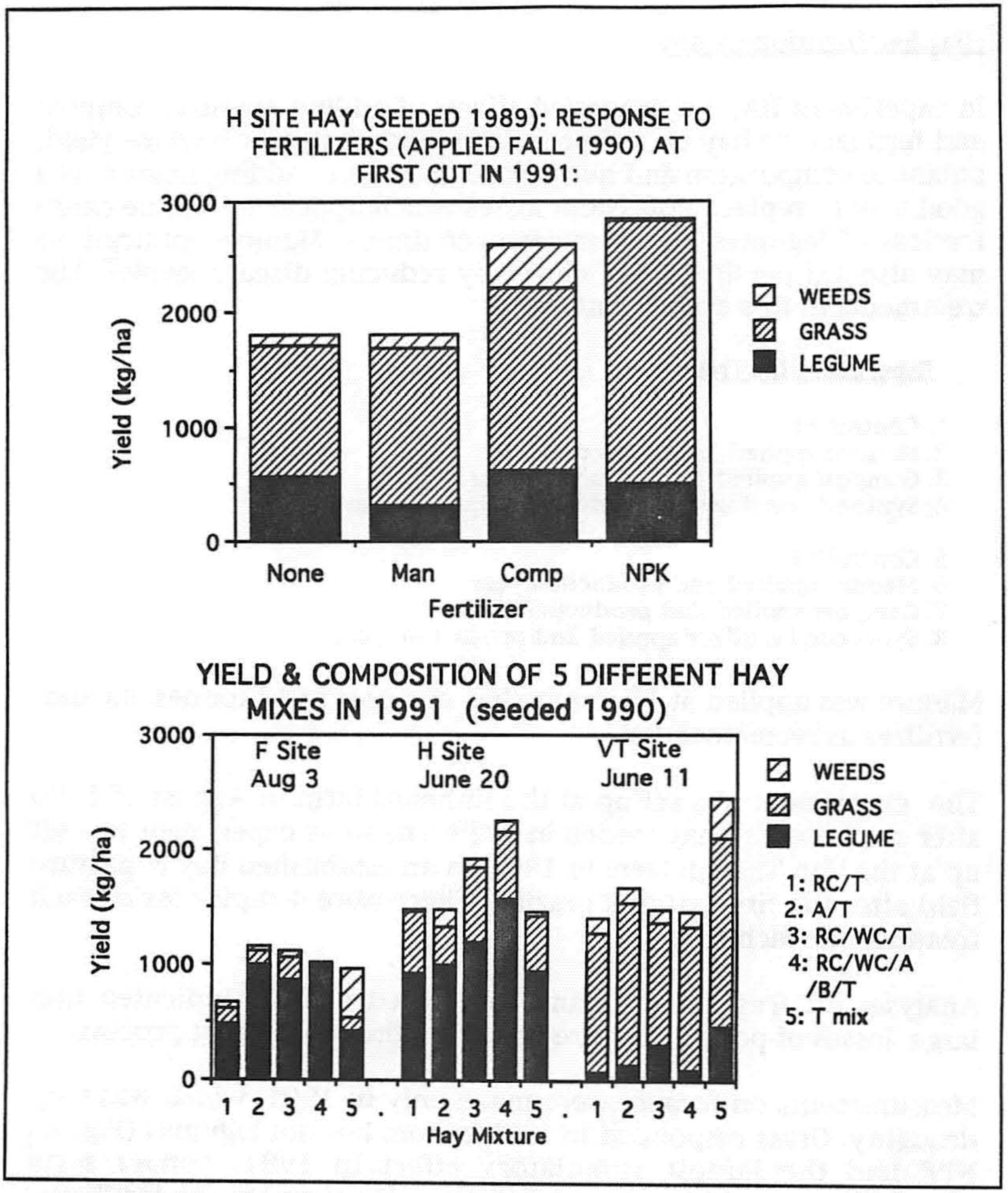
Manure was applied at 15 tonnes/ha, compost at 12 tonnes/ha and fertilizer as recommended.

The experiment was set up at the Hubbard farm in August of 1990 after second cut of hay seeded in 1989. The same experiment was set up at the Van Thielen farm in 1991 on an established hay & pasture field after the first cut and grazing. There were 4 replicates of each treatment at each site.

Analyses of fresh manure and composted manure indicated that large losses of potassium were occurring the composting process.

Measurements on forages were made only in 1991, which was very droughty. Grass responded to fertilization, but not legumes (Fig. 2). NPK had the largest stimulatory effect in 1991. Longer term observations would be required to properly evaluate the fertilizing value and effects on legumes of the different amendments.

In response to a request from Werner Van Thielen, a second fertilization experiment was set up to compare the response of forage to pig slurry and cattle manure. On June 28, 1991, after the first harvest of hay, and grazing, the manures were spread in 3



Summary Figure 2. Some effects of fertilizing hay, and of different seeding mixtures on yield and composition.

strips (none - liquid pig slurry - solid cattle manure) placed across and perpendicular to 5 strips of different hay mixes established in 1990 (Expt. IIB, described below). The cattle manure had no effect on yield, while the pig slurry increased yield by 2.6 fold (July 19) and 1.9 fold (Aug. 23). A large part of the stimulation could have been associated with the water applied with the slurry during the very droughty period. As in the experiment described above, grasses and weeds, but not legumes, responded to fertilization.

(IIb) Testing of different Mixes

Regional agronomists cite or have identified two difficulties with the use of common triple mix (red clover/Alsike/timothy) locally. First, the varieties are not defined and therefore the performance of the individual components is not predictable or repeatable with different seed batches, this is a limitation of using any "common" seed. Second, this particular mixture has been found to do poorly in Nova Scotia. The Alsike tends to be aggressive in the establishment year, crowding out red clover, but it does not survive the winter very well. This results in poor red clover as well as poor Alsike in the second year, and the legume component and quality of the mixture decline quickly. Ladino white clover has been substituted for Alsike in many commercial mixes. Although this problem has been publicized to some extent, common triple mix is still the most commonly used seed and there is a need for more on-farm testing or demonstration of the relative performance of common and improved mixtures. [8]

There are two basic strategies in choosing the number of components for forage mixtures: (i) use a simple mixture (one legume and one grass) with varieties that are known to respond well to the local environmental and management regimes, or (ii) use a complex mixture with more varieties and species to allow for variability in performance of the individual components between years, locations and management. A diversity of species is reported to reduce winterkill in red clover.[9] There are tradeoffs with both strategies. If a simple mixture is chosen, one or more of the components may not do so well because of peculiarities of the site or year, or it may not be so adaptable to multiple types of uses (e.g. hay and grazing as opposed to just one or the other). With more complex mixtures, some of the components are not likely to do well and may reduce productivity compared to a simpler mixture, or there may be significant negative effects of one component on another. More complex mixtures tend to be favored by organic farmers.[10,11] There have been few or no formal comparisons of mixtures with a wide range in numbers of components, however.

The hay mixes that we tested were:

<u>**Experiment IIB Treatments**</u>

1. **RC/T;** (two component mix)
2. **A/T;** (alfalfa hay)
3. **RC/WC/T;** (improved triple mix)
4. **RC/WC/A/T/B;** (complex, 6 component mix)
5. **Common Triple Mix** (traditional mix)

A=Apica alfalfa,
B= bromegrass,
RC=Marino Red Clover,
T=Champ Timothy,
WC= 1:1 mix of Sacramento and Sonja white clovers

The mixes were established at 3 sites, at two of those (Firth, Hubbard) in plots replicated 3 times, and at one (Van Thielen) in large unreplicated strips. The mixes were undersown in mixed grain at the Firth site, and direct seeded at the other two. At the Firth and Hubbard sites, the forages are used only for hay; at the Van Thielen site, they are also grazed by cattle, and the field receives regular applications of pig slurry.

Common triple mix did poorly at the Firth and Hubbard sites in the establishment year in comparison to improved mixes. There was a large grass component in the establishment year only at the Van Thielen site, that being one which had received heavy applications of manure in previous years.

At the Van Thielen site in 1991 (first production year), grass dominated the mixes (Fig. 2). Legumes accounted for less than 27% of the biomass in the different mixes. Given the dominance of grasses and the lack of replication at this site, it is not possible to draw any conclusions as to which mix might be superior at this site. In any case, it appears that on a heavily manured site such as this one, it would be more important to select grasses than legumes.

At the Firth and Hubbard sites, legumes accounted for 44 to 87% of the hay biomass. At the Hubbard site mixes 3 and 4 (improved triple mix and complex mix) gave the highest yields; at the Firth site, alfalfa and the complex mix were highest. The two component mix (#2) did well at Hubbard site, but not at the Firth site. The alfalfa mix did poorly at the Hubbard site. Thus the data suggest that on average under these conditions, improved triple mix and complex mixes are likely to perform better than 2-component mixes.

At the Hubbard site, large variation in the production of clover within the site appeared to be related to variation in levels of soil Ca (soil ratings covered the range L to M-), with very poor legume performance on low Ca soil.

In response to the farmer's request, the effect of mowing or not in the establishment year on the first production year biomass and composition was examined at the Hubbard site. There was significantly more legume and higher total biomass in the first production year in strips which had not been mowed compared to mowed strips.

These appear to have been the first replicated experiments of this sort in Nova Scotia, and the first in the region to compare a diversity of hay mixtures ranging from simple to complex. It was originally intended that the experiment be conducted over three or more years, as it is in the 2nd and 3rd production years that the greatest differences could be expected. However, funding was not available to carry on observations after the first production year.

Tentatively, it is concluded:

(i) on heavily manured sites, grasses predominate and there is little advantage to selection of improved legume components in mixes;

(ii) on sites receiving lower N loading, the traditional triple mix can be improved upon; on average, improved triple mixes and complex mixes will do better than two component mixes;

(iii) the improved legume species require at least an L+ level of Ca in the soil for good yields.

III. Winter Cereal Trials

There are many potential benefits from winter cereals (e.g. weed control, winter cover, more grain and straw, and better planting conditions than for spring cereals) - if they can be grown successfully. Few farmers currently grow winter cereals in Cumberland county, apparently because they have a reputation for poor winter survival in the county. The straw is an especially valued component of cereals on livestock farms; besides improving the bedding, use of more straw can increase retention of potassium and improve composting qualities of cattle manure and bedding.

Better varieties for Nova Scotia have been introduced within the last 10 years. Mixtures of different species and of winter cereals have been shown to improve yield stability for example through reduced foliar disease and compensatory growth where there is winter kill of one species.[12] In our model rotation, the winter cereals are grown in year 4 after 3 years of hay. Dr. C. Caldwell at NSAC pointed out that take-all could be a problem for winter wheat following hay. Rye and triticale have more resistance.[13] and this may be a benefit of mixtures as well so it is expected that the take-all problem would be restrictive only if growing the grain as a cash crop. Since the principal objective is to increase home grown feed, we do not see this as a problem. Sequences of 3 year leys into cereals are used in Europe.[14]

One of the REAP-Cumberland farmers (C. Hubbard) had been growing winter rye for some time, and a second (W. Van Thielen) tried it for the first time in 1989/90. In 1989, informal trials of 8 different winter ryes were set up on two farms. Oak Manor rye, which had been selected on an organic farm in Ontario, exhibited good grain yields and also very high yields of straw which is especially valuable on livestock farms. Hence in 1990, the new trials included 1/2 acre plots of the Oak Manor rye to further test it and to multiply seed. We also included plots of Schmidt rye (another rye selected on an organic farm in Ontario) and of Spelt[a] which is grown by ecological farmers in Ontario as a cash crop.

In 1990, unreplicated, large strips of the following winter cereals were set up on the Hubbard farm and on the van Thielen farm on ground that had been in hay:

Experiment III Varieties and mixtures in the Winter Cereal Trials

1. Triticale (OAC Trillium)
2. Rye (Kustro)
3. Wheat (Borden)
4. Wheat + Rye
5. Wheat + Triticale
6. Triticale + Rye
7. Oak Manor Rye
8. Schmidt Rye
9. Spelt (from EFAO[b])

1991 was a very poor year for summer cereals because of drought, but the winter cereals did well, especially at the VT site (Fig. 3). There was little disease, except for some ergot in the ryes and triticale at the Van Thielen site; most of it occurred near the edges of stands. The Schmidt rye appears to be a superior alternative to the common or Kustro rye in these systems, giving higher grain and higher straw yields. Farmers planted enlarged acreage's of spelt and Schmidt rye in 1991 with the seed harvested from the 1991 plantings. The rye-wheat mixture also gave good yields on both farms; possibly with the Schmidt rye subtituted for Kustro, they would be even better.

IV. Use of Catch Crops after Winter Cereals.

The term "catch crop" is generally used in North America to refer to a fast growing crop planted after cultivation of soil to conserve the flush of nutrients produced on cultivation. Many organic farmers are using brassicas as catch crops, seeding them in mid-summer to early fall after

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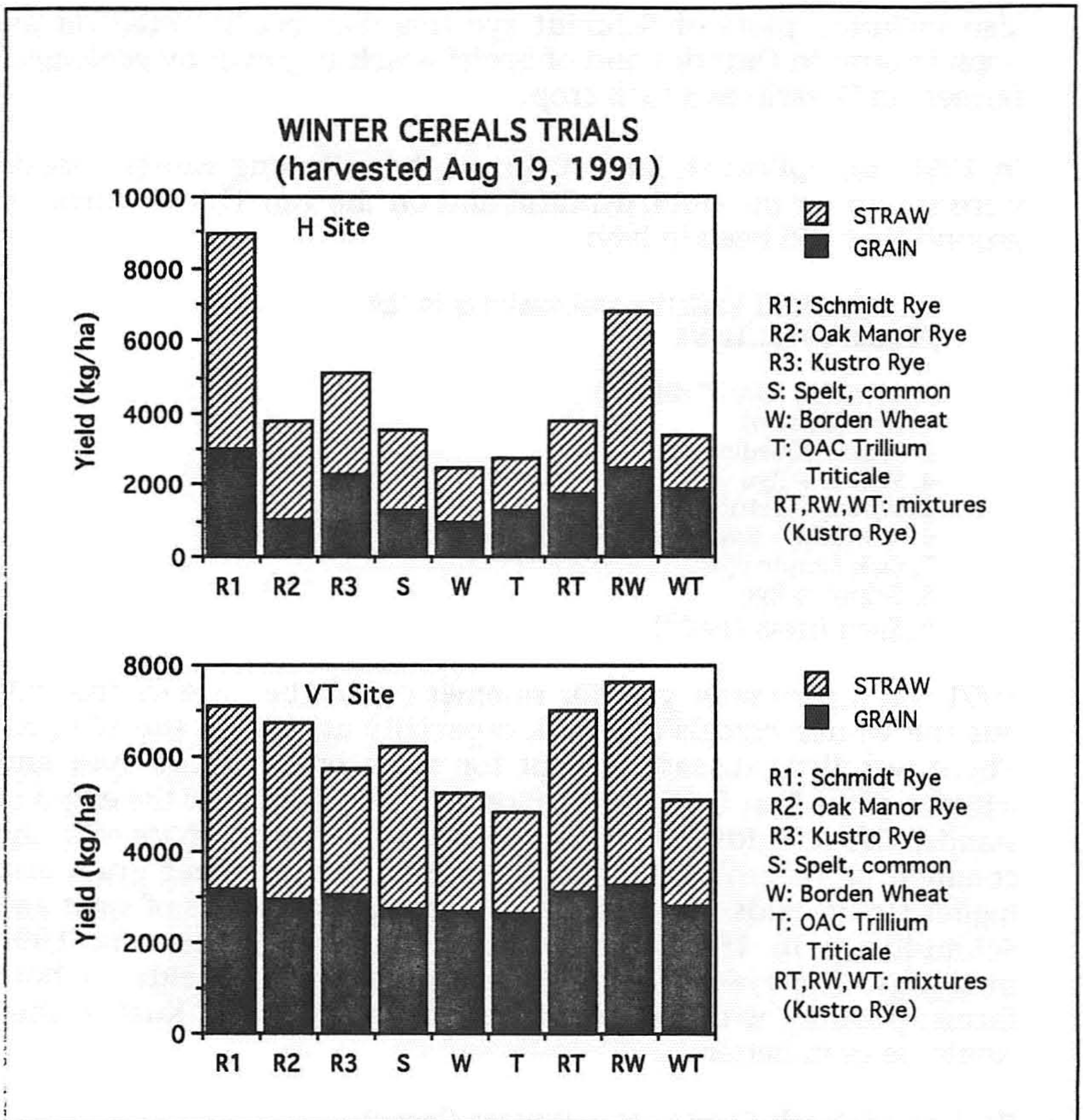
[a]The spelt was suggested by two farmers from the Ecological Farmers Association of Ontario, John MacKinnon and Ted Zettel, who spoke at the first general meeting of REAP-Cumberland , held in March 1990.

[b]Ecological Farmers Association of Ontario



Summary Figure 3. Winter cereal trials

harvesting cereals.[10,11] Catch crops can improve weed control in the next crop, reduce nitrate leaching, increase aggregate stability and in some cases, provide a late season forage.[15]. There has been little testing of catch crops in the Maritimes. Trials in P.E.I. suggested that the relatively late harvest of cereals (compared to central Canada) is a limitation.[16]

Catch crops examined included:

<u>Experiment IV Catch Crops Tested</u>

None (weeds)

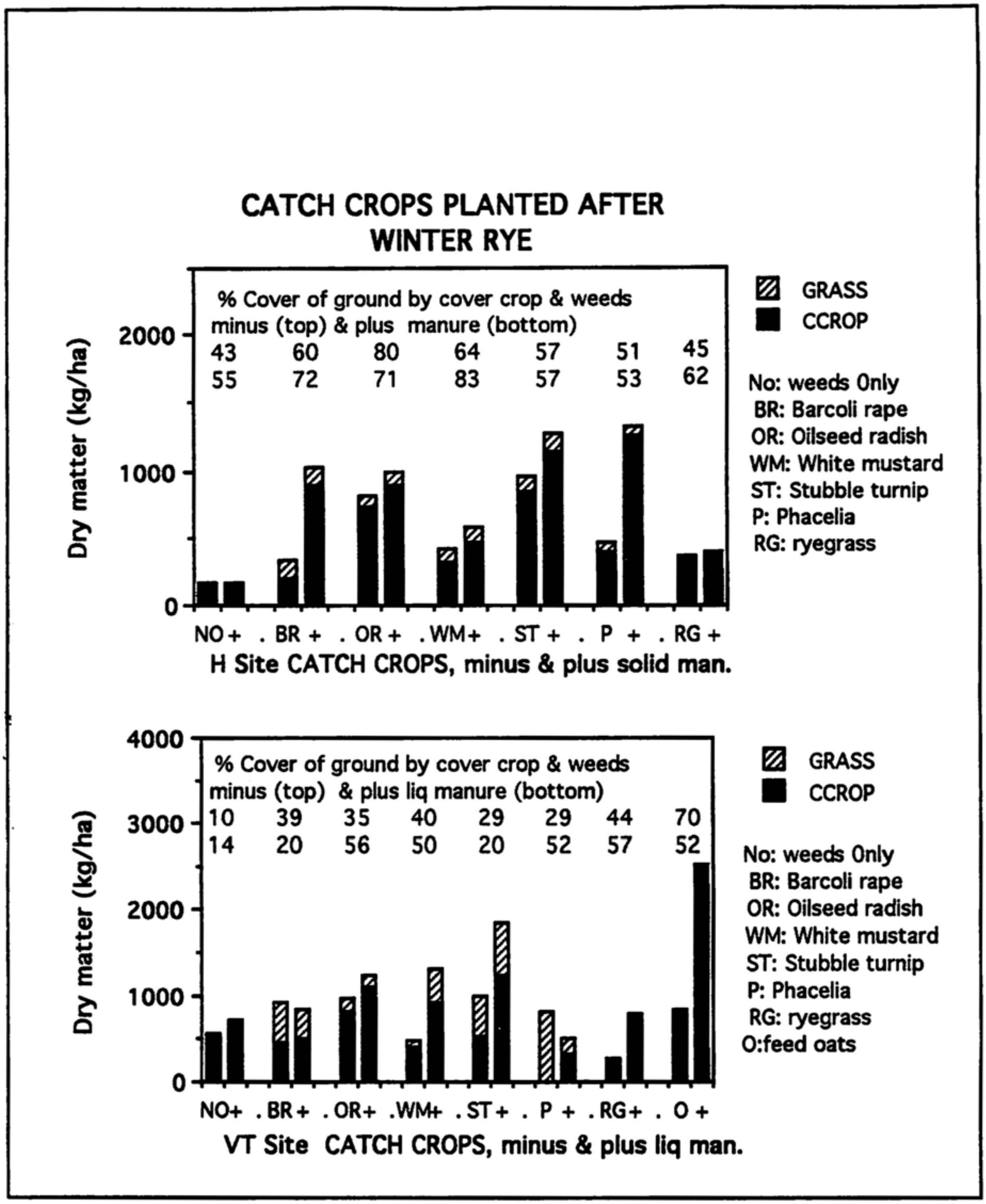
Brassicas: oilseed radish
stubble turnip
Barcoli rape
white mustard

Grasses: ryegrass
oats (Van Thielen farm only)

Other: *Phacelia tanecifolia*

Werner van Thielan decided to seed oats on the part of the field not covered by the trial catch crops, so this served as an additional catch crop trial at that site. *Phacelia tanecifolia* is a catch crop used to some extent in Europe; Minas Seed began selling in 1991. Advantages cited for it are (i) that it is very frost susceptible so doesn't become a weed; (ii) there are no other cultivated plants in its family so it is a good break crop.[17] Brassicas are sometimes not desirable as catch crops because they carry diseases of other crops or other brassicas. Oilseed radish is popular amongst organic farmers. One of the REAP-Cumberland farmers (David Firth) found that the tap roots grew so vigorously that they plugged tile drains. White mustard is an alternative with a less vigorous tap root.

The catch crops were planted in mid-September on large unreplicated strips on 2 fields from which winter rye had been harvested. Solid manure or hog slurry was applied to half of the strip areas. By November, the best cover at the H site (70-80% compared to 30-64% by weeds in control plots) was achieved by oilseed radish; it accumulated 20-30 kg N above that in weeds on control plots. The above ground biomass was less than 1 tonne/hectare. At the VT site, ryegrass and seedoats also ranked



Summary Figure 4. Groundcover and biomass of different catch crops in November, 1990 (seeded Sept. 14). Ryegrass and oats biomass includes weedy grasses.

high in cover. However, on all sites, the total cover (catch crop + weeds) was much less than 100%, which can be attributed to the late planting (Fig. 4). The relatively late harvest of cereals may limit effective use of catch crops after cereals in this region. It may be more appropriate to overseed annual legumes in the winter cereals in spring and then to plow fields late in the fall.

V. Comparison of Winter Cereals and Winter Cereal or Ryegrass/Legume Mixes with Ryegrass for Annual Pasture.

Poor midsummer forage production is a factor limiting utilization of forage in grazing systems. Annual ryegrass has been used successfully as a means of improving forage production in mid-summer, but high seed and fertilizer costs are limitations to this system for some farmers. As alternatives, we examined spring planted winter cereals (which do not head out) alone and in mixtures with annual legumes for mid-summer forage. Winter cereal seed is much cheaper than ryegrass seed, and the legumes could be expected to substitute for some of the fertilizer. Trials of this nature have been done in the region[18] and indicated some potential but there apparently has not been much if any adoption of these practices.
At three sites, we compared yields of ryegrass, spring sown winter triticale and rye with and without 2 annual legumes (Hairy vetch, Persian clover):

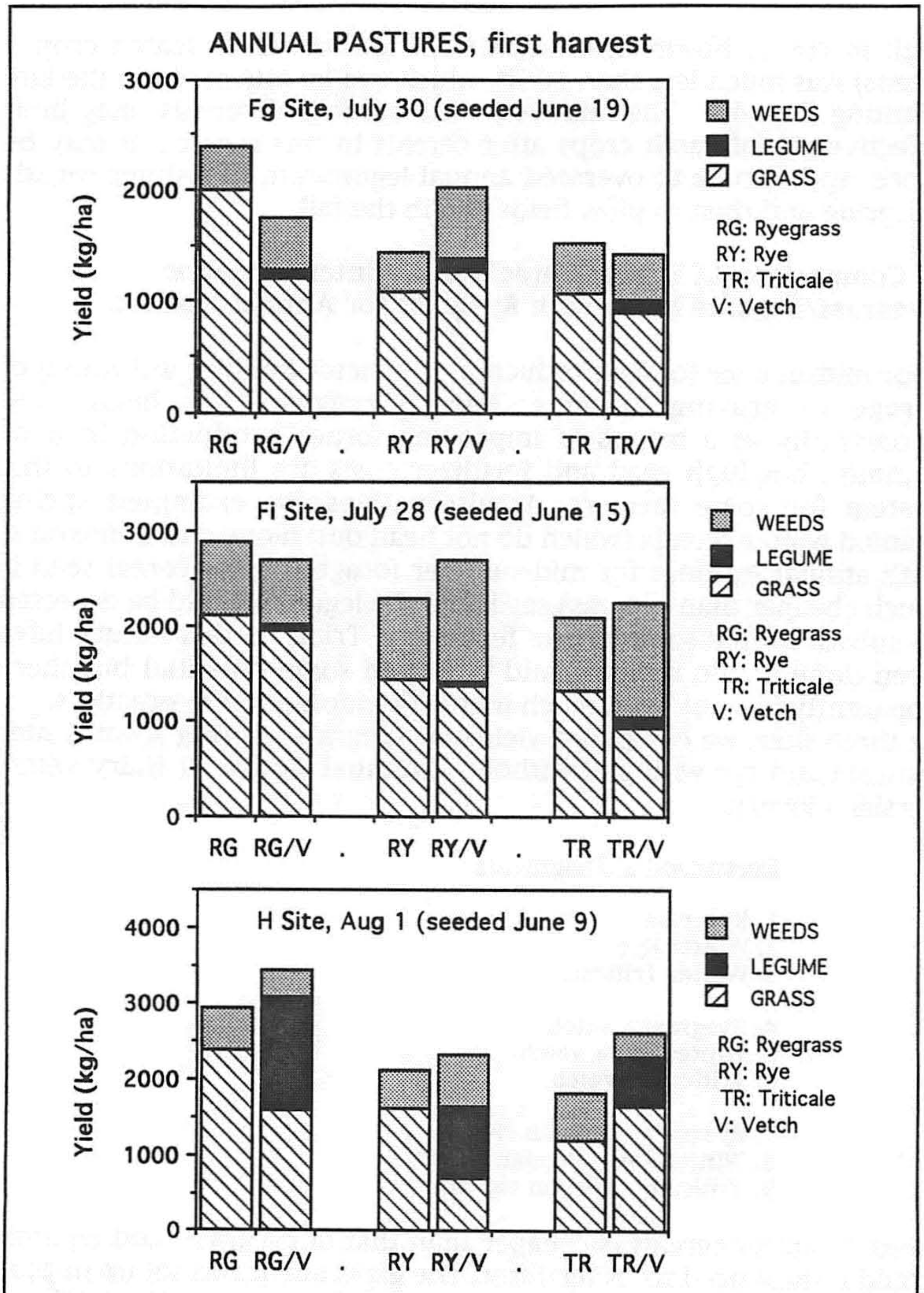
<u>Experiment V Treatments</u>

1. Ryegrass
2. Winter Rye
3. Winter Triticale

4. Ryegrass + vetch
5. Winter Rye + vetch
6. Triticale + vetch

7. Ryegrass + Persian clover
8. Winter Rye + Persian clover
9. Triticale + Persian clover

Seed of winter cereals is cheaper than that of ryegrass, and legumes could reduce need for N fertilizer. The experiment was set up in plots with 3 replicates; they were grazed by sheep at one site, beef and sheep at a second and were cut by scythe at the third. Of the two legumes, only vetch contributed significant biomass and only at one site; that site had the lowest rate of N fertilization of the 3 sites.



Summary Figure 5. Yield and composition of annual pasture established using ryegrass or winter cereals alone and with vetch

Cereals did not yield well compared to ryegrass. Nitrate in ryegrass reached levels of 1-3% of dry matter at two of the sites (Sites Fg, Fi, the most heavily fertilized) which are in the potentially toxic range.[19] At the Firth site, annual weeds made up a large part of the biomass at first grazing; they were grazed down readily, and were not a large component in two subsequent grazings.

CONCLUSIONS

The most immediately useful results to come out of the formal and informal research appear to be the following:

(1) On-farm demonstration of potential for improving forages by use of improved mixes, particularly complex mixes, on moderate to low fertility sites. As a result of informal farmer trials in 1989, Sonja clover is already incorporated as a regular component of hay mixes on one of the farms and proved to make a highly quality silage. (Sonja clover was first released commercially in 1990; it had been tested mostly for use in rotational pastures). On higher fertility (heavily manured) sites, it appears that there is much less advantage in selecting mixes with improved legume components.

(2) Demonstration of possible nitrate toxicity factor in annual ryegrass pastures in Cumberland Co.

(3) Identification of intensity of N loading and specific soil Ca levels as key factors determining differences in legume performance between and within the Cumberland farms; high N loading suppresses legumes in mixtures, and low Ca limits their production under low N loading.

(4) The identification and multiplication of novel ryes for Cumberland Co. with exceptional yields of straw. The ryes were ones that had been improved by selection over the years on two organic farms in Ontario.

(5) The identification and multiplication of a new cash crop (spelt) for the organic market.

Also of potential value, but requiring more research are the following:

(6) Initial testing of a new approach for managing residues, controlling weeds and maintaining fertility in organic vegetable production (Appendix D).

(7) Identification of certain weeds as possible selenium accumulators (of importance for sheep grazing on Se deficient soils). (J. Scott, thesis)

(8) Indications that in a drought year, native pasture and native hay, yield better than conventionally seeded paddocks and hayfields. (J. Scott, thesis).

(9) Value of composts and manure for hay: in the short term, they stimulate grasses, but the longer term benefits, particularly for legumes still need to be evaluated. There were indications that large losses of potassium occur during composting in exposed piles which is well known to organic farmers.[11] Research should conducted to determine appropriate methods, and benefits of covering farm compost piles locally; conserving the K is likely to be critical to realize maximum benefits of applying manures or compost to hay.

Options that were investigated that did not work out as well as had been hoped are:

(10) Use of grain legumes as silage crops: although good yields were obtained, and the crops could serve as nurse crops, none of the farmers have adopted this option; use of grain legumes in silage is however being further researched by at least one farmer elsewhere (Eric Bosveld, personal communication) and at NSAC by Dr. R. Martin, and may prove to be of use in other systems.

(11) Use of catch crops after harvesting of winter cereals: because of the relatively late harvest of winter cereals in this region, catch crops do not accumulate a lot of biomass; overseeding cover crops into winter cereals in spring may be a better option.[20]

(12) Use of winter cereals and annual legumes as alternatives to ryegrass: productivity of cereals was generally low, and vetch and Persian clover did not do well on moderately fertilized soils. However, the concept encouraged farmers to experiment with other mixtures such as Alsike clover and ryegrass (J. Scott, thesis).

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PLATE 1: Formal Experiments

A. On field day, August 25, 1990, visitors examine Experiment I on the Van Thielen farm. In foreground, cereal/pea mixture was undersown with triple mix; the nurse (silage) crop has been harvested except at left. At back, full canopy of fababeans, also undersown, can be seen.

B. Experiment I, early October at the Hubbard farm. At left a narrow band of the nurse (silage) crops has been left standing. Triple mix that was undersown has developed a good cover where the silage crops were harvested.

C. Hay mixes (Experiment IIb) at the Firth site, August 1991, first production year.

D. Hay mixes (Experiment IIb) at the Hubbard site, early October in the establishment year (1990). In the foreground, the hay was cut in July; in the background, it was not cut. In 1991, hay yield was higher where it had not been cut in 1990.

E. Samples of cereals harvested at Van Thielen farm, August 1991 illustrate differences in straw production (Experiment III) From left, barley, wheat, Triticale, spelt, Kustro rye, Oak Manor Rye, Schmidt rye.

F. Experiment IV: catch crops planted after winter wheat. Photo shows cover by *Phacelia* and grass weeds in October, Hubbard site.

G. Setting up Experiment V on an annual pasture at the Firth farm, in early June, 1990.

H. Same field as in G, at first grazing, July 28, 1990. About 25% of the biomass at first grazing consisted of weeds (see Summary Figure 5); sheep stripped weeds bare of leaves.

I. White muscle disease in autopsied lamb, due to deficiency of selenium.

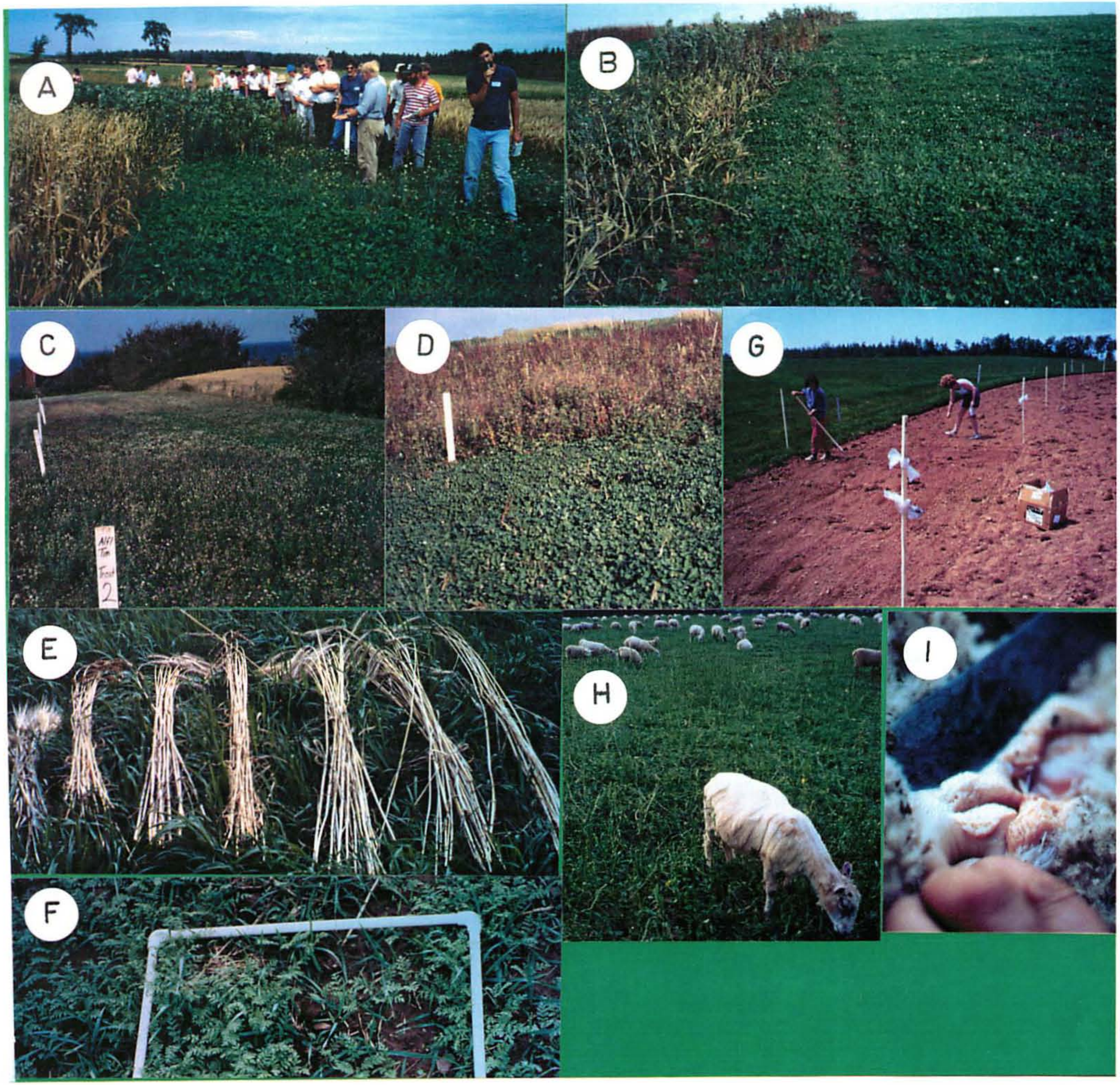
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PLATE 2: Informal Experiments: field crops, hay and pasture

A. Legume test field, Hubbard farm, 1989. Fababeans, lupins (shown) and vetch were planted on this field; photo illustrates lupins in August.

B. Sonja clover was added to the triple mix used to establish this field in 1989. Photo, taken in June 1990 shows excellent establishment of the Sonja clover (white flowers).

C. Native pasture, Hubbard farm, managed with intensive rotational grazing.

D. Compost spread on a strip of the pasture in photo C, in June 1991. Jennifer Scott compared pasture production in plus and minus compost strips on two such fields

E. Native pasture, Van Thielen farm, managed with intensive rotational grazing. Productivity of native pasture measured in 1991, a very droughty year, exceeded that of reseeded pastures (data collected by Jennifer Scott).

F. Dan Ferguson broadcasting oats for an annual pasture, 1990. Broadcasting seed with a fertilizer spreader, followed by harrowing is a common employed method for seeding small grains on Cumberland Co. farms.

G. Schmidt winter rye, July 1991, on Van Thielen farm. In 1989/90, the farmers tested 8 different ryes; a common type from Oak Manor (an organic farm in Ontario) gave high yields of grain and exceptional yields of straw. In 1990, they obtained Schmidt rye, selected on another organic farm, and it proved superior to both Oak Manor and the traditional, Kustro rye.

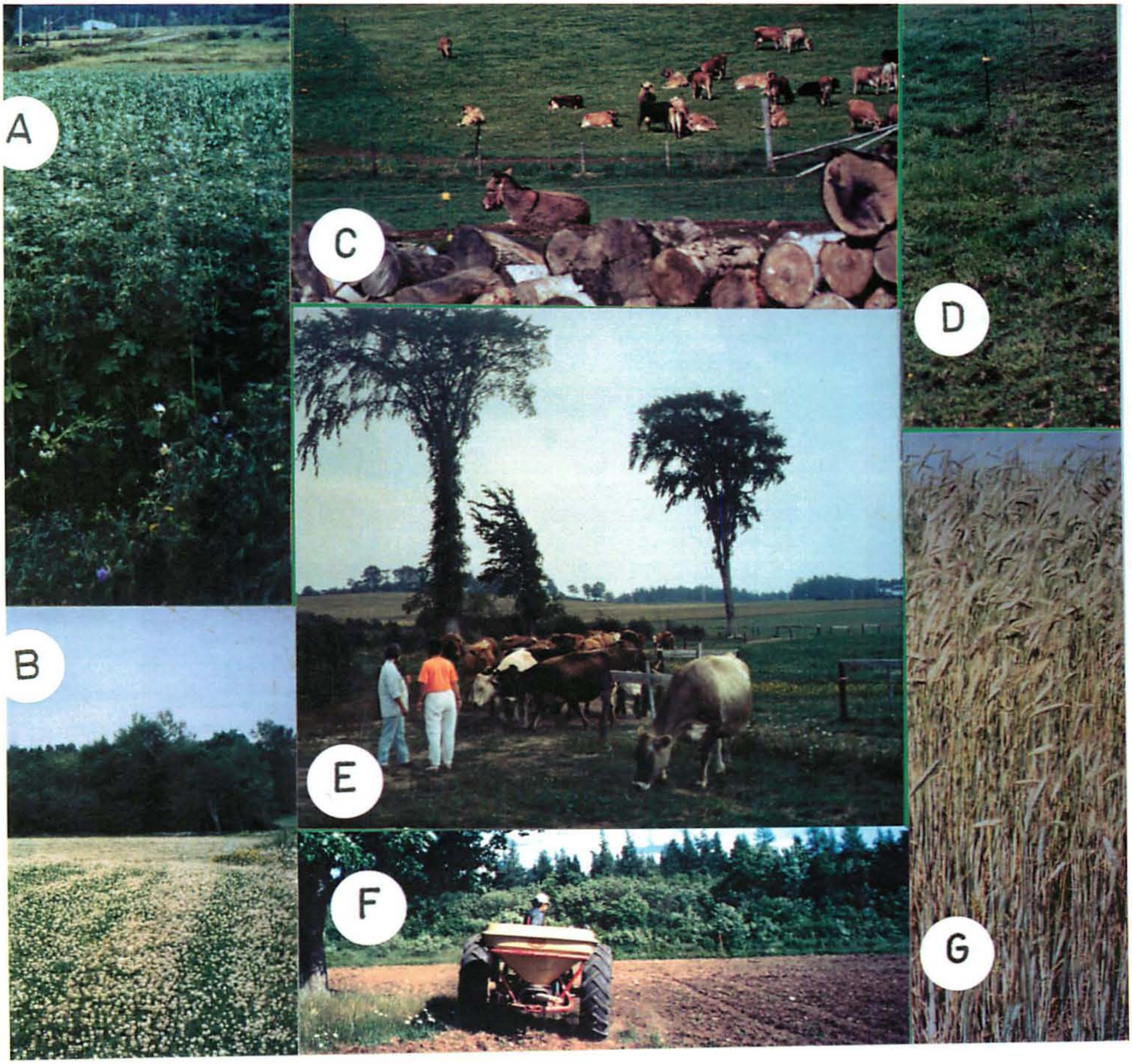
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PLATE 3: Informal Experiments: organic vegetable production

Photos illustrate a system of management for controlling weeds, adding nitrogen and managing residues in organic vegetable production that was tested in 1990/91 on the Hubbard farm.

A. An example of the high density of the weed population in an organic vegetable production system managed with frequent rotovation.

Photos B to G illustrate the experimental organic vegetable garden established on the Hubbard farm in 1990. The field was ploughed in May 1990 and raised beds 50 cm wide, 20 cm height with 50 cm between beds were prepared using a hilling implement. Areas between beds were mulched with approx 5 cm straw or old hay. Crops were seeded into the raised beds

B. Beans on raised beds and in straw filled depressions. Bean seeds were dropped into the straw, to determine whether they would germinate there. The depression retained more moisture and were subject to less drying by wind, than the raised beds. The straw would be expected to immobilize N and thereby stimulate N_2 fixation in legumes.

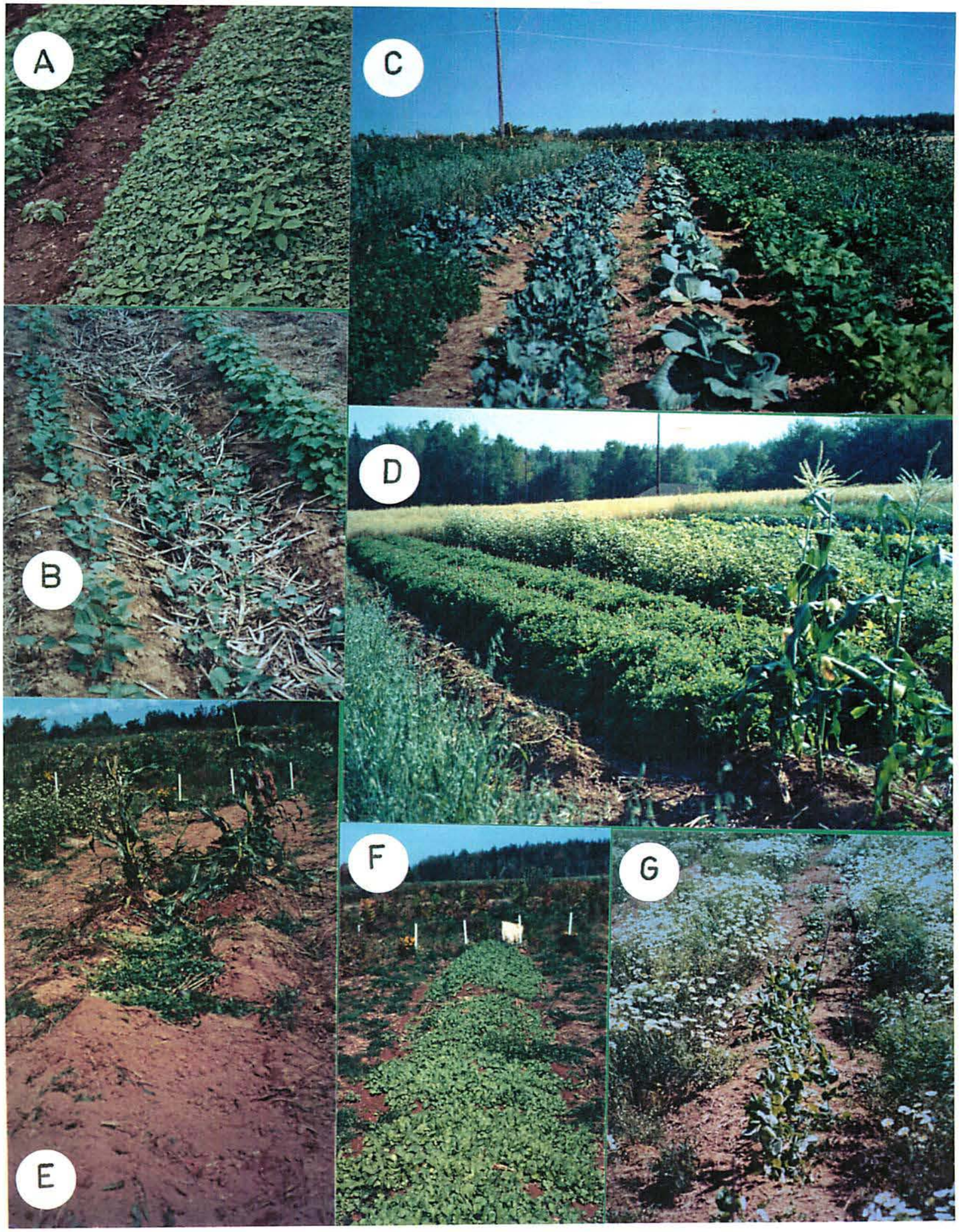
C. Rows of vegetables and green manure/mulching crops

D. Photo illustrates green manure/mulching crops. At left: oats & vetch; centre: crimson clover (2 rows), and next row over: buckwheat. Corn in the foreground.

E. In early September, the crimson clover and corn residues were turned into the depression between two raised beds, and the soil from the raised beds hoed over the residues. Then oilseed radish or ryegrass were seeded into the new raised bed

F. The same bed as in E, early October, with a covering of oilseed radish.

G. The same bed, July 1991. Vegetables were seeded directly into the raised bed in early June. No weeding was conducted. The bed remained almost completely free of weeds, while there was dense growth of weeds in adjacent beds which were left undisturbed from the previous year.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METHODS: general

We attempted as much as possible to integrate the experiments and trials into the normal routine of the farms. This was done to minimize intrusiveness on the farm, reduce the costs, and to incorporate the farm variables as part of the experimental background. Thus in a typical experiment, seeding was done using hand operated cyclone seeders, and all other operations (field preparation, rolling, weeding etc.) by the farmer. In this case, the hand seeding was convenient to the researchers and simulated the farmers' seeding as the farmers use fertilizer spreaders or Brillion seeders to plant seed (rather than seed drills). All experiments were conducted on at least 2 farms, i.e. they were replicated at least twice between farms; some were replicated within farms. The degree of replication within and between farms was decided on the basis of what type of question we are attempting to answer and the background information available. It was also a function of the constraints of time (such as the necessity of getting a lot of things done on different farms in a short interval), and of advice of Mr. Eric Bosveld (NSDAM), Dr. J. Papadopoulos (Agriculture Canada at Nappan), and Dr. C. Caldwell (NSAC). Other details of experiments (treatments, varieties, seeding rates) were also modified according to advice given by the same personnel.

For experiments replicated within farms, a RCB (Randomized Complete Block) design was used with each treatment replicated once in each block, and there were 3 to 4 blocks (replicates) in total. In most cases there was not a separate guard area around each plot, but we did not sample in the outer 1/2 meter of the plot. Diagrams of the field experiment plots are given in Appendix C. For biomass sampling, vegetation was taken from one to three quadrats within each block, the quadrats being placed by use of a grid and random numbers, or by "blind walks". Details are given under each experiment.

For biomass measurements, vegetation was weighed in the field using spring balances, and subsamples weighed and retained for drying. Subsamples were a minimum of 100 g fresh weight. If the vegetation was of a uniform type, then composite subsamples were prepared. However, if the vegetation was varied and the dry -to-fresh weight ratio likely to differ -e.g. for samples of weeds in which the predominant weed species differed, then a subsample was taken from each field sample. The subsamples, in paper bags were put into solar dryers(see photo). These were large black boxes (about 1.5 m by 1.5 m basal area) constructed from plywood with ventilation holes and polyethylene covers. There is a chicken wire net raised above the bottom on which bags are placed. On sunny days, temperatures in the boxes go above 60 °C. Samples were left until they were brittle, then weighed on a top-loading balance and the dry-to-fresh weight ratios calculated. Composite samples were prepared for analyses of CP (Crude Protein), ADF (Acid Digestible Fibre) and in some cases, nitrate. The samples were chopped into small pieces using a guillotine cutter, subsamples taken (circa 3 grams each) and sent to Nova Scotia Department of Agriculture and Marketing at Truro for analysis.

Right: Researchers examine the solar dryer during the 1990 field day.

Soil samples were taken with a standard soil corer to 6 inches (15 cm) depth. Except on small plots, 30-40 core samples were taken, mixed together and air dried or frozen (for nitrates). On small plots, 5 cores per plot were taken and all replicates for a treatment were combined (i.e. 15 to 20 cores in total). Samples were boxed and sent to NSDAM for analysis.

Data were analyzed using the SuperANOVA program (Abacus Concepts, Berkeley, Calif.) for MacIntosh computer and Statview + Graphics (Abacus Concepts Inc.) and Cricket Graph (Cricket Software, Philadelphia) for other tests and plotting. Fisher's Protected LSD test was used to determine the probability of differences between means arising by chance (i.e. of a Type I error). Two levels of significance, 0.05, 0.1 are reported, which mean that the differences could have arisen by chance in one case out of 20 (or less), or one case out of 10. The 0.1 level is reported routinely because, given the limited replication possible in these experiments and that they were conducted on farms where more variability could be expected (than in specialized experimental fields), there is a high likelihood of a type II error when only the 0.05 level is considered, i.e. that no difference will be detected when there is a difference. Since we want to identify practices that show potential and that would be subject to further testing, rather than to prove a particular hypothesis, it is appropriate to give consideration to differences that are significant at the 0.1 level of probability.

I: GRAIN LEGUMES FOR SILAGE & FORAGE ESTABLISHMENT

I. 1 Treatments

1. **Fababeans** (Encore) 120 kg/ha
2. **Lupins** (PEI Common) 120 kg/ha
3. **Fababeans/Lupins** 60/60
4. **Peas** (Lenca)/ **Barley** (Leger)/ **Oats** (Marion) 80/25/25
5. **Barley** (Leger)/**Oats** (Marion) 80/50

All were undersown with M-46 (Bishop Seed) Triple mix

The experiment was set up at two sites, and silage harvest measured in 1990. In 1991, we compared production of the forage established under the different nurse crops.

1.2 Methods

Site 1 on Hubbard farm:

The plots were set up on the "Experimental Field". The history of this field is as follows:

1987: Oats grown with 250 lbs/acre 17-17-17
1988: Barley/clover grown with 250 lbs/acre 17-17-17
1989: Oats/Alsike clover grown with 200 lbs/acre 17-17-17
1990: Outside of the experimental area: Oats/Alsike clover, with manure; Peas; Winter Wheat (planted 1989).

The experiment was set up on June 8 in a RCB (randomized complete block) design with blocks and plots set out in a single line along a slope upwards to the east (Block 3 highest, Block 1 lowest). Plots are 10 x 4.75 m. Seed was hand broadcast, then harrowed, and brillion seeded with M46 triple mix (Bishop Seed Co.); at the same time, 1/2 acre area each of lupins and fababeans, undersown, were planted by the farmer.

Seedling counts were made on July 13 in three 50 x 50 cm quadrats placed at randomly selected positions within each plot.

Height and light penetration measurements were made several times through the season on one plot of each treatment. The heights of 10 crop plants, 10 clover and 10 timothy were measured. Light readings were made above the canopy, and at the top of the undersown forage using a lux type sensor; percent light reaching the undersown forage was calculated.

Treatments 4 and 5 were sampled on August 3 when cereals had headed out. Three 50 x 50 cm quadrats placed randomly within plots were sampled. The heights of the 3 longest barley, 3 longest oat and 3 longest pea plants were measured in each quadrat. For each plot, vegetation was cut at 8-10 cm height. The fresh weight of each component was determined on site using a spring balance, and a weighed subsample was dried to determine the dry-to-fresh weight ratio. Half of each plot was cut with a scythe following this sampling. On Aug 28th, the whole plot was mowed as were those of other treatments, and the crops taken for silage.

For silage, crops were mowed with a mower conditioner on Aug 28 and collected on Aug 29 with a forage harvester and transferred to a silage heap.

Treatments 1,2, and 3 were sampled on August 27, as above, except that clover, timothy and weeds, not separated from nurse crop biomass on Aug 3, were separated. The predominant weeds were noted. On October 15/16, the triple mix forage was sampled. One 50 x 50 cm quadrat was taken from each plot, as above, except that it was clipped at about 5 cm.

In 1991, two 50 x 50 cm quadrats were cut from each plot on June 20,separated into grass, clover and weeds, weighed and subsamples dried.

Site 2 on Van Thielen farm:

The experiment was set up on May 29 in a low lying, flat field close to a stream.

The history of this field is as follows:

1987: 5t/acre lime;
1988 Green manure (pasture mix) plowed down; in fall solid manure applied and plowed
1989 Barley; a coat of solid manure was applied first and harrowed; after harvest, 263 gallons per acre liquid manure plus a coating of solid manure were applied and the soil was plowed.
1990 Harrowed in spring, no manure; outside of plots barley undersown with triple mix was planted; also a small area of oilseed radish.

The plots are 5 x 10 m, set out in RCB design with 3 replicates. Seed was sowed by hand, and harrowed by farmer after seeding. There was heavy rainfall the following day, and most of the area was submerged.

Sampling was conducted as at the Hubbard farm on July 4 (seedling counts), August 5 (treatments 4 and 5, nurse crops harvested), August 28 (treatments 1,2,3, nurse crops harvested)), and on Oct. 16 (forage sampled). The farmer had intended to graze down the experimental silage crop after August 5, but was not able to shift animals to do this; consequently, the vegetation was not cut, except by hand on half of each plot of treatments 4 and 5 on Aug. 6.

The grain crops were not cut and removed at the Van Thielen site, and matted down over winter which killed a lot of the undersown crop. Consequently, formal observations were not continued in 1991, except to make some visual estimates of percent cover.

I. 3. Results

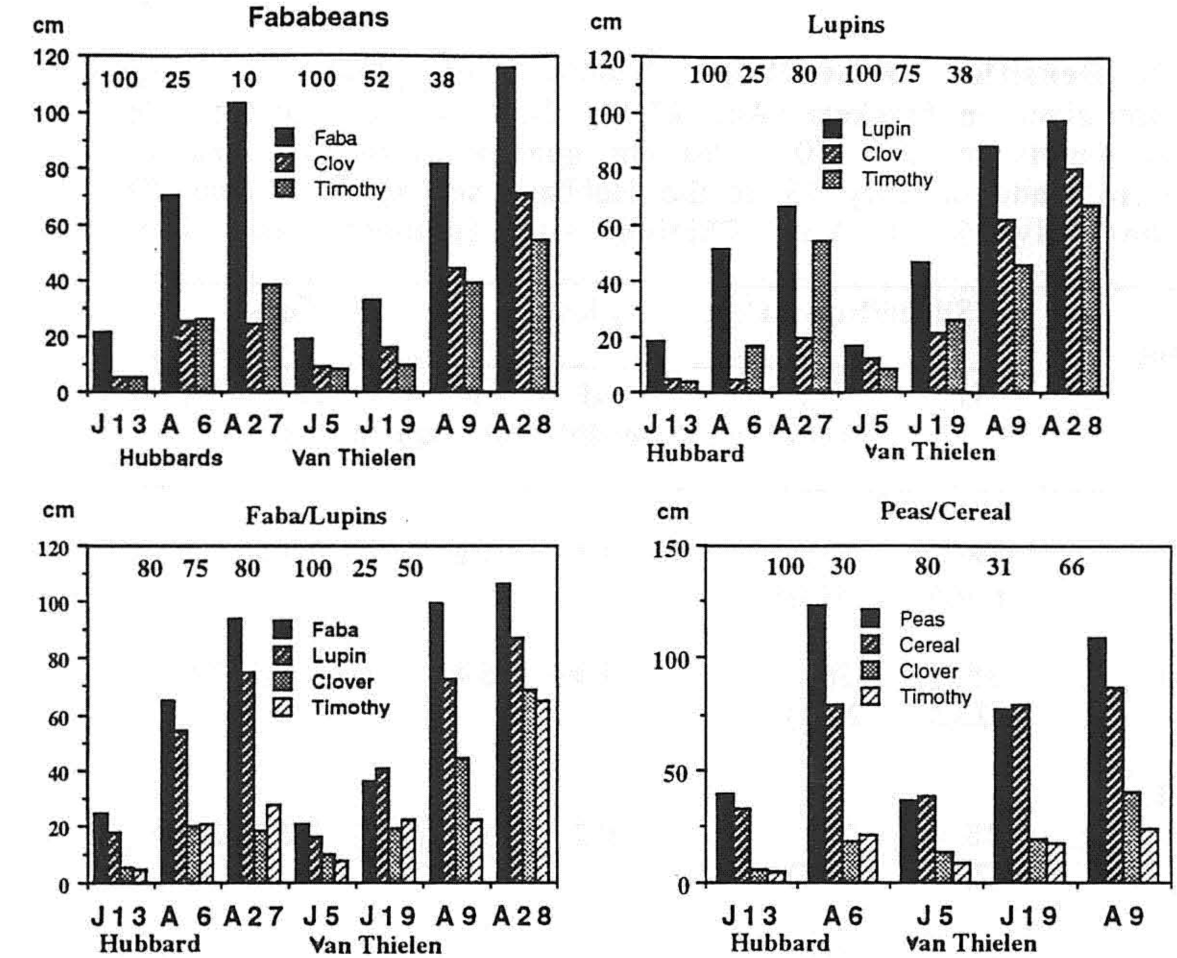
Establishment

The conditions in 1990 were not very favorable for establishment of the grain legumes, or for their subsequent growth. There was a late, cold spring, and flooding occurred at the van Thielen site immediately after seeding. A drought followed through most of June and July. Nevertheless, there was good establishment (Table 1), the crops grew quickly after the rain and produced reasonable crops (Fig. 1; Table 2). Some of the clover, particularly red clover, grew tall and stemmy and flowered under the grain legume canopy; this was most pronounced at the van Thielen site (Fig. 1).

Silage harvest

At both sites, fababeans produced the most dry matter for silage harvest but the protein yields per hectare for fababeans and lupins were similar or were higher for lupins (Table 2). The undersown clover contributed significantly to the silage biomass at the van Thielen site, especially under lupins. At the Hubbard site, clover biomass was lower and weed biomass higher compared to the van Thielen site. At both sites, weed biomass was much lower in the faba/lupin mixture than in fababeans or lupins alone (Table 2).

Total protein yield was much higher for fababeans and lupins than for cereal or peas + cereals (Table 2). The pea seeding rate was considered (by C. Hubbard) to be too high relative to cereals (80 kg peas, 50 kg cereals).



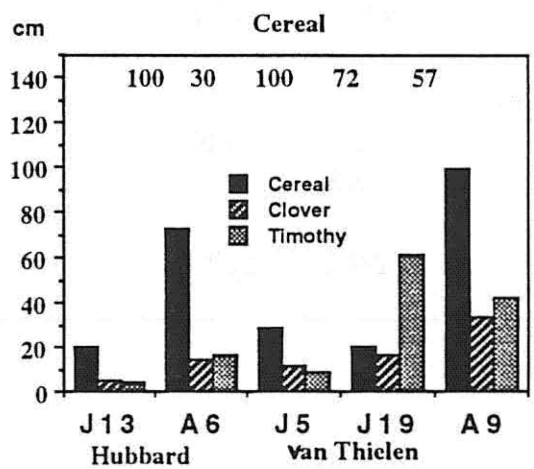


Figure 6. Heights of crop and undersown forage at reference sites on different dates. Numbers on top are the percent of incident light reaching the top of the underwon forage. Crops were planted on June 8 at the Hubbard site and May 29 at the Van Thielen site.

Table 1. Densities of seedlings. Numbers of plants at silage harvest are given in brackets (Aug 27,28). Numbers of seedlings are based on counts in nine 50 x 50 cm quadrats (3/plot). Seedling counts were made on July 13 at the Hubbard site (planted June 8) and on July 5 at Van Thielen site (planted May 29).

Treatment	Silage/Nurse Crop		Clover		Grass	
	H	VT	H	VT	H	VT
	(Avg. no. of seedlings per square meter)					
1.Faba	48.8 (39.5	51.2 51.0)	131	172	391	257
2. Lupin	35.6 (23.5	26 20.4)	109	254	258	265
3.Faba/Lup						
Fabas	28.4 (23.1	28 21.3)	92	199	222	352
Lupins	16.4 (10.5	19.6 9.8)				
4. Peas/Cer						
Peas	52	70.8	79	204	182	167
Cereal	188	131				
5. Cereal	295	212	104	245	159	259

Table 2: Summary of yield and quality data (silage harvest, 1990). The cereal and cereal/pea treatments were sampled when the cereal began to head out, and the other treatments when the lower pods on fababeans had turned black. Dry Matter values are averages for 3 replicates. % PROT (Protein) and ADF (Acid Digestible Fibre) values are for composite samples.

TREATMENT	Dry matter (kg/ha)				Total Crop (Crop,clover,weeds)			
	CROP	CLOVER (kg/ha)	WEED	TOTAL	% DM	%PROT	%ADF	PROT
Hubbard site								
1. Fababeans	4371p[a]	65.6p	519p	4956p	18.7	19.2	29.8	952
		(88.2%)[b]	(1.3%)	(10.4%)				
2. Lupins	3400p	175p	607p	4182p	15.2	22.6	26.4	945
	(81.3%)	(4.2%)	(14.5%)					
3. Faba/Lup	4048p	164p	166q	4377q	17.2	20.3	28.7	889
	(92.5%)	(3.8%)	(3.8%)					
4. Peas/Cer				3493qr	13.9	21.3	29.1	744
5. Cereal				3111pr	21.8	9.9	34.9	308
Van Thielan site								
1. Fabas	7076p	665p	292p	8033p	16.3	18.2	36.7	1462
	(88.0%)	(8.3%)	(3.6%)					
2. Lupins	4753q	1963q	223p	6939p	16.5	21.9	28.1	1519
	(68.5%)	(28.3%)	(3.4%)					
3. Faba/lup	4389q	1064pq	106p	5559q	16.3	18.5	34.4	1028
	(78.9%)	(19.1%)	(1.9%)					
4. Peas/Cer				4947qr	18.0	19.6	27.4	969
5. Cereal				4340pr	24.0	13.9	30.4	603

[a] Within columns, probability that means not sharing a letter (Type I error) come from the same population is 0.1 or less; tests also significant at =0.05 are :

Hubbard: Total Biomass: Faba versus peas/cer, cereal

Van Thielen: Total Biomass : Faba versus peas/cer, cereal

[b] Percent of total biomass is given in brackets

Overall, crop biomass at the Van Thielen site averaged 1.37 times that at the Hubbard site, and total biomass, 1.48 times that at the Hubbard site. The Van Thielen site had higher levels of nutrients than the Hubbard site, although pH was lower (Table 3).

There were large differences between blocks at the Hubbard site, with the lowest yields in block 1, which was found by soil analysis to be particularly low in calcium; yields were highest in Block 2 which had the highest calcium level (Table 4). In a separate experiment by C. Yang (PhD student at Dalhousie University) performed on the lower part of the 1/2 acre stand of fababeans in this field, it was found that fababean yield was increased by application of Ca, but not by N,P, or K fertilizers (unpublished data).

Table 3. Soil data for the two Experiment 1 sites.

SAMPLE	LOI[a] (%)	pH	P_2O_5	K_2O	Ca	Mg
			(kg/ha)			
Hubbard,[b] June 90	6.1	6.6	114M-	106L+	1395L	461M+
Van Thielen, Jn 90	4.3	5.6	327	183	2376	505
Hubbard,[b] May 91						
Block 1	4.7	6.1	150M	214M	1247L	378M
Block 2	7.5	6.2	294H	356H	2566M-	567H-
Block 3	7.3	6.1	258H-	254H-	2377M-	574H-

[a] LOI = loss on ignition, a measure of organic matter

[b] June 90 sample was taken from the entire experiment area (including experiments 1, 2b, 5) on Hubbard Field E; in May 91, samples were taken only from experiment 1 plots, and by blocks.

Table 4. Data illustrating variation between blocks at Hubbard site. Biomass values are means of 3 replicates, soil analysis is for 1 sample

	Total biomass at silage harvest '90	Clover in fall 1990	Soil Ca (spring 91)
	(kg/ha)		
Block 1	3419p	568 p	1247
Block 2	4539q	1077 p	2566
Block 3	4112pq	918 p	2377

[a] Biomass data were subjected to 2-way ANOVA followed by Fisher's Protected LSD test. Within columns, probability that means not sharing a letter come from the same population is 0.1 or less; tests also significant at =0.05 are : Total Biomass Block 1 versus Block 2.

Table 5. Data on ADF (acid digestible fibre), CP (crude protein), and DM (dry matter) at harvest. Values calculated from other numbers given in the table are given in bold type. Values are for single composite samples. DM% is percent of dry matter in harvested material; CP% and ADF% are percentages of CP and ADF in the dry matter. "All" refers to crop + forage + weeds.

Component & Measurement	Fababeans Hub	Fababeans Van Th	Lupins Hub	Lupins Van Th
TREATMENTS 1,2				
Pods:				
DM%	15.6	15.7	8.9	9.1
CP %	28.0	27.9	21.8	30.8
ADF %	23.5	27.0	35.0	20.9
Stems:				
DM%	18.3	16.4	15.1	16.1
CP %	18.4	15.7	24.1	23.5
ADF %	30.4	39.1	25.7	26.0
% pods in crop D.M.	8.1	20.2	10.2	12.8
Pods + stems, D.M.%	18.0	16.2	14.5	15.2
As harvested, all				
DM %	18.7	16.3	15.2	16.5
% Protein	19.2	18.2	23.9	24.4
% ADF	29.8	36.7	26.6	25.3
D.M. yield (kg/ha)	4371	7076	3400	4753

Table 5 (concluded)

Component	Fababeans Hub	Fababeans Van Th	Lupins Hub	Lupins Van Th
Protein yield (kg/ha)	**839**	**1288**	**813**	**1159**
TREATMENT 3				
Pods:				
DM%	12.5	15.6	8.5	9.3
Stems:				
Dry%	18.5	13.3	17.7	15.9
% pods (dry)	6.0	16.4	5.4	19.2
% Prot	**19.0**	**17.7**	**24.0**	**24.9**
%ADF	**30.0**	**37.1**	**26.2**	**25.0**

As harvested:	Hubbard	Van Thielen
% lupins in mix:	30.2	21.4
DM% crop only	**16.9**	**16.0**
DM%, all	**17.2**	**16.3**
%Prot, all	**20.3**	**18.5**
% ADF, all	**28.7**	**34.4**

Data for Clover and Weeds:

	%DM	CP	ADF
Clover in Fabas H:	18.7		
Clover in Fabas VT	16.0		
Weeds in Fabas H	24.7		
Weeds in Fabas VT	20.1		
Clover in Lupin H	20.9	16.8	25.1
Clover in Lupin VT	19.0	16.1	34.8
Weeds in Lupin H	17.5	17.1	25.8
Weeds in Lupin VT	20.0		
Clover in Mix H:	20.7		
Clover in Mix VT	15.9		
Weeds in Mix H	21.4		
Weeds in Mix VT	35.5		

Silage quality:
C. Hubbard commented, regarding the silage made from fababeans and lupins, that there was not enough to compare properly with his Sonja clover silage. The Sonja silage packs down better. Analysis of the fababean/lupin silage is shown below.

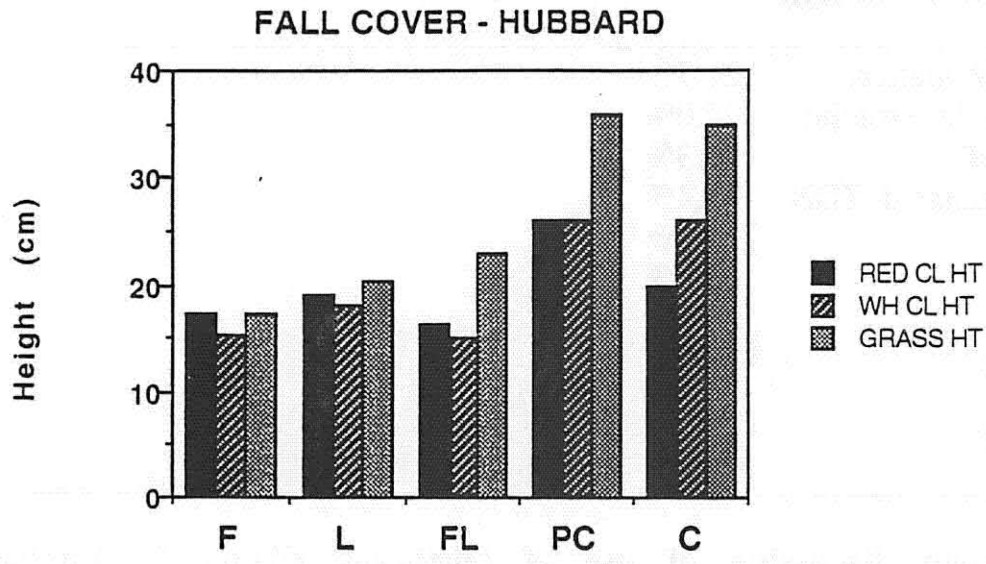
Table 6. Composition and pH of fababean/lupin silage (100% dry basis).

Dry matter:	21.7%
Crude Protein:	26.0%
ADF	24.3%
Estimated TDN	73.4%
Ca	1.17%
P	0.32%
K	3.23%
Mg	0.35%
pH	4.2

In a group discussion of use of fababeans silage, C. Hubbard remarked that their cows (Jerseys) appeared not to like the fababean silage, nor had they liked freshly cut fababeans given to them on a one-shot basis in 1989. B. Jack and D. Hinners on the other hand said that their Jerseys had ravished fresh fababeans given to them in a 1989 trial. It's likely that the preferences of the Hubbard cows were conditioned by previous diet.

Fall Cover
Fall cover at the Hubbard site (Oct 16, 1990) was 90-100% (visual estimate). The vegetation was approximately 2 x taller where it had been established under cereal/pea or cereal, which had been cut earlier in the season than fabas and lupins (Fig. 2).

We did not estimate the percent cover at the Van Thielen site where the crop was not cut at all (except on half of each of the cereal and cereal/pea plots which were cut by hand), but it was much less than at the Hubbard site. At the van Thielen site, the cover was 100% in the hand-cut cereal and cereal- pea plots, and biomass was much higher than on the uncut portions of those plots. It had been planned to mow the pots later in the fall, but that turned out not to be feasible because of wetness. Finally they were mowed in winter when the ground was frozen. However, the fababeans and lupins had lodged by that time and formed a mulch on the ground which completely suppressed clover in the spring of 1991. Hence the experiment at this site was discontinued. The data do illustrate much poorer cover of the undersown crop when the silage crop was left standing until grain harvest.



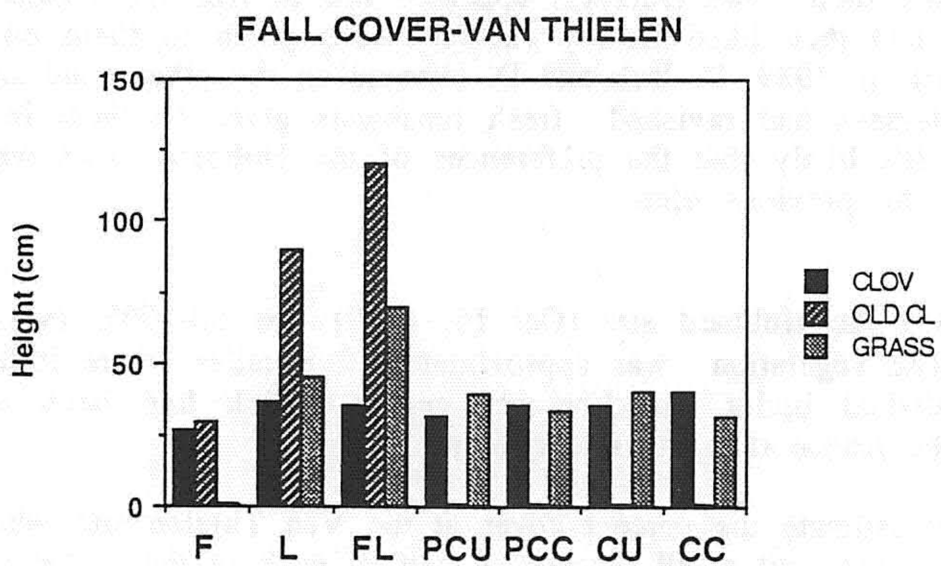


Figure 7. Heights of undersown forage on October 16,1990. F=fababeans, L=lupins, P=peas, C=cereals; on lower figure, PCU and PCC, and CU and CC refer to peas/cereals cut and uncut and cereals cut and uncut. "OLD CL" refers to clover that had flowered.

Table 7. Biomass of undersown forage on October 16. Note: all plots were cut for silage at Hubbard site; at Van Thielen site, half the pea/cereal and cereal plots were cut, the other half was left uncut, and none of the other treatments were cut. Values are means for 3 plots at Hubbard site; only one block was sampled at Van Thielen site.

Site &Treatment	Grass		Clover		Old Clover
	(kg dry matter/ha)				
Hubbard					
Faba	92	p[a]	489	p	
Lupin	169	q	533	p	
Faba/lupin	105	p	557	p	
Pea/cereal	208	q	1250	q	
Cereal	75	p	1442	q	
Van Thielen					
Faba	0		137		120
Lupin	0		759		676
Faba/lupin	0		228		1189
Pea/cer (uncut)	0		482		0
Pea/cer (cut)	188		2758		0
Cer (uncut)	0		137		0
Cer (cut)	564		1655		0

[a]Within columns, probability that means not sharing a letter come from the same population is 0.1 or less; tests also significant at =0.05 are (Hubbard only):
Grass: Cer/pea versus cereal, faba, faba/lupin
Clover: Pea Cereal versus faba,
Cereal versus faba*

<u>POTENTIAL GRAIN YIELD and other comments on fababeans and lupins</u>

Seeds were taken from 15 fababean plants at each site on October 16. The yield was 208 gram harvestable seed at Van Thielen, 46 g at Hubbards. At densities of 51, 39.5 plants/m^2 respectively (Table I), these translate into yields of 7070 and 1210 kg/ha.

The first number (7070 kg/ha) probably greatly overestimates real yield. The numbers do, however, suggest that a good grain yield could have been taken from a crop at the Van Thielen site but not from the Hubbard site. Part of the difference at the two sites was due to greater damage by Chocolate Spot at the Hubbard site. On a scale of 0-5, with 5 as complete destruction of reproductive parts, the Chocolate spot at Hubbards was assessed as 2.5 in all plots, while at van Thielen it was 0.5 to 1. The same seed was used at both sites, so the difference between sites must have been related to soil/culture conditions.

Lupins would not have produced a crop at either site as they did not dry down well. At both sites, some lupin plants were completely stripped of leaves and pods, and some plants were yellow. There was a heavy pod set on plants not so affected.

<u>First Production Year (1991) for the Undersown Forage</u>

At the Van Thielen site, where the grain crops had not been harvested in 1990, there was a lot of winter kill of the undersown crop. Average Percent cover on the ground on July 15, 1991, was estimated as 47-55% in the Faba, Lupin, Lupin/Faba and Cereal/Pea plots, and 76% in the Cereal plots. At the Hubbard site, cover was close to 100%.

Formal observations were carried out at the Hubbard site only (Table 8). As in 1990, there were large differences between replicates (Blocks), with replicate one having poorest yields. The effect was greatest on clover, not very pronounced on grass.

The total yields were low due to the drought. At sampling, timothy had headed out, approximately 20% of red clover and 5% of the ladino was flowering.

The forage established under cereal had the highest clover content in 1991, that established under fababeans, the lowest; also the % cover of the ground was lowest under fababeans. Lupins did not supress establishment and yield as much as fababeans. The clover was roughly 50% ladino and 50% red, except in Block I in which about half of the total clover was wild white clover; wild white was insignificant in Blocks 2 and 3.

Table 8. Biomass of forage and other data for Hubbard site, June 20, 1991. Biomass values are means for 3 plots; forage analyses were made on composite samples (not separated into components).

Treatment/ Replicate	Clover	Grass	Weeds (kg/ha)	Total	%Cover	CP%	ADF%	TDN%	DE[a]
Fababeans	365 p[b]	665 pq	175 p	1206 p	58 p				
Lupins	410 p	782 p	26 p	1218 p	88 q				
Faba/Lup	425 p	736 p	14 p	1156 p	79 q	12.0	29.7	66.3	2.92
Peas/Cer	370 p	661 pq	125 p	1156 p	85 q				
Cereal	582 p	428 p	116 p	1126 p	90 q	14.8	29.7	66.3	2.92
One	99 p	536 p	103 p	737 p	66 p				
Two	562 q	763 p	122 p	1445 q	88 q				
Three	697 q	665 p	18 p	1380 q	96 r				

[a] Estimated digestible energy Mcal/kg

[b] Within columns, probability that means not sharing a letter come from the same population is 0.1 or less; tests also significant at =0.05 are:

Grass: Cereal versus Lupins,

For Replicates:

Clover: One versus two, three

Total: One versus two, three

Cover: One versus two, three; two versus three

I. 4 Conclusions

The experiments suggest that very good yields of silage could be obtained from fababeans or lupins in the region, while undersowing the crops. It appears that there is some loss in the clover component in forage undersown in grain legumes compared to underseeding in cereal.

When the grain legumes are not cut early for silage, as at the Van Thielen site, it appears that there will be poor establishment of the undersown forage.

Total yields of fababeans were higher than lupins, but the quality of the lupin material may be better (higher CP, lower ADF). Fababeans appeared to make a satisfactory silage. It may be possible to get good grain yields from fababeans, but farmers should try a small acreage first. The common lupin variety did not produce mature grain at either site, nor did it in 1989 at the Hubbard farm. Total protein yield from fababeans and lupins was 25-50% higher than that from yield from fababeans and lupins was 25-50% higher than that from peas and cereal, but the relative feeding qualities are not known at this point.

II. IMPROVING HAY QUALITY

II.1 Treatments

Experiment IIA Treatments

1. Control #1
2. Manure applied 1st production year
3. Compost applied 1st production year
4. Synthetic Fertilizer applied 1st production year

5. Control #2
6. Manure applied 2nd production year
7. Compost applied 2nd production year
8. Synthetic Fertilizer applied 2nd production year

Experiment IIB Treatments

1. Marino Red Clover/Champ Timothy (8/5 kg/ha)
2. Apica Alfalfa/Champ Timothy (12/5)
3. Marino Red Clover/Sacramento & Sonja White Clover/Champ Timothy (8/1&1/5)
4. Marino Red Clover/ Sacramento & Sonja White Clover/Apica Alfalfa/Champ Timothy/ Saratoga Brome(5/1/1/5/2/4)
5. Common Triple Mix (12.5 kg/ha)

II.2 Methods.

EXPERIMENT IIA

In 1990, the experiment was set up at the Hubbard farm on a Sonja clover/Timothy dominated hay mix that had been seeded in 1989 on "Field G". The treatments were applied on August 23, after the second cut. A third cut was taken from the field in September. (It had been intended to put treatments out after first cut, but this was not possible because of a heavy work schedule). Plots were 6 x 5 m; there are three blocks with 8 treatments per block and 4 blocks (replicates). The manure came from the Hubbards manure pile (from Jerseys). The "compost" was one year old manure stacked in a small pile, but not turned. Mr. Hubbard began a regular compost pile in the summer of 1990. The fertilizer recommendation based on a soil test in June, was for 50 kg N, 30

P2O5 and 25 K2O. A mix was prepared to give these proportions. Samples of manure and compost were frozen and later analyzed by NSDAM.

Soil samples were taken from all plots, 5 cores/plot on December 8. Each plot sample was analyzed for pH, electrical conductivity and nitrate in 1:1 water extracts (weight of fresh soil to volume of water). The nitrate was determined with Merckoquant test strips. These tests were done by C. Yang (PhD student in D. Patriquin's lab) without knowledge of the different treatments. A composite soil sample was prepared for standard soil analyses.

In 1991, the same experiment was set up at Van Thielens on the lower part of the field field where the hay mixes were set up (below). The plot size was 5 x 6 m; NPK was applied at the same rate as for the Hubbard manure experiment. Fertilizers were applied on June 22, 1991.

Also in 1991, manure, compost and NPK were applied to a second set of plots at the Hubbard site after the first cut (end of June) rates as before. The same manure and compost, from the Van Thielen farm, were used at both sites.

Observations on fertilized plots, 1991.

Hubbards: June 18: Plants were clipped in three quadrats (50 x 50 cm) in each plot. Total fresh weight was determined and a subsample dried. Contents of 1 quadrat in each plot were separated into grass, legume and weed components, weighed and the whole sample or subsamples dried and weighed again. Maximum heights of legume, grass and weed components in each quadrat, percent cover and weed species were recorded.

On August 26, all plots (including those fertilized in 1990 and 1991, total 8 plots per block; 4 blocks) were sampled. Two quadrats were taken from each plot. No separations were made. Percent grass, clover and weeds in each quadrat were estimated visually, and maximum heights of the components measured. Samples were weighed and a composite sample dried.

Van Thielen: On July 19 and Aug 27, sampling was conducted as described above for the June 18 sampling of the Hubbard site, except that on the Aug. 27 sampling, two rather than 3 quadrats were sampled in each plot.

EXPERIMENT IIB
Initially it was intended to set these comparisons up as unreplicated strip demonstration trials, seeded by the farmers. However, it was evident that it would be very difficult to sow the relatively small amounts of seed at different rates using the Brillion seeder. Also, because of the late spring, there were some changes in available field space. Hence at Hubbards we set up a replicated experiment on a smaller area. At the request of David Firth, we set up a replicated rather than unreplicated experiment. The experiment was set up as planned (unreplicated, large strips) at the Van Thielen farm, except that it was just seeded by hand with a cyclone seeder.

All legume seed was treated with *Rhizobium* inoculant.

At harvest, samples were taken using 50 x 50 cm quadrats. Vegetation was cut at 5 cm height to simulate mowing or grazing. For a certain proportion of quadrat samples at each site (details below), maximum heights of legume, grass and weed components were measured and the biomass separated into legume, grass and weed components. Fresh weights were measured on-site, and subsamples taken to obtain dry-to-fresh weight ratios. Weeds considered to account for 80% of the weed biomass were ranked in abundance (1 highest).

Details for individual farms

FARM 1: FIRTH

Field: Seashore Field (2.6 ha)

Crop 1990: The field was disced with a triple K harrow, chain harrowed and 200 kg 12-24-24 fertilizer applied before seeding. On June 19 a barley/pea/vetch mixture (92/29/20 kg/ha) was sown using a Vicon spreader followed by harrowing. It was undersown, except in the experimental area, with a mixture of Ladino clover/Farol Timothy/Meadow Fescue (2/3/5 kg/ha). The mixed grain was harvested for silage on Aug 13.

Previous crops: In 1987, there was hay on this field, and in 1988 and 1989, fertilized ryegrass. The ryegrass was used for hay (first cut) and green feed (second cut)

Date experiment set up: June 21

Plot details: Plots are 3 x 11 m set out in one N-S oriented row located on the east side of the "Seashore Field". There are 3 replicates, RCB design. The soil was harrowed lightly before seeding. Seed was distributed by hand. It had been intended to pack it afterward, but rain overnight prevented this from being done.

Observations in 1990: The plots were sampled on October 15. One 50 x 50 cm quadrat sample was placed in each plot at a standard (predetermined) position. Heights of tallest grasses, legumes and weeds were recorded for each quadrat, the vegetation cut at approximately 5 cm, separated into grass,legume, and weed components and the fresh weight determined. One composite sample of each vegetation type was dried to determine the dry-to-fresh weight conversion ratio.

Observations in 1991

The plots were inadvertently mowed on June 19, so we did not sample the first cut. Plots were sampled on Aug. 3, prior to second cut. Two quadrats were sampled in each plot; biomass separations were conducted on one quadrat. Percent cover was estimated for each quadrat.

FARM 2: HUBBARD

Field and previous crops The plots were set up on the "Experimental field". The history of this field is as follows:

1987: Oats grown with 250 lbs/acre 17-17-17
1988: Barley/clover grown with 250 lbs/acre 17-17-17
1989: Oats/Alsike clover grown with 200 lbs/acre 17-17-17
1990: Outside of the experimental area: oats/Alsike clover, with manure; peas; winter wheat.

Date experiment set up: June 8, 1990

Plot details: Each plot is 15 x 5 m; there are 3 replicates (blocks) . Blocks are set across the slope to the east, 1 lowest, 3 highest. Seed was broadcast by hand, and packed with a Brillion seeder.

The plots were sampled on Aug 21. On Aug 24, one half of each block, the east or west half (selected randomly) was cut with a bush mower; the other half was left standing.

Observations in 1990: The plots were sampled on August 24, 1990. Three 50 x 50 cm quadrat samples were placed in each plot using random number tables to locate them. For one of the three quadrats, heights of tallest grasses, legumes and weeds were recorded. The vegetation was cut at approximately 5 cm height, separated into grass,legume, and weed components and the fresh weight determined. A subsample of each vegetation type was dried to determine the dry-to-fresh weight conversion ratio. For the other two quadrats, only the total biomass was determined; one composite sample (from the two quadrats) was dried to determine the dry-to-fresh weight conversion ratio.

Observations in 1991
Plots were sampled just before the field was mowed in June and again in August. Two quadrats were sampled in the mowed and two in the unmowed sections of each treatment in each block. Percent of different legume species in the legume component was estimated for each quadrat, and heights were measured as above. One quadrat sample from each pair of two was separated into legume, grass and weed components. Samples for chemical analysis were taken from the mowed plots only.

FARM 3: Van Thielen

Field: 3 acre field , 2nd field to east of pig barn

Crop 1990: Common Triple Mix, broadcast and harrowed on June 14. The whole field was mowed on July 28 because of heavy weed growth.

Previous crops: This field had been hayed or pastured since 1972; it was hayed the last 3 years and received applications of liquid hog manure. The field was plowed in spring of 1990 and received 3t/ac lime and an application of solid manure.

Date experiment set up: seeded: June 13

Plot details: Each plot consists of a 12 m wide strip across the width of the field (27.5 m). There is one plot per treatment (no replicates), laid out in the order 5,4,3,2,1 across a gentle slope (5 highest). Plots were mowed on July 28. Samples were taken August 28th, after which cattle grazed the field.

Observations in 1990: The plots were sampled on August 28. Ten 50 x 50 cm quadrat samples were placed in each plot by traversing it twice, and throwing the quadrat with eyes closed. For every second quadrat, heights of tallest grasses, legumes and weeds were recorded and the proportion of different legumes in the legume component and of different grasses in the grass component estimated. The vegetation was cut at approximately 5 cm, separated into grass,legume, and weed components and the fresh weight determined. One composite sample of each vegetation type was dried to determine the dry-to-fresh weight conversion ratio. For the other 5 quadrats from each plot, total fresh weight was determined, and a composite subsample dried.

Observations and application of manure in 1991

June 11: 7 quadrats were taken at random from each treatment strip. Fresh weight was determined for each sample. Quadrats 1 & 3, and 5 & 7 were combined and a subsample taken for drying. Separations were carried out on quadrats 2,4,6, with subsamples taken from each component for drying. Heights were measured as above but in all quadrats,and weeds were ranked. Cover % was estimated for each quadrat, and also the percent of legume in the biomass. Cattle were grazed on the field from June 15 to 19.

On June 28, the experimental area was divided into three 9 meter strips oriented perpendicular to the strips of different hay mixtures. Cattle manure and hog slurry were applied at rates of 1.5 loads (135 bu spreader) per acre and 3000 US gallons per acre. A composite soil sample (#14) was taken from the entire area before spreading manure.

July 19: Three quadrats were taken in each manure treatment area for each mix, i.e. 9 quadrats per mix in total. % Cover, and percent compositon were estimated visually, and heights measured as above. Separations were made for 1 quadrat in each set of 3; subsamples were taken from all individual samples for drying.

August 23: 5 quadrats were taken from the unfertilized part of each hay mix strip; for hay mix #4 only, 5 quadrats were also taken from the cow manure and pig slurry strips. Total fresh weights were determined, and subsamples dried. No separations were made, but % composition was estimated visually.

II.3. Results 1. Fertilizing Hay

The composition of the manure and "compost" (actually aged manure, not turned) is given in Tables 9 and 10. . The aged manure used in 1990 (from the Hubbard farm) had a lot of soil mixed in with it and was not as rich in nutrients as the fresh manure. Manure and compost were taken from the Van Thielen farm in 1991. The contents of N and P are similar for the Van Thielen manure and composted manure, but the K content of the composted manure was much lower suggesting that a lot of K was lost during composting; this is suggested also by the much lower K:P ratio for composted versus fresh manure.

Table 9. Composition of manure and compost used in 1990 (100% dry basis).

Sample	D.M.%	O.M.%	N%	P_2O_5%	K_2O%	N/P	K/P
Fresh man	31.4	76.8	2.6	1.81	1.31	1.44	0.72
Aged man	43.6	33.3	1.3	0.82	0.35	1.58	0.43

Calculated loading in kg/ha:	N	P_2O_5	K_2O
Fresh man	122	85	62
Aged man	68	43	18
Fertilizer	50	30	25

Table 10. Composition of manure and compost used in 1991.

Sample	DM%	N%	P2O5%	K2O%	N/P	K/P
Fresh	18.4	2.22	1.26	3.41	1.76	2.71
Composted	23.9	3.07	1.65	1.10	1.86	0.66

Calculated loading in kg.ha	N	P2O5	K2O
Fresh manure	61	35	94
Composted manure	88	47	32
NPK	50	30	25

The analyses of composite soil samples for different treatments are given in Tables 11 and 12. There appear not have been any pronounced effects of the additions on soil properties at these times.

Table 11. Soil properties under hay to which manure, aged manure or NPK fertilizer were applied (Hubbard site). Applications were made on Aug 23, 1990 (Set 1), and June 28, 1991 (Set 2). Composite samples (all reps combined) were analyzed.

SAMPLE	LOI[a] (%)	pH	P_2O_5	K_2O	Ca	Mg	NO3 ppm
			(kg/ha)				
June 8, 90							
whole field	5.4	6.1	154M	207M+	1032L-	225M	
Dec 8, 90							
Control1	5.5	6.2	309H	273H-	1719L+	306M	<1
Manure1	5.4	6.2	312H	304H-	1800L+	343M+	<1
Compost1	5.5	6.0	246H-	284H-	1382L	285M	<1
Fertilizer1	5.2	5.8	272H	292H-	1225L	228M	<1
May 21,91							
Controls	5.4	5.8	192M+	171M	1204L	228M	
Aug 6, 91							
Control1	5.5	5.8	266H-	192M	1611L	270M	9
Manure1	6.0	5.8	190M+	176M	1491L	282M	9
Compost1	6.3	5.7	195M+	202M+	1526L	300M	13
NPK1	6.2	5.6	193M+	190M	1402L	277M	6
Aug. 2, 91							
Control2	6.1	5.7	211H-	223M+	1518L	302M	9
Manure2	6.5	5.9	244H-	247H-	1955L	336M+	6
Compost2	5.9	5.7	251H-	206M+	1297L	248M	8
NPK2	6.5	5.8	257H-	191M	1590L	262M	12

Table 12. Soil properties under hay to which manure, aged manure or NPK fertilizer were applied (Van Thielen site). Applications were made on June 22, 1991

SAMPLE	LOI[a]	pH	P_2O_5	K_2O	Ca	Mg	NO3
	(%)		-------------	(kg/ha)	-------------		
ppm							
<u>May 21,91</u>							
Field	6.2	6.6	649H+	169M	3937M	793H	
<u>July 31,91</u>							
Control1	6.0	6.5	681H+	133M-	2254M	886H	15
Manure1	6.3	6.6	748H+	201M+	4823M	964H+	26
Compost1	6.6	6.5	758H+	193M	4430M	856H	57
NPK	6.0	6.4	696H+	134M-	4122M	782H	67

No biomass samples were taken in 1990.

In 1991, yields for all fertilizer treatments, except for compost in the Van Thielen August sampling, were numerically higher than the controls (Table 13), Only some of the NPK treatments, and the compost treatment for Hubbard June sampling were significantly higher than controls at the 0.1 or lower probability level, however. From the Hubbard June and Van Thielen July samplings, it can be seen that grass was more affected than the legume components by fertilizing. There was a significant carryover effect of applying NPK to hay at Hubbards in 1990; yield at both cuts in 1991 was improved; compost applied in 1990 had a similar effect at first cut but not at the second.

Fertilizing increased the total protein at the Van Thielen site, but not at the Hubbard site (Table 14).

There was a lot of variability in the plots, which makes the statistical tests somewhat insensitive. Probably the drought was a complicating factor, i.e. under closer to normal conditions, we might have seen less variability and possibly more response to the organic fertilizers.

Table 13. Manure experiments: Crop Biomass and Components, 1991

Site, Treatment Time	Total Biomass	Clover	Grass	Weeds
	(kg Dry Matter per hectare)			
HUBB Jn 18: Fert 90				
Control	1804 p[a]	559 pr	1150 p	95 p
Manure	1808 p	305 q	1376 p	128 p
Compost	2599 q	624 rp	1597 pq	379 q
NPK	2846 q	506 pq	2319 q	21 p
HUBB Aug 26				
Control Fert 90	608 p	No separations		
Manure Fert 90	667 p			
Compost Fert 90	696 p			
NPK Fert 90	1251 q			
Control Fert 91	655 p	No separations		
Manure Fert 91	892pqr			
Compost Fert 91	832 p			
NPK Fert 91	1214 r			
VAN TH Jy 19 Fert 91				
Control	328 p	65 p	166 p	96 p
Manure	371 p	94 p	228 p	48 p
Compost	540 p	69 p	379 p	91 p
NPK	805 p	185 p	482 p	138 p
VAN TH Aug 27 Fert 91				
Control	1217 p	270 p	743 p	205 p
Manure	1650 p	261 p	864 p	525 q
Compost	1096 p	106 p	689 p	301 p
NPK	1355 p	299 p	833 p	223 p

[a]Within columns, probability that means not sharing a letter come from the same population is 0.1 or less; tests also significant at α =0.05 are:

HUBB. Jn:
Clover: Manure versus compost
Grass: NPK versus control
Weeds: Compost versus Control, NPK
HUBB. Aug
Total Biomass: NPK 90 versus Control 90, Manure 90, Compost 90, Control 91, NPK 91 versus Control 91, Manure 91, Control 90,Manure 90, Compost 90 Manure 91 versus Control 90#
VAN THIELEN. Aug
Weeds: Manure versus Control*, NPK*

Table 14. Manure Experiments: Forage Analyses.

Sample		CP%	ADF%	TDN%	DE[a]	Ca%	P%	K%	Mg%
VT Aug 27									
Control		16.5	27.1	69.7	3.07	0.61	0.42	2.25	0.26
Manure		19.0	25.3	72.0	3.17	0.65	0.45	2.76	0.24
Compost		17.3	27.7	68.9	3.03	0.54	0.41	2.58	0.20
NPK		20.9	24.9	72.6	3.19	0.61	0.42	2.68	0.25
HUBB Aug 26									
Cont	1	14.3	26.9	69.9	3.08				
	2	9.9	30.8	64.9	2.85				
Man	1	13.0	27.7	68.9	3.03				
	2	11.4	30.5	65.2	2.87				
Comp	1	14.9	26.4	70.6	3.11				
	2	14.1	28.1	68.4	3.01				
NPK	1	13.0	28.9	67.3	2.96				
	2	13.5	28.1	68.4	3.01				

[a] Estimated digestible energy, Mcal/kg

II. 3. Results 2: Comparison of different hay mixtures in establishment year

The hay mixes were established under 3 quite different regimes:

- At the Firth farm, the mixes were undersown in mixed grain on June 21. The field had fertilized ryegrass on it previously. The mixed grain was harvested for silage on Aug. 21. Plots were sampled Oct. 15.

- At the Hubbard farm, the mixes were direct seeded on a new hay field (under grains previously) June 8 and sampled Aug 24.

- At the Van Thielen farm, the mixes were direct seeded June 15 into recently broken sod; the field was mowed July 28 to control weeds and sampled Aug 28. This field had received a lot of liquid hog manure in the past.

The mixtures were sampled at the 5-10% flowering stage for red and Alsike clovers at Hubbard and Van Thielen sites; it had not reached this stage at the Firth site. Heights of forage at harvest increased between farms in the order Firth- Van Thielen- Hubbard (Fig. 8), as did total biomass (Table 11). (Note at the Firth site, where the hay had been established by undersowing, it was not intended to take a cut of hay off in the establishment year). At Firth and Hubbard sites there was very little grass (timothy, brome and weedy grass species) in the biomass at harvest, while grass was a significant component at the the Van Thielen farm. This probably reflects the intensity of N loading in the past which would be greatest at Van Thielens, least at Hubbard. The CP values are also higher for the Van Thielen site, suggesting higher N loading (assuming identical stages at cutting).

Alfalfa was noticeably chlorotic compared to other legumes at the Hubbard site. At all sites, a leaf spot disease was observed on undersides of leaves of red clover.

At Van Thielen and Firth sites, legume biomass and the total biomass were lowest in the Common Triple Mix plots. At the Hubbard site, mixes yielded roughly equivalent legume biomass and total biomass, except for those with alfalfa which did not do well (Table 11, Fig. 9).

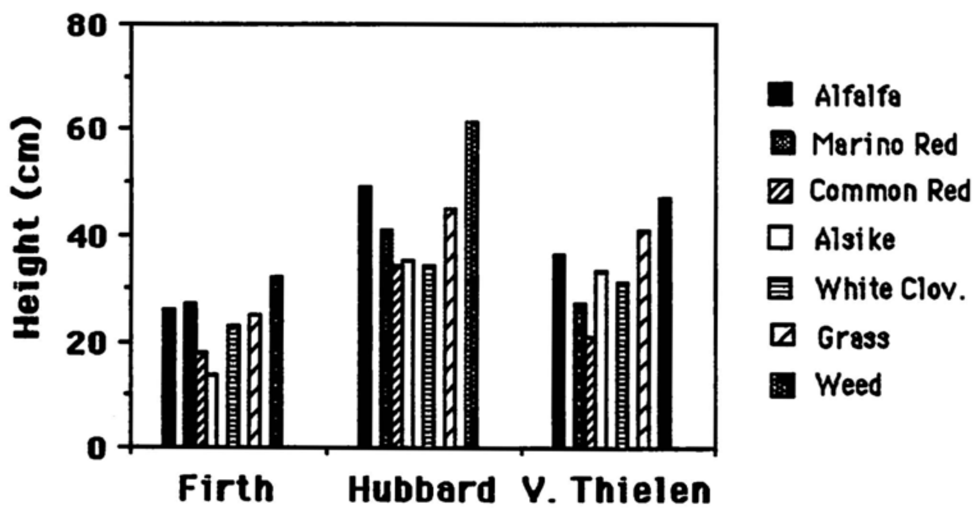


Figure 8. Heights of legumes, grasses and weeds at biomass harvest (see text). Values are averages for all treatments at each site.

Table 14. Dry matter yields of different hay mixes 1990. Values are averages based on 3 plots per treatment at Firth and Hubbard sites. At the Van Thielen site, the plots were not replicated, and values are averages for replicate samples within individual plots (see methods).

Farm & Mix	Dry matter yields (kg/ha)			
	Clover/Alf	Grass	Weeds	Total
FIRTH				
1. RC/T	494 p[a]	7 p	208 p	709 p
2. A/T[a]	638 q	(0) p	91 q	729 p
3. RC/WC/T	628 q	(0) p	188 pr	816 p
4. RWA/B/T	614 p	35 p	84 qr	733 p
5. Tmix	208 p	45 p	322 p	576 p
HUBBARD				
1. RC/T	1630 p	0 p	1234 pq	2864
2. A/T[a]	1210 p	58 p	815 p	2083
3. RC/WC/T	1807 p	0 p	1257 pq	3065
4. RWA/B/T	1621 p	39 p	1509 q	3170
5. Tmix	1457 p	91 p	981 pq	2529
V. THIELEN				
1. RC/T	1038 p	719 p	542 p	2300 p
2. A/T[a]	949 pr	571 p	487 p	2009 p
3. RC/WC/T	902 pr	521 p	654 p	2077 p
4. RWA/B/T	661 pr	490 p	730 p	1880 pq
5. Tmix	425 r	330 p	736 p	1491 q

[a]Within columns, probability that means not sharing a letter come from the same population is 0.1 or less; tests also significant at =0.05 are

<u>Firth site on October 15.</u>
Weeds: Triple mix (5) versus 2, 4; Complex mix (4) versus ,3,5
Alf/timothy (2) versus 5

<u>Hubbard site on August 24.</u>
Total: Alfalfa/Timothy (2) versus 3, 4

<u>Van Thielen site on Aug. 28.</u>
Total: Triple mix (5) versus 1

[b]% of alfalfa in clover/alfalfa (4): Firth 21.7%, Hubbard 33.3%, Van Thielen 31.8%

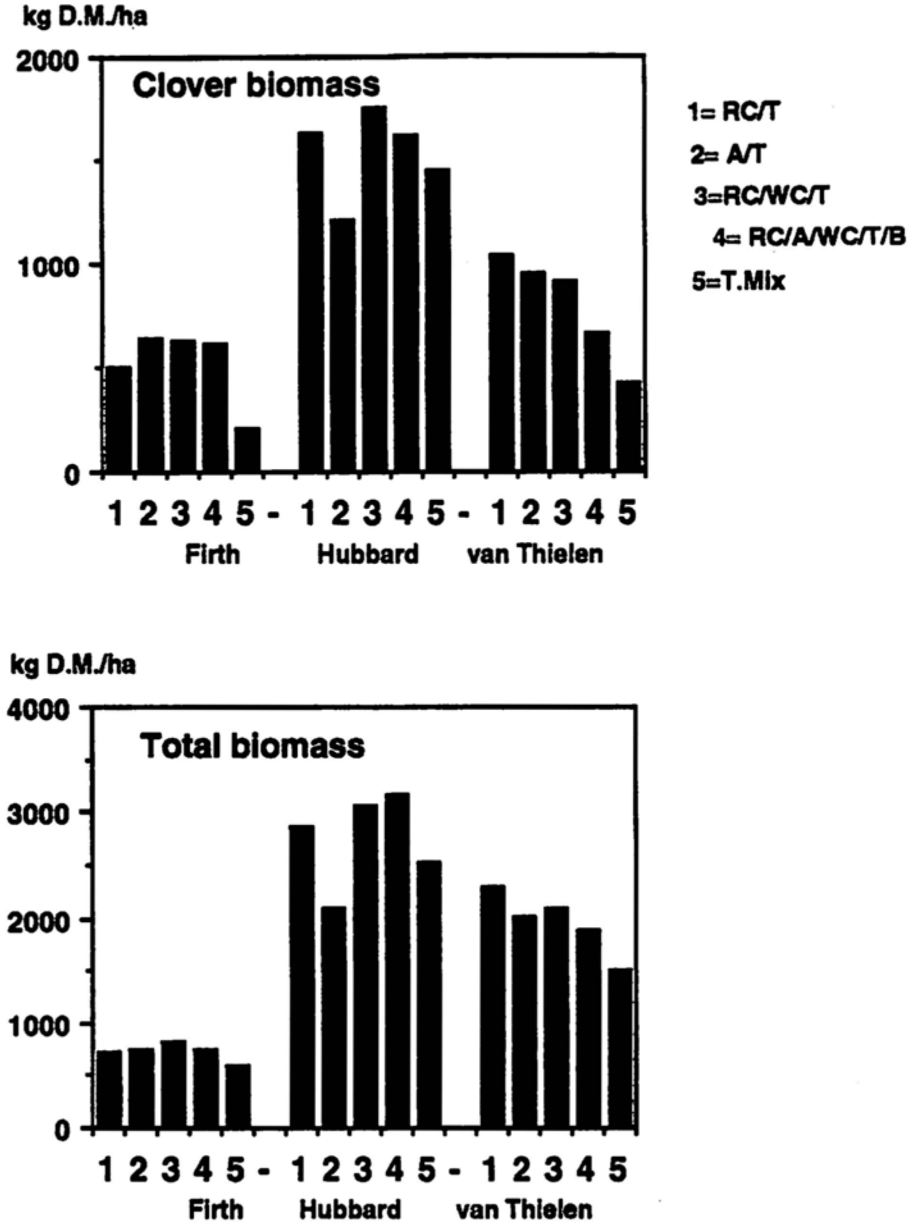


Fig. 9. Clover biomass and total biomass in hay mixes, 1990 (data from Table 11).

Table 15. Crude Protein and Acid Digestible Fibre content of forages.

Farm & Mix	%Crude Protein/%Acid Digestible Fibre (dry weight basis)			
	Legume	Grass	Weeds	Total
HUBBARD				
1. RC/T	21.8/19.3	-	13.2/25.7	19.8/19.3
2. A/T	13.1/23.8	-	11.5/21.7	10.5/28.5
3. RC/WC/T	17.9/20.3	-	15.0/23.2	18.6/22.2
4. RWA/B/T	22.3/19.1	-	14.5/20.8	15.9/26.6
5. Tmix	22.1/21.7	13.3/30.0	12.8/20.7	15.5/24.8
Van THIELEN				
1. RC/T	23.2/21.3	21.6/30.7	-	20.8/27.8
2. A/T				
alfalfa:	19.9/21.1	20.2/30.7	18.2/22.7	21.4/25.0
clover:	25.0/23.2			
3. RC/WC/T	25.3/17.3	-	-	22.2/25.5
4. RWA/B/T	23.9/20.9	-	-	20.9/26.9
5. Tmix	25.3/20.8	-	-	19.7/23.7

Nitrate contents: Hubbard Mix 3: 0.15%
Van Thielen Mix 3: 0.48%

The percentage of different legumes and grasses in mixes was estimated subjectively for each sample at the Van Thielen farm; averages of the estimates are given in Table 16.

Table 16. Average values of visually estimated percentages of different clovers and grasses at the Van Thielen site in 1990.

Treatments	Legume component	Grass Component
RC/T	Red: 65% Other 35% (Alsike, wild white, hop)	Timothy 25% Couch and others 75%
Alf/T	Alfalfa 60% Other 40%	Timothy 25% Couch and others 75%
RC/WC/T	Red 40% White & Other 60%	Timothy 42% Couch and others 58%
RC/WC/Alf T/B	Alfalfa 33% Red 26% White 34 Other 7%	Brome 56% Couch & others 44%
Triple Mix	Red 23% Alsike 75% Wild white 2%	Timothy 25% Couch 75%

As at the Van Thielen site, at the Hubbard and Firth sites we noted good establishment of white and red clovers in Mixtures 1,3, and 4; Alsike was noted to be predominant in the Triple Mix, and although there was little grass, it was mostly Brome in Mixture 4.

The predominant broadleaf weeds at the three sites were

Firth: corn spurry, dandelion, mouse ear chickweed, plantain
Hubbard: lambsquarter, sow thistle, hemp nettle, cudweed
Van Thielen: hemp nettle, Canada thistle, plantain, knotweed, dandelion, barnyard grass

At the Hubbard site, block effects were noted as in experiment I, with lowest yields of legumes and lowest values of P,K and Ca in Block I (Tables 14, 15). Weed biomass values were highest where clover biomass was lowest (Table 15).

Table 17. Soil data for the Experiment IIB sites 1990 & 1991.

SAMPLE	LOI[a] (%)	pH	P_2O_5	K_2O	Ca	Mg
			(kg/ha)			
Firth June, 1990	5.5	6.5	275H	149M-	2951M-	324M
Hubbard, Jn 1990	6.1	6.6	114M-	106L+	1395L	461M+
V Thielen, Jn 1990	5.1	6.6	875H+	251H-	4246M+	767H
Hubbard, May 8, 1991						
Block 1	5.0	5.9	135M-	201M+	1127L-	340M+
Block 2	5.5	6.0	156M	204M+	1570L+	414M+
Block 3	6.0	6.1	208H-	216M+	1738L+	450M+
Firth, Aug 21, 91	10.4	6.8	227H-	72L	2711M	350M+
Hubb Aug 21, 91	7.0	6.2	180M+	169M	1733L	413M+
VT Aug 21, 91						
No added man	6.0	7.1	670H+	135M-	3922M	713H
Cattle man	5.5	6.9	684H+	311H-	3277M	647H
Hog slurry	7.3	6.7	717H+	154M-	3434M	566H-

[a] Loss on ignition

Table 18. Data illustrating variation in production between blocks at Hubbard site (Exp. IIB).

Hubbard:	Clover		Weed		Total	
	(kg dry matter/ha)					
Block 1	851	p[a]	1577	p	2429	p
Block 2	1938	q	836	p	2886	p
Block 3	1846	q	1066	p	2912	p

[a]Within columns, probability that means not sharing a letter come from the same population is 0.1 or less; differences also significanct at =0.05 are : Clover: 1 vs 3, 1 vs 2

II .3. Results 3: Comparison of different hay mixtures in first production year

1991 was very droughty for most of June and July (Appendix A), and forages did poorly generally in Nova Scotia; in many cases, they began to flower while short and at a stage not really worth harvesting in terms of volume of material.

At the Firth site, the plots were inadvertently mowed before sampling could be conducted in June. The plots were sampled before mowing in August.

At the Hubbard site, plots were sampled in June and again in August, before mowing.

Plots at the Van Thielen site were sampled 3 times, prior to turning in cattle to graze for 3-5 days. Cattle manure and pig slurry was applied in strips after the first cut (see below).

Average maximum heights of the legume and grass components at each sampling are given below (n=24 to 30):

Site	Grass (cm)	Legume (cm)
Firth, Aug 3	40	29
Hubb June 21	56	44
Hubb Aug 5	38	39
VT, June 11	49	25
July 21	35	18
Aug 23	31	19

In 1990, the establishment year, biomass of common triple mix ranked 5th, 4th and 5th at the Firth, Hubbard and Van Thielen sites respectively. In 1991, it ranked 4th, 4th and 1st at the three sites respectively (Fig. 5 and Table 19). . Thus the second year results are consistent with the first year results for the Firth and Hubbard sites, but not at the Van Thielen site. (Note that the different mixes were set up in single strips at the Van Thielen site, therefore differences between the strips could be due to positional effects and/or to the mixes themselves. At the Firth and Hubbard sites, there were 3 replicates of each mix, so differences not attributable to background variation can be attributed to the mixes rather than to position).

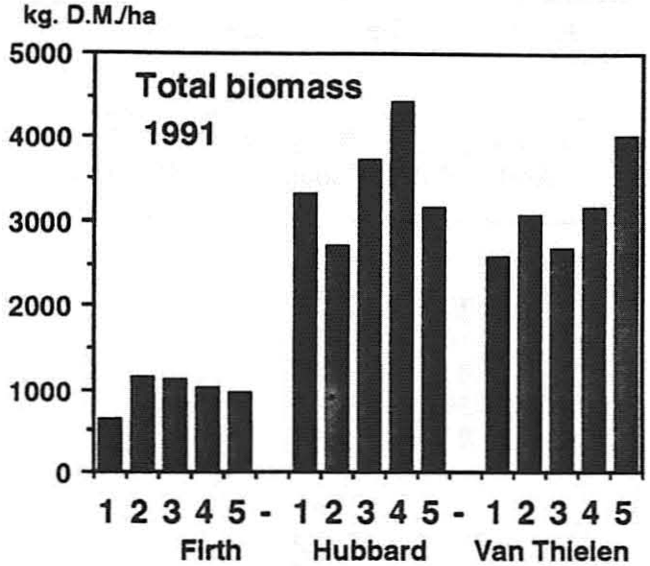


Figure 10. Total biomass of the different hay mixes in 1991. Data from Firth site are for the second cut only; data for Hubbard and Van Thielen sites represent the whole season yields. Compare with Fig. 9 for 1990 (p. 60).

As well as ranking low in terms of total biomass, the common triple mix treatments also had the lowest % of legumes in the biomass at the Firth and Van Thielen sites (Table 19) and the greatest weed biomass (Table 20). There was a relatively high proportion of Alsike in the legume component at both sites (Table 19).

Table 19. Visually estimated legume species composition at the three sites, 1991. Each number is an average from 6 separate estimates.

Site & Hay Mix	Visual Estimates %RC	%WC	%Alsike	%Alf	% legume in biomass by wt[a]	Total Yield Rank[a] (1 high)
Firth, Aug 3						
1. RC/T	98	0	0	2	68	5
2. A/T	0	0	0	100	87	1
3. RC/WC/T	48	50	2	0	78	2
4. RWA/B/T	38	3	0	59	97	3
5. Tmix	67	3	30	0	44	4
Hubbard, Aug 5						
1. RC/T	98	1	1	0	69	2 (3)[b]
2. A/T	15	12	4	69	79	5 (5)
3. RC/WC/T	62	24	14	0	92	3 (2)
4. RWA/B/T	44	39	6	21	85	1 (1)
5. Tmix	46	9	42	3	74	4 (4)
Van Th., Jy 21						
1. RC/T	58	5	37	0	29	5 (5)
2. A/T	72	7	18	4	11	2 (3)
3. RC/WC/T	85	13	1	0	4	4 (4)
4. RWA/B/T	20	63	14	3	41	3 (2)
5. Tmix	38	55	7	0	44	1 (1)

[a] Calculated from data in Tables 20,21, & 22.

[b] Numbers in brackets are for all harvests combined. At Firth's, the first harvest was missed, but visually it was evident that #2 ranked top at that time.

Table 20. Biomass data for different hay mixes at Hubbard and Firth sites, 1991. Forage chemical analyses were performed on composite samples from mowed plots.

Hay mix	Clover	Grass	Weeds	Total	CP%	ADF%	TDN%	DE[a]
HUBBARD								
June 20, 1992								
1. RC/T	918 p[b]	545 p	23 p	1485 p	17.0	23.4	74.5	3.28
2. A/T	1000 p	329 p	143 q	1534[c] p	12.5	26.1	71.0	3.12
RC/WC/T	1189 p	658 p	67 pq	1914 p	14.8	26.0	71.1	3.13
4/ RWA/B/T	1575 p	577 p	93 pq	2010[c] p	18.1	21.2	77.3	3.40
5. Tmix	943 p	487 p	27 rp	1457 p	15.6	25.2	72.2	3.18
Aug 5, 1992								
1. RC/T	1259 pr	475 p	87 p	1821 p	14.3	28.2	68.2	3.00
2. A/T	929 p	199 pq	52 pq	1180 q	16.1	25.8	71.4	3.14
3. RC/WC/T	1668 qr	120 q	33 q	1820 p	18.2	25.5	71.8	3.16
4. RWA/B/T	2052 q	329 pq	23 q	2405 r	17.2	27.5	69.1	3.04
5. T mix	1257 pr	290 pq	137 r	1684 pq	15.0	28.4	68.0	2.99
FIRTH								
Aug 3,1992								
1. RC/T	437 p	137 p	72 p	646 p	17.8	22.2	76.0	3.34
2. A/T	1003 p	105 p	45 p	1153 q	22.0	21.7	76.8	3.38
3. RW/WC/T	873 p	189 p	58 p	1120 q	16.8	24.4	73.2	3.22
4. RWA/B/T	987 p	21 p	12 p	1020 pq	21.6	21.4	77.2	3.40
5. Tmix	426 p	111 p	424 q	960 pq	20.8	18.7	80.7	3.55

[a]Estimated digestible energy, Mcal/kg

[b]Within columns, probability that means not sharing a letter come from the same population is 0.1 or less; differences also significant at α =0.05 are:

Hubbard, June 21:

Weeds: Tmix (5) versus 2; RC/T (1) versus 2

Hubbard, Aug.5

Legumes: A/T (2) versus 3, 4; Tmix (5) versus 4; RC/T (1) versus 4

Weeds:RWA/B/T (4) versus 1, 5; Tmix (5) versus2, 3

Total: A/T (2) versus 1, 3, 4; Tmix (5) versus 4*

Firth, Aug. 5

Weeds: Tmix (5) versus 1, 2

[c]Total is not the exact sum of constituents because some of the sorted subsamples were lost during a storm (n= 4 or 5) and totals are based on weights of all samples before subsampling (n=6)

Table 21. Van Thielen Hay Mixes 1991: comparison of total biomass on 3 dates for the 5 mixtures. Data are for unfertilized plots, except for July 19 for which unfertilized and cow manure plots are combined.

Hay Mix	Total Dry Weight (kg/ha) and protein %								
	June 11		July 19		Aug 23		Total		
	DW	Pr%	DW	Pr%	DW	Pr%	DW	Pr%	DE[a]
1. RC/T	1408p[b]	16.3	367pq	19.4	792p	20.1	2567	467	12800
2. A/T	1684p	14.5	476q	14.9	888p	18.9	3048	483	14900
3. RC/WC/T	1488p	14.9	393pq	15.7	808p	16.3	2689	415	12900
4. RWA/B/T	1468p	14.7	490q	16.2	1192p	19.6	3150	332	14600
5. Tmix	2452p	19.4	298p	14.3	1272q	22.2	4022	800	20200

[a]Estimated digestible energy Mcal/kg

[b]Within columns, probability that means not sharing a letter come from the same population is 0.1 or less; differences also significant at =0.05 (Unpaired t-tests: 7 quadrats on June 11 per plot, 6 on July 19 and on Aug 23) are:

July 19: Tmix (5) versus 2, 4

Aug 23: Complex mix (4) versus 1,

Table 22. Van Thielen Hay Mixes, 1991: Biomass composition and total biomass at first sampling (June 11). Chemical analyses were performed on complete (not separated) samples.

Hay Mix	Total Dry Weight (kg/ha)				CP%	ADF%	TDN%	DE[a]
	Clover	Grass	Weed	Total				
1. RC/T	77	1199	134	1410	16.3	24.7	62.4	2.74
2. A/T	133	1414	135	1682	14.5	25.4	61.4	2.70
3. RC/WC/T	311	1058	115	1484	14.9	24.9	62.0	2.73
4. RWA/B/T	104	1222	142	1468	14.7	24.5	62.2	2.75
5. Tmix	468	1626	353	2447	19.4	22.6	65.1	2.86

[a]Estimated digestible energy Mcal/kg

[b]Statistical Significance Tests Unpaired t-tests: none of the differences in biomass between mixes were significant at 0.1 level

Table 23. Clover yield and nutrient content of forage from different replicates at the Hubbard site, 1991. Data are for mowed plots only, all mixes combined.

Date	Component	Block	Yield	CP%	ADF%	TDN%	DEa	Ca%	Mg%	K%	P%
Jn 20	Grass	I	570	12.5	29.6	66.4	2.92	0.29	0.16	2.22	0.17
		III	719	12.2	32.8	62.2	2.74	0.27	0.16	2.35	0.24
Jn 20	Clover	I	583	20.9	20.7	78.0	3.43	1.41	0.45	2.49	0.17
		III	1173	22.0	22.1	76.2	3.35	1.50	0.49	2.61	0.23
Aug 5	Clover	I	613	17.9	27.3	69.4	3.05	1.12	0.48	1.41	0.17
		II	518	19.4	26.0	71.1	3.13	1.19	0.51	1.40	0.16
		III	2129	18.2	26.0	71.1	3.13	1.21	0.48	1.48	0.17

At the Hubbard site, total yield varied between blocks (replicates), with block 1 lowest, as in 1990 (data for 1991 are not shown). The visually estimated proportion of the legume component made up from Alsike in Mix 5 on Aug. 5 was highest in Block 1. (The estimated proportion of alsike in Hay Mix #5 in Block 1 was 65% 1 versus 21 and 22% in Blocks 2 and 3 respectively; total biomass in Mix # 5 averaged 500, 2391 and 2178 kg/ha in Blocks 1,2 &3 respectively). There was not much difference in % of different nutrients in grass or clover between different blocks (Table 23).

The high yield in the common triple mix strip at the Van Thielen site was probably due to a positional effect, in some way related to the dry weather. Roughly, the ranks decrease in the same order (Tables19, 21) as the plots are laid out which was sequentially down a slope with Treatment 5 at the top (Appendix C). There was not very good survival of Alsike in treatment #5, which otherwise might explain the high yield; in fact there was more alsike in other strips where it was not planted in 1990. The main legume component in the triple mix treatment was wild white clover, which had not been planted in 1990. It is therefore difficult to make any firm conclusions regarding the mixes at the Van Thielen site. In any case, this site had the lowest overall proportion of legumes, and had more grass than the other sites (Tables 20, 22), as in 1990, probably due to higher N loading. Therefore one might expect that there would be less benefit for improved legume components in hay mixes at the Van Thielen site than at the Firth and Hubbard sites. Probably the emphasis in selecting a mix for grazing and hay where a lot of manure is being applied should be on the grass rather than the legume component.

At the Hubbard site, the alfalfa/timothy mix did poorest (Table 20), and the complex mix (#4) gave the highest yield as was the case in 1990. Overall, this site had the highest contribution from legumes, as also was the case in 1990.

At the Firth site, the common triple mix did poorly, also the RC/T mix (#1); in 1990, mix #1 ranked 4th, Triple mix 5th. The alfalfa/timothy mix did best in 1991, but mixes #3 and #4 also did well in terms of total biomass (Table 20). Alfalfa is well known to be discriminating, doing very well on certain sites and poorly on others in Nova Scotia, and it is most often a matter of trial and error to find out whether it will do well on a particular site. Its poor performance at the Hubbard site (which drains rather slowly), and good performance at the Firth site (better drained) is a good illustration of this point. At both sites, the complex mix (#4) did well.

We made only a few observations on the grass components. In mix #4, timothy was 2 or 3 times more abundant than brome in 1991; in 1990 at the Van Thielen site, Brome was predominant. This pattern is consistent with informally reported patterns, i.e. for Brome to do better the first year, and timothy to take a year to get well established. Weedy grasses accounted for about 20% of grass biomass at the 3 sites.

II. 3. Results 4. Effects of manuring the hay mixes at the van Thielen site:

In 1991, Werner Van Thielen asked us to examine the effects of pig slurry and cow manure on the mixes, as he has both types of manure available. On June 28, after the first harvest (June 11) and grazing (June 15-19), cow manure and pig slurry were applied in strips laid across the five hay mix strips. During the two subsequent harvests, the manured and unmanured plots were sampled separately. There was no effect of cow manure on yield measured on July 19 and Aug 23; the pig slurry approximately increased the yield by fold 2.6 on July 19 (Table 24) and 1.9 fold on Aug 23 (Table 25).

Part of the stimulatory effect of the pig slurry could have been due to the water applied in the slurry during the very droughty period. The fresh-to-dry weight ratio for the pig slurry treated plots was higher than that for either the cow manure or the no fertilizer plots. N alone will cause an increase in the fresh to dry ratio, so the increase in fresh to dry ratio could have been due to water and N.

The biomass separation data for individual mixes (Table 24) is not reliable as each number is based on only one separation per manure treatment. However considering the data for all hay mixes together (the bold numbers, underlined), the data suggest that grasses and weeds, but not legumes responded to the pig slurry.

Protein content was increased substantially by pig slurry Nitrate content also increased (Tables 24, 25).

Table 24. Biomass composition of hay mixes at Van Thielen site on July 19, 1991. Values for parts of each strip receiving no manure, cow manure and pig slurry are given in succession. Each number is the mean of values from 3 quadrats.

Hay Mix	Biomass Component (kg dry matter per hectare)			
	Clover& Alfalfa	Grass	Weeds	Total
1	4/211/56	243/104/891	155/20/11	402/335/958
2	59/49/5	381/317/881	29/15/24	468/478/908
3.	18/10/224	359/297/638	90/10/256	467/317/1119
4.	10/390/6.5	392/128/809	147/6/463	451/527/1283
5.	81/178/200	203/67/686	20/7/426	303/291/1252
Avgs	**34/167/98**	**315/182/781**	**88/12/236**	**418/389/1104**
Avg. Fresh-to-dry weight ratio:				2.8/3.1/4.0

For the total biomass, and for the ratios, pig versus cow and pig versus no fert are significant at 0.05 level; differences between cow and no fertilizer are not significant at the 0.1 level

Nutritional analysis (composite samples)

Hay Mix	Fertilizer	Protein %	ADF%	TDN%	DE[a]	NO35
1	none	19.4	26.0	71.1	3.13	
2	none	14.9	31.2	64.4	2.83	
5	none	14.3	31.9	63.5	2.79	
3	none	15.7	27.4	69.4	3.05	0.07
	beef man	15.3	33.5	61.3	2.70	0.06
	pig slurry	26.0	24.7	72.8	3.21	0.60
4	none	16.2	29.7	66.4	2.92	
	beef man	22.1	24.2	73.4	3.23	
	pig slurry	22.6	27.2	69.5	3.06	

a Digestible energy Mcal/kg

Table 25. Comparison of no fertilizer, cow manure and pig slurry for mixture #4 only, harvested Aug. 23, 1991).

Treatment	kg/ha		fresh/dry	CP%	ADF%	TDN%	DE[a]	Ca%	P%	K%	Mg%
No fertilizer	1192	p[b]	5.4[b]	19.6	29.1	67.0	2.95	.77	.43	.12	2.76
Cow	1084	p	4.9	21.3	26.5	70.4	3.10	.88	.47	.07	2.73
Pig	2246	q	6.8	24.2	28.1	68.4	3.01	.92	.45	.38	2.96

[a]Digestible energy Mcal/kg
[b]For each data set, pig versus cow and pig versus no fert are significant at 0.05 level (unpaired t-tests; n=5 per group).

II. 3. Results 5. Effects of mowing in the establishment year on hay mixes in the subsequent year at the Hubbard site

At the Hubbard site, strips of hay in each block were mowed in the establishment year (on Aug. 21, 1990), while the remaining strips were not mowed. This experiment was requested by the farmer.

In 1991, there was little effect of mowing or not mowing evident at the first cut on June 20, except that weed biomass was lower in the mowed strip. At the second cut, biomass was higher in the strip that had not been mowed in the establishment year, and the the effect appeared to be more significant for the legumes than for the grasses (Table 26).

Statistically, there is no indication that mowing or not mowing affected responses of the mixes differently (see probability values P P interact Mow x Mix).

Table 26. Comparison of hay mixes in mowed versus unmowed strips, Hubbard Site 1991 (data for all mixes averaged).

	Unmowed (kg dry matter/ha)	Mowed	P diff	P interact Mow x Mix
June 20: Total	1708	1651	0.85	0.58
Legumes	1224	937	0.32	0.80
Grass	392	684	0.31	0.36
Weeds	93	33	0.17	0.78
Aug 5 Total	2045	1520	0.12	0.55
Legumes	1779	1087	0.07	0.41
Grass	202	363	0.14	0.51
Weeds	63	70	0.88	0.92

Statistics: Data were analyzed using a split plot ANOVA model with mowing versus not mowed as the main plot variable, and hay mixes as the subplot variable (3 replicates).

II. 4. Conclusions

Overall, the observations confirm the contention that common triple mix can be improved upon. The explanation for poor performance of Common Triple Mix in Nova Scotia is (1) seed is not certified; (2) that Alsike crowds out the red clover in the establishment year but then it doesn't survive the winter very well, with the result that the legume component declines rapidly. According to Eric Bosveld commenting on observations of Bill Thomas, "Alsike clover, in some cases, will do quite well in the year after seeding" (as we observed for the Firth and Hubbard sites), "but normally there is very little left by the 2nd production year. The differences in protein were very much more pronounced in the second and third production years." Thus our observations were consistent with Thomas's observations.

There appear to be two strategies in commercial mixes to deal with the Alsike problem: (1) leave out the Alsike, giving a 2 component red clover/timothy mix and (2) substitute a white clover such as Ladino for the Alsike, i.e. an improved triple mix.

Both of these types of mixes were included in our trials, and in addition, alfalfa/timothy and a complex, 6 component mix. As expected, performance of the alfalfa mix is very site dependent. Overall, an improved triple mix or a complex appears to be a good bet, the simple RC/T mix however is not such a good bet: it did well at the Hubbard site, but poorly at the Firth site.

There appear to have been few or no replicated trials of the sort we have conducted, carried out in Nova Scotia, and few or no trials anywhere of a range of mixtures with 2 to 6 components. It had been hoped that modest financial support could have been obtained to continue observations for at least one more year , i.e. 1992, as was the original proposition, and preferably 2 more years. An application for funding to support one more year of observations was made, but was turned down. Thus we do not have information on the longer term differences between the mixtures.

The block variation at Hubbards along with that in Experiment I, and the differences in performance of legumes and grasses between farms illustrates the sensitivity of the legumes to soil fertility status - probably Ca in the case of the block variation, and N between farms, i.e. production of the legumes is restricted by low Ca and suppressed at high N. Grasses were substantial components only at the Van Thielen site which had a history of fairly heavy manure applications. At such sites such it seems fairly clear that emphasis should be placed on grass components rather than legumes, because it is the grasses which respond to the high fertility.

III. WINTER CEREALS

III. 1 Treatments

1. **Triticale (OAC Trillium)**
2. **Rye (Kustro)**
3. **Wheat (Borden)**
4. **Wheat + Rye**
5. **Wheat + Triticale**
6. **Triticale + Rye**
7. **Oak Manor Rye**
8. **Schmidt Rye**
9. **Spelt (from EFAO)**

Unreplicated strips of each cereal or mixture were planted at the Hubbard and Van Thielen farms in 1990.

III. 2. Methods

The Hubbard site was on part of a hay field that was ploughed and manured in early September, 1990. One cut of silage and one of hay were taken from the field in 1990, which had been in hay for 5 years. The plots for treatments (1) to (6) were 8 x 50 yards (7.3 x 46 m), the Schmidt rye, spelt and Oak Manor rye were planted in larger areas according to seed available (see Appendix B for field diagrams). The plots were separated by 3 m strips with seeded with oilseed radish. The seeding rate was 120 lbs/acre except for Spelt which was 160 lbs/acre. Seed was broadcast by hand on Sept. 13 using cyclone seeders, and harrowed.

The van Thielen site was on a field that had been in long term hay. A mid-summer cut of hay spoiled and was not baled. The field was tile drained in August, manured, ploughed and plots set up on Sept. 12. Plots for treatments (1) to (6) were 40 x 40 yards (36 x 36 m), with 9 m strips between them, planted with oilseed radish; (7), (8) and (9) were planted in larger or smaller areas according to seed available. Feed oats were seeded in the remainder of the field as a catch crop.

Strips of the different cereals were sampled on Aug 19 and 19, 1991 just prior to combining. Eight 35 x 35 cm quadrats were sampled, the quadrats distributed throughout the length of each strip. For each quadrat, maximum height of the grain was recorded, and at Hubbards only, maximum height of the weeds. The weeds were ranked in order of abundance (assessed visually). Quadrats were cut at approximately 5 cm height, and heads separated from straw. The number of heads were counted, and fresh weight determined. Subsamples of heads and straw were dried and weighed again. A second subsample of approximately 20 heads was kept for mechanical separation of grains and chaff at Nappan.

Analysis of the data showed that there had been some bias in selection of heads for the Nappan samples. The following table gives the ratios of average head weight for all samples from the field, to the average head weight for the Nappan samples.

Grain	Ratios Hubbard	Ratios Van Thielen
Sch rye	0.96	0.91
OM rye	0.61	0.82
C. rye	0.70	0.85
Wheat	0.91	0.80
Trit	1.49	0.89
Spelt	0.46	1.13
R + T	0.68	0.71
R+W	0.52	0.71
W+T	0.82	0.72

Accordingly, the grain yields calculated from the average grain per head from the Nappan samples times the number of heads (field sampling) were multiplied by the factors above.

III. 3. Results

Van Thielen site In 1991, the winter cereal crops as a whole at the Van Thielen site exhibited good growth and final yields in spite of the drought. The spelt looked spotty in the spring but gave good final yields. There were no significant fungal diseases except for some ergot at in the ryes and triticale; most of it occurred near the edges of the stands. The Schmidt rye grew tallest and gave the second highest straw yield, and second highest grain yield (common rye + wheat had the highest values for straw and grain). Spelt had a good yield and exceptionally high protein.

Hubbard site Overall, growth was patchy, and there was a lot of weed growth, except in the Schmidt rye. Yields were considerably lower, on average than at the van Thielen site, except for the Schmidt rye. The patchiness appears to be due to winter kill, and/or some movement of seed following planting in the fall. The 3 quadrats with the highest number of heads in each cereal type (bottom part of table), had head densities approximately equivalent to average values at the Van Thielen site. Yields for these high density Hubbard quadrats were consistently lower than the average quadrat yield at the Van Thielen site, except for the Schmidt rye; the rye + wheat had the second highest yields.

Table 27. Harvest data for cereals, Van Thielen & Hubbard sites, 1991. Protein values are for zero moisture

VARIABLE	SCHMIDT (Ryes)	O. MANOR (Ryes)	COMMON (Ryes)	SPELT	WHEAT	TRIT	R + T (Mixes)	R + W (Mixes)	W + T (Mixes)
V. THIELEN									
# Heads/m^2	296	354	362	268	350	404	362/48	347/127	153/129
SE	35	42	65	39	45	44	58/24	35/17	36/27
Height (cm)	146	141	119	114	88	105	125/nd	123/92	89/99
SE	6.2	5.0	5.1	3.3	2.3	3.4	2.1	1.5/3.6	4.6/1.9
Weeds (kg/ha)	555	1105	1607	1478	863	501	410	653	819
SE	215	498	857	422	170	192	156	156	283
Straw (kg/ha)	3978	3833	2701	3519	2531	2204	3930	4418	2326
SE	753	510	470	607	276	251	473	373	285
Grain + chaff	3902	3830	3973	4080	3342	5993	4265	4203	3686
(kg/ha) SE	601	446	662	561	434	795	474	265	548
Total Crop	7870	7663	6638	7599	5692	8196	8195	8622	6012
SE	1328	930	1105	1150	700	1032	942	632	820
Grain (kg/ha)	3112	2915	3042	2704	2680	2622	3071	3236	2764
Grain, prot %	11.1	11.3	9.3	16.2	9.8	10.2	8.9	9.9	9.6

VARIABLE	SCHMIDT (Ryes)	O. MANOR (Ryes)	COMMON (Ryes)	SPELT	WHEAT	TRIT	R + T (Mixes)	R + W (Mixes)	W + T (Mixes)
HUBBARD									
# Heads/m2	401	320	471	132	180	101	245/18	301/131	87/66
SE	41	65	38	51	33	30	61/9	64/38	29/22
Height crop	140	116	104	89.1	80	85	101/nd	102/87	82/nd
(cm) SE	3.5	5.8	4.2	4.3	2.0	3.9	5.5	4.8	4.8
Height weeds	91	112	121	105	112	107	123	108	119
(cm) SE	12	1.8	3.5	2.5	4.4	5.9	4.9	8.4	2.2
Weeds (kg/ha)	1403	4395	1582	2839	3971	3987	4808	1655	4430
SE	268	362	386	443	516	555	845	432	377
Straw (kg/ha)	4739	1627	2281	995	867	765	1302	2703	770
SE	569	426	270	417	190	373	379	618	259
Grain + Chaff	4055	1187	2492	1010	1231	953	1579	2751	1355
(kg/ha) SE	417	283	306	426	245	410	439	564	484
Total Crop	8794	2814	4774	2005	2099	1718	2881	5454	2125
(kg/ha) SE	959	704	569	841	432	781	815	1159	742
Grains (kg/ha)	2510	617	1869	582	628	752	1136	1760	854
Protein %	9.8	10.6	9.0	15.1	11.6	11.0	9.8	9.8	10.7

TABLE 27. Concluded. Values for the 3 top yielding quadrats at Hubbard site.

VARIABLE	SCHMIDT (Ryes)	O. MANOR (Ryes)	COMMON (Ryes)	SPELT	WHEAT	TRIT	R + T (Mixes)	R + W (Mixes)	W + T (Mixes)
HUBBARD									
Top 3 quadrats # heads/m2	500	498	571	288	277	169	386/30	457/236	180/109
Weeds (kg/ha)	971	4164	1163	1527	2453	3496	3695	726	3628
Straw (kg/ha)	5960	2747	2852	2215	1457	1388	1983	4275	1518
Grain + Chaff	4883	2057	3017	2288	1952	1683	2481	3926	2971
Total Crop	10843	48-5	5864	4503	3409	3071	4464	8201	4308
Grain kg/ha	3023	1070	2262	1320	996	1330	1786	2512	1871

PRINCIPAL WEEDS

Hubbard: hemp nettle, timothy, alsike & red clovers, grass, chickweeds, dandelion, daisy, plantain.

Van Thielen: Timothy, sheep sorrel, daisy, plantain, red clover, white clover, grass, cudweed, chickweeds.

Table 28. Soil analysis data for winter cereal sites in 1991.

SAMPLE		LOI (%)	pH	P2O5 (kilograms per hectare)	K2O	Ca	Mg
V THIELEN							
Schmidt Rye	May 21	3.9	5.9	208H-	59L	1231L	281M
	Aug 21	5.0	7.0	187M+	62L	2434M	556H-
Oak Manor Rye	May 21	4.4	5.8	117M-	57L	888L-	217M
	Aug 21	4.5	6.2	266H-	99L+	1841L	436M+
Common Rye	May 21	4.4	5.7	162M	56L	957L-	207M
	Aug 21	4.5	6.3	126M-	71L	1374L	346M+
Spelt	May 21	3.5	6.1	165M	86L	1247L	284M
	Aug 21	4.4	6.5	116M-	57L	1863L	375M+
Wheat	May 21	4.1	6.2	204M+	78L	2024L	467M+
	Aug 21	4.3	6.3	103L+	61L	1106L	272M
Triticale	May 21	4.9	5.9	145M	61L	944L-	232M
	Aug 21	4.4	5.9	132M-	61L	1319L	319M
Rye + Triticale	May 21	4.4	5.7	162M	56L	957L-	207M
	Aug 21	3.9	5.9	134M-	65L	960L-	238M
Rye + Wheat	May 21	3.7	6.3	160M	72L	2042L	467M+
	Aug 21	5.1	6.0	122M-	85L	1066L	252M
Wheat + Triticale	May 21	4.0	6.2	138M-	73L	1779L	531H-
	Aug 21	4.7	6.1	105L	69L	1027L	245M

Table 28, concluded.

SAMPLE		LOI (%)	pH	P2O5	K2O	Ca	Mg
				(kilograms per hectare)			
HUBBARD							
Schmidt Rye	May 21	6.3	6.7	326H	146M-	2470M	560H-
	Aug 21	6.2	7.3	274H	125M-	3176M	891H
Oak Manor Rye	May 21	6.7	6.5	260H-	172M	1883L	460M+
	Aug 21	6.1	6.5	203M+	105L+	1539L	382M+
Common Rye	May 21	6.4	6.4	199M+	158M	1617L	431M+
	Aug 21	6.6	6.5	137M-	106L+	1631L	448M+
Spelt	May 21	6.0	6.4	250H-	129M-`	1859L	400M+
	Aug 21	6.0	6.8	242H-	1-7L+	2121L	513H-
Wheat	May 21	6.5	6.6	233H-	150M	2054L+	491H-
	Aug 21	5.8	6.9	158M	94L+	1840L	466M+
Triticale	May 21	6.4	6.5	253H+	194M	2209L	489H-
	Aug 21	6.0	6.7	169M	90L+	1660L	407M+
Rye + Triticale	May 21	6.5	6.6	259H-	135M-	1935L	477H-
	Aug 21	6.1	6.7	159M	79L	1703L	404M+
Rye + Wheat	May 21	6.0	6.6	192M+	142M-	1922L	489H-
	Aug 21	5.5	6.7	150M	90L+	1796L	474H-
Wheat + Triticale	May 21	5.9	6.4	204M+	125M	1681L	426M+
	Aug 21	5.5	6.6	143M	96L+	1637L	425M+

IV. CATCH CROPS.

IV. 1. Treatments

None (weeds)

Brassicas:	**oilseed radish**	20 kg/ha
	stubble turnip	2.5 kg/ha
	Barcoli rape	2.5 kg/ha
	white mustard	15 kg/ha
Grasses:	**ryegrass**	20 kg/ha
Oats	**(van Thielen only)**	
Other:	**Phacelia tanecifolia**	12 kg/ha

Catch crops were planted in unreplicated strips; manure (Hubbard) or hog slurry (Van Thielen) was applied crosswise to the strips, giving minus manure and plus manure sections/

IV. 2 Methods

1. Van Thielen In September, liquid hog manure was applied to winter rye stubble, the field ploughed and harrowed. In the experimental area, 2 large strips (100 yards long by 33 and 40 yards width) running approximately N-S did not receive the liquid manure. On Sept. 14, 1990, the experimental catch crops were seeded with hand seeders (Cyclone) in E-W strips 10 yards by 220 yards, except forPhacelia, which was 5 yards wide. On the remainder of the field, the farmer (W. van Thielen) broadcast feed oats, and then went over the entire field with a finger weeder to cover seed. There were 2 control strips; others were single strips.

2. Hubbard. A similar sequence of preparation was followed at this site except that 1/2 of the field received solid manure before plowing, and soil was chain harrowed after seeding. Catch crops were seeded on Sept. 14. Strips were 5 m (Phacelia), 10 m (controls, Barcoli rape, stubble turnip, white mustard), 18.5 m (oilseed radish) or 20 m (ryegrass) in width by approximately 50 m length.

Soil sampling

Soil was sampled at the Hubbard site on Dec. 7; 20 cores were taken from each control and from oil radish and stubble turnip strips; manured and unmanured sections were sampled separately. These were frozen immediately, and later analyzed for pH, nitrate (using Merckoquant strips), and electrical conductivity in 1:1 water extracts. Composite samples were sent to NSDAM for standard soil analyses. Soils at the van Thielen site were sampled on Dec. 14 in similar fashion. Unforunately, the samples were removed from the freezer at one point and inadvertently thawed for several weeks, so that analyses of nitrate in these samples would not be indicative of the in situ values, and were not performed.

Fall sampling of biomass

Fall sampling for cover and biomass was conducted in November. To estimate percent cover, a meter stick was thrown in 10 places, and the vegetation (if any) touching the meter stick at the 10 cm lines was recorded, giving a total of 100 sites. To estimate densities of plants, counts were made of the cover crop, grasses and broadleaved weeds in ten 35 x 35 cm quadrats. When ryegrass and oats were the cover crops, no distinction was made between the cover crop grasses and the weedy grasses. To estimate biomass, plants were collected randomly to give a bag-full, which were dried and weighed; the numbers collected were recorded so that weights of individual plants could be calculated. For grasses, the vegetation was clipped in five 27 x 27 cm quadrats, dried and weighed.

IV. 3. Results

Growth of the catch crops was limited, and none gave close to 100% cover. At the van Thielen site, the seeding turned out to be somewhat erratic, perhaps because it was on a slope and seed was washed down by rain. Nevertheless, all catch crops increased the cover above all control values (Table 29), except for Barcoli rape and stubble turnip in the + manure strips. Biomass of the different catch crops on manured strips was 1.1 (Barcoli rape) to 3.1 (oats) times that on non-manured sections (excluding *Phacelia*, which had very poor establishment on the unmanured sections). Stubble turnip and oilseed radish produced the biggest individual plants. Oats had the highest overall biomass (Tables 30, 31).

At the Hubbard site, there was much more volunteer growth of grasses, and effects of the cover crops on total cover were less pronounced than at the van Thielen site. Oilseed radish gave the highest cover (Table 32), and oilseed radish and stubble turnip produced the biggest plants (Table 19), as at the van Thielen site. The effects of catch crops on total biomass in the fall were more pronounced than effects on percent cover. Data on nitrogen contents suggest that the catch crops took up 20-30 kg N above that held in weeds on the control plots (Table 34). On December 7, the manured parts of plots had higher values of P,K, Ca and Mg (Table 35) and electrical conductivity (Table 36) than non-manured parts. No nitrate was detectable.

At the Hubbard site, a heavy growth of grass over the field in the spring of 1991 obliterated any potential effect of the cover crops, and it was decided not to conduct further observations there. Also, because of the drought, the field was not worked until late in the summer.

At the van Thielen site in 1991, a barley/pea silage crop undersown with hay mix was planted. It was decided not to sample each of the 10 different cover crop strips separately - given that the treatments were not replicated, the irregularity of seeding of the cover crop, the relatively low biomass and cover achieved by the cover crops, it seemed very unlikely that we would get convincing results concerning effects of the different cover crops on the subsequent crop. We did, however, take 10 quadrats from each of the lower manured and lower unmanured strips, and at Werner van Thielen's request from an adjacent field planted with the same crop. Those results suggest that the application of hog slurry on the fall approximately doubled the yield of the spring sown crop (Table 38).

Table 29. Percent cover of soil by catch crop and weeds, van Thielen site, Nov. 28, 1990. +/-M refers to manure.

CATCH CROP	CCROP COVER %		GRASS COVER%		BROADLEAF COVER%		TOTAL %	
	-M	+M	-M	+M	-M	+M	-M	+M
Control 1			10	20	2	1	12	21
Control 2			7	5	1	1	8	6
Barcoli Rape	31	13	7	6	1	1	39	20
Oilseed Radish 1	32	48	2	2	0	0	34	50
Oilseed Radish 2	35	61	1	0	0	0	36	61
White Mustard	39	43	1	7	0	0	40	50
Stubble turnip	22	7	7	11	0	1	29	20
Phacelia	16	48	12	3	1	1	29	52
Ryegrass	44	70			0	0	44	70
Oats	56	52			1	0	57	52

Table 30. Density of catch crop and weeds, and weights of individual catch crop plants, van Thielen site, Nov. 28, 1990.

CATCH CROP	CCROP #/m2		Grass #/m2		Broadleaf #/m2		CCROP g/plant	
	-M	+M	-M	+M	-M	+M	-M	+M
Control 1			20	32	6	7		
Control 2			12	12	7	6		
Barcoli Rape	67	54	14	17	4	4	0.67	0.92
Oilseed Radish	69	93	10	13	0	0	1.20	1.20
Oilseed radish 2	53	77	3	16	1	1		
White Mustard	66	91	10	20	6	2	0.60	1.00
Stubble turnip	22	49	14	14	3	4	2.40	2.50
Phacelia	2	93	12	18	8	7	0.60	0.35
Ryegrass	108	110			7	3		
Oats	140	116			2	6		

Table 31. Calculated dry matter per hectare in catch crops, van Thielen site, Nov. 28, 1990. Numbers in brackets are values estimated for catch crop + weeds.[a]

Catch crop	Biomass (kg/ha) -M	Biomass (kg/ha) +M
Control 1	565	715
Barcoli rape	449	497
	(914)	(840)
Oilseed radish 1	828	1116
	(961)	(1230)
White mustard	396	910
	(462)	(1310)
Stubble turnip	528	1225
	(993)	(1854)
Phacelia	12	325
	(809)	(496)
Ryegrass	270	800
Oats	830	2530

[a] Contribution of grass was estimated as
(% cover by grass/%cover grass in control)x biomass of control

Table 32. Cover of soil by catch crop and weeds, Hubbard site, Nov. 6, 1990.

CATCH CROP	CCROP COVER %		GRASS COVER%		BROADLEAF COVER%		TOTAL %	
	-M	+M	-M	+M	-M	+M	-M	+M
Control 1			28	60	2	4	30	64
Control 2			46	43	9	2	55	45
Barcoli Rape	25	32	32	39	3	1	60	72
Oilseed radish	59	39	20	31	1	1	80	71
White mustard	44	48	20	35	0	0	64	83
Stubble Turnip	30	32	26	43	1	0	57	57
Phacelia	36	38	15	24	0	1	51	53
Ryegrass	44	62	0	0	1	0	45	62

Table 33. Density of catch crop and weeds, and weight of individual plants, Hubbard site, Nov. 6, 1990.

CATCH CROP	CCROP #/m2		Grass #/m2		Broadleaf #/m2		CCROP g/plant	
	-M	+M	-M	+M	-M	+M	-M	+M
Control 1			209	122	57	371		
Control 2			112	150	69	73		
Barcoli rape	38	60	95	92	1	0	0.51	1.05
Oilseed radish	106	92	74	90	0	0	0.68	0.98
White mustard	97	117	78	127	01		0.33	0.40
Stubble turnip	77	78	59	89	0	0	1.10	1.47
Phacelia	200	223	108	141	0	1	0.20	0.56
Ryegrass	366	390			37	51		

Table 34. Estimated Dry matter catch crops, and nitrogen content of selected cover crops, at the Hubbard site, November 6, 1990.

CATCH CROP	CCROP kg/ha		Percent nitrogen		Nitrogen kg/ha	
	-M	+M	-M	+M	-M	+M
Control 1	194	145	2.62	2.83	5.1	4.1
Control 2	137	173				
Barcoli rape	194	900				
	(338)	(750)				
Oilseed radish	721	901	4.51	2.49	32.5	22.4
	(811)	(996)			(34.8)[a]	(25.1)
White mustard		320	468			
	(410)	(575)				
Stubble turnip	847	1150	3.12	3.04	26.4	35.0
	(964)	(1283)			(29.5)	(38.8)
Phacelia	400	1250				
	(467)	(1323)				
Ryegrass	366	390				

[a] Calculated value with grasses included.

Table 35. Soil Data for Catch Crops at Hubbard Site, December 7, 1990.

Sample	LOI (%)	pH	P_2O_5	K_2O	Ca	Mg
			(kilograms per hectare)			
Control, no manure	3.8	6.3	218H-	392H	1837L+	394M+
Control plus manure	3.8	6.4	286H	473H+	2070L+	441M+
Catch Crops, no manure	4.3	6.1	195M+	396H	1931L+	431M+
Catch Crops, plus manure	4.4	6.2	239H-	540H+	2031L+	488M+

Table 36. pH, electrical conductivity and nitrate of 1:1 water extracts of soils from catch crop experiment at Hubbard site, December 7.

Sample	pH	conductivity (dS/m)	nitrate-N (ug/liter)
1a. Control 1, no manure	6.8	66	<1
1b. Control 2, no manure	6.5	46	<1
2a. Control 1, plus manure	6.5	92	<1
2b. Control 2, plus manure	6.6	84	<1
3a Stubble turnip, no manure	6.4	50	<1
3b Oilseed radish, no manure	6.2	65	<1
4a Stubble turnip, plus manure	6.6	100	<1
4b Oilseed radish, plus manure	6.2	84	<1

Table 37. Soil data for catch crop sites in the spring (May 9, 1991)

SAMPLE	LOI (%)	pH	P2O5	K2O (kilograms per hectare)	Ca	Mg
Van Thielen						
Control, no manure	4.5	5.8	103L+	130M-	1433L	196M
Control, manured	5.0	5.8	110L+	110L+	1339L	230M
Oil Radish, no manure	4.9	6.1	106L+	145M-	2138L	306M
Barcoli Rape, manured	3.7	6.0	117M-	123M-	1792L	213M
Hubbard						
Control, no manure	5.8	6.4	252H-	406H	1813L	346M+
Control, manured	5.5	6.4	316H	484H+	2033L	404M+
Oil radish, no manure	4.3	6.6	330H	562H+	2482M	530H-
Stubble Turnip, manured	4.7	6.5	282H	567H+	2100L	450M+

Table 38 Yield of barley/pea (silage crop) and weeds at the Van Thielen site, July 24, 1991. Values are means for 10 quadrats. Forage analyses data are for composite samples.

Field & Treatment	Dry wt (Kkg/ha, SE)	% weeds in biomass	% protein	ADF%	TDN%	DE[a]
MAIN, not manured	1688 (148)	16.0[b]	10.8	24.6	72.9	3.21
manured	2956 (141)	4.4[b]	8.7	21.1	77.5	3.41
ADJACENT	3679 (440)	11.8[c]	11.6	24.3	73.3	3.23

[a]Estimated digestible energy Mcal/kg
[b]Main weeds were horsetail, hempnettle, vetch, daisy
[c]Main weeds were timothy and other grasses , corn spurry, vetch

EXPERIMENT V. ANNUAL LEGUME/GRASS MIXTURES

V.1. Treatments

1. **Ryegrass** (Marshall) 30 kg/ha
2. **Winter Rye** (OAC Trillium) 150 kg/ha
3. **Triticale** (Common) 150 kg/ha

4. **Ryegrass** 20 kg/ha + **hairy vetch** 20 kg/ha
5. **Winter Rye** 100 kg/ha + **hairy vetch** 20 kg/ha
6. **Triticale**100 kg/ha + **hairy vetch** 20 kg/ha

7. **Ryegrass** 20 kg/ha + **Persian clover** 12 kg/ha
8. **Winter Rye** 100 kg/ha + **Persian clover** 12 kg/ha
9. **Triticale** 100 kg/ha + **Persian clover** 12 kg/ha

V. 2 Methods

Ferguson site:
The experiment was set up in a RCB design with 3 replicates on June 19 on a field that had been native pasture until July 1989. It had a pH in 1989 of 5.6. The field was manured after ploughdown in 1989; in 1990, 2 coats of manure were applied and 4 tons of lime per acre. Plots were 2.5 x 12 m. Seed was broadcast by hand and raked in. Observations were made on July 30 as described for the Firth site, and again Sept. 9, but in that case only one block was sampled. Cattle were turned into the pasture shortly after our samplings.

Firth site:
The experiment was set up in a RCB design with 3 replicates on June 15 along the border of a field that had been in pasture for about 20 years. It was ploughed in the fall of 1989. Ryegrass (Maris Ledger) and some Barcoli rape was sown on the rest of the field on June 16 and fertilized with 300 kg/ha 12-24-24. Each plot was 7 x 4 m. Legume seed was inoculated, the seed was sown by hand, raked in lightly, and rolled by the farmer on June 16.

On July 28, just before sheep were turned into the pasture, the plots were sampled. Two 50 x 50 cm quadrats were placed in each plot using random numbers to locate them. Heights of the 3 longest grasses, legumes and weeds were measured in each quadrat, and the weeds making up an estimated 80% of the biomass ranked in order of abundance. The vegetation was cut at approximately 5 cm height, the quadrats combined, and vegetation sorted into grass, legume and weed components. The fresh weights were determined and subsamples (50-100 g) bagged and subsequently dried to determine dry-to-fresh weight ratios. To compare the Marshall ryegrass with the pasture variety, 1 quadrat was taken in the pasture adjacent to each replicate of treatments 1 and 7 and processed as above. The field was sampled again on August 22 using the same methods, and again on Oct.8 In the last case, 2 quadrats were taken but the proportion of weeds and legumes was estimated visually.

Hubbard site:
The experiment was set up in a RCB design with 3 replicates on June 9. The three blocks are are set out perpendicular to the slope (treatments parallel to slope). Plots are 8 x 3 m with no borders. Seed was broadcast by hand and worked in lightly by raking and later packed with a Brillion seeder. Observations were made on Aug 1 and 30 as at the Firth site except that only the uppermost block was sampled. It was cut with a scythe after sampling on Aug 1. On August 24, one half of each of the other blocks was mowed; we will look at grain yield from winter cereals next year in mowed and unmowed sections.

V. 3 Results

Grass and legume heights and biomass

Heights of grasses at sampling are shown in Fig. 11. At Ferguson's and Firth's, the sampling was conducted just before livestock were turned in to graze the farmers' ryegrass pastures. The farmers' ryegrass (Maris Ledger at Firths; Promenade at Ferguson) had not headed out, but the Marshall ryegrass in the plots had started to do so. Ryegrass was taller than the cereals at all sites. The cereals grow in a more prostrate habit. Weeds stood higher than the winter cereals at all 3 sites on the first cut (Fig. 11), but were shorter relative to the sown grasses on the second cuts. Vetch grew above cereals at the Hubbard site but not at other sites, and at all sites, Persian clover remained low in height. Biomass followed similar patterns (Table 39, Figs. 12, 13).

Legume establishment and growth was not very vigorous at the Ferguson and Firth sites. Vetch produced a lot of biomass at first cut at the the Hubbard site (Fig. 13). Persian clover was very poor at all sites. It did produce a fair amount of growth in uncut mixes at the Hubbard site by September, but not in the swathed plots. It's possible that Crimson clover would have done better. In other experiments at the Hubbard farm, Crimson and Persian clovers were sown to provide green manure for vegetables; Crimson clover exhibited better germination, more rapid initial growth and greater final biomass (unpublished data).

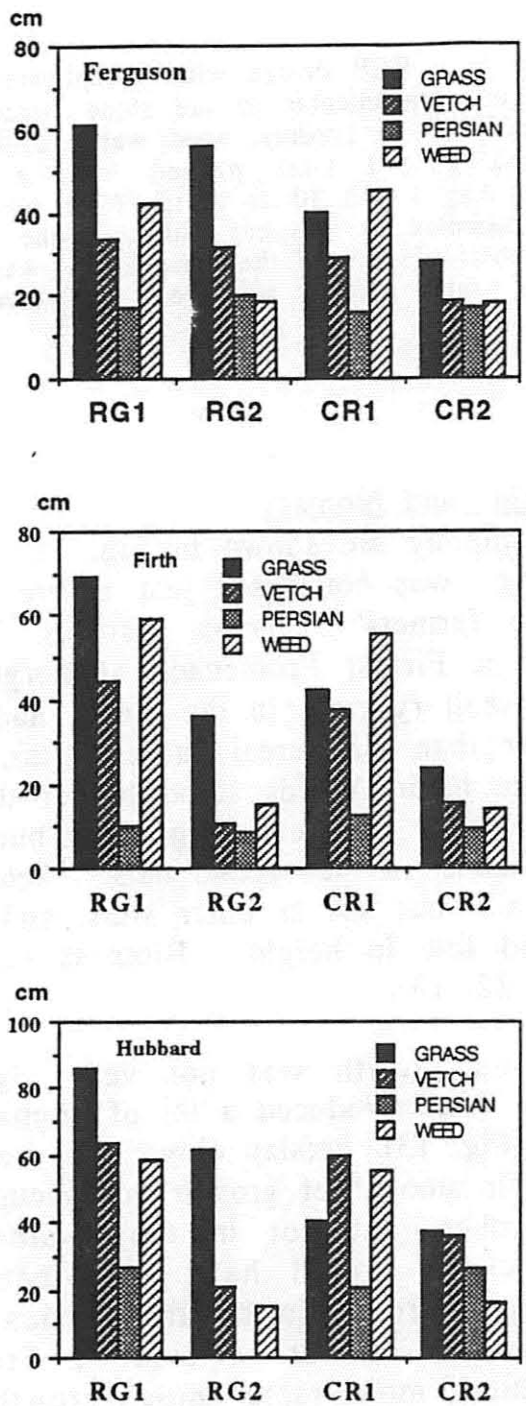


Fig. 11. Maximum heights of grass, legumes and weeds at each farm.
RG=ryegrass plots, CR = cereal plots with data for rye and triticale combined. 1 and 2 refer to first and second cuts (or grazings).

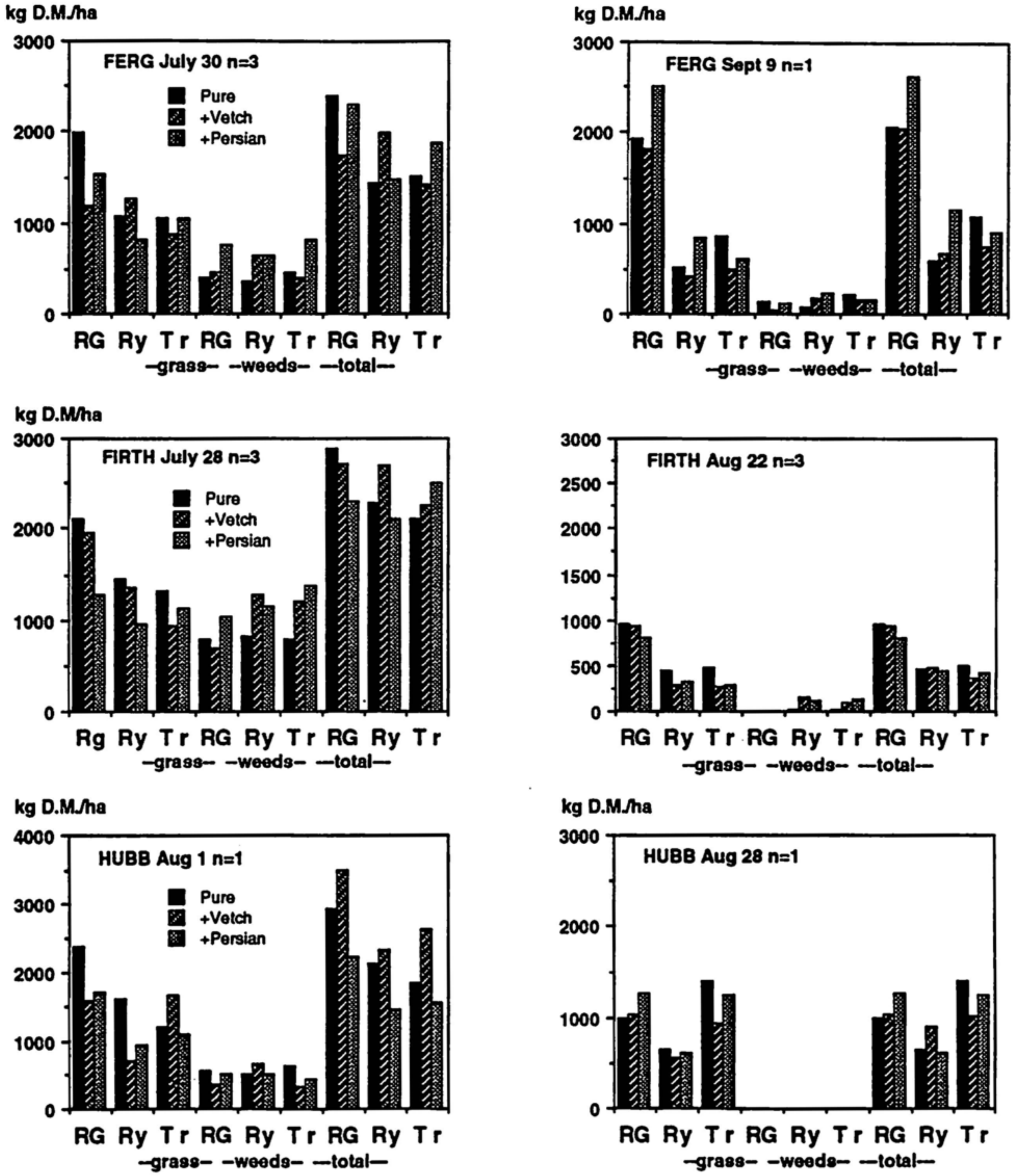


Fig. 12 Dry matter yields in pasture experiment. RG, Ry, Tr refer to ryegrass, rye, triticale (These are the same data as in Table 39)

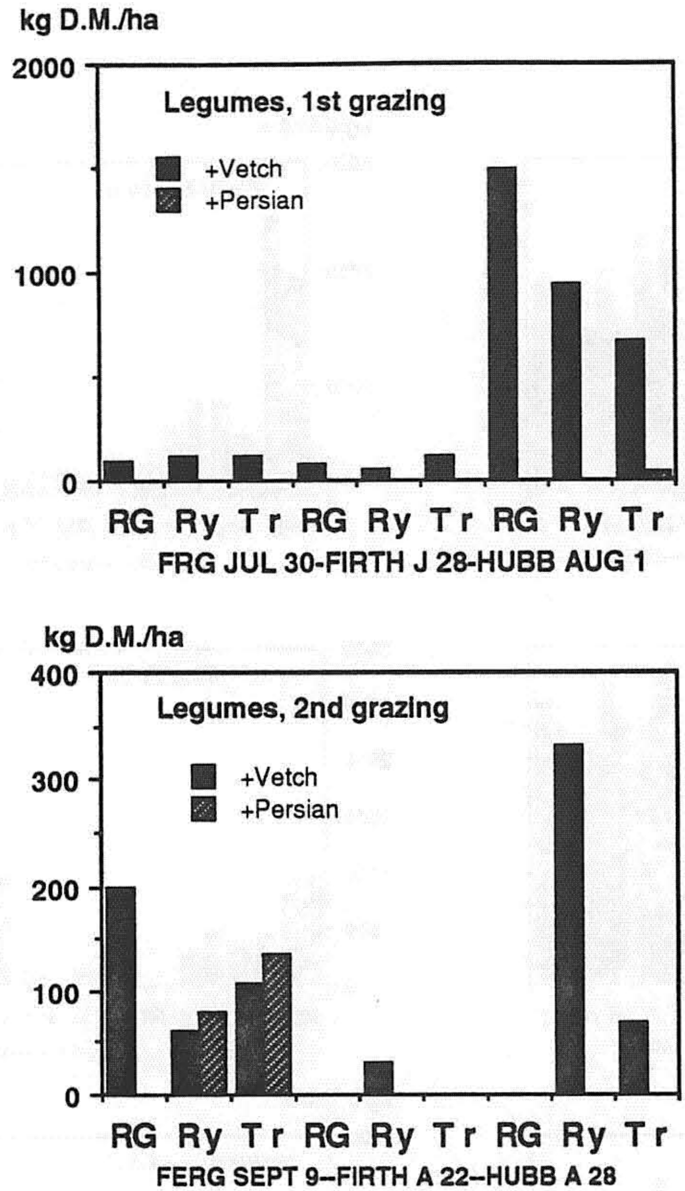


Figure 13. Legume biomass in Experiment V. RG, Ry and TR refer to plots with ryegrass, rye and triticale respectively

Table 39. Biomass data for the annual pasture experiment.

		Dry Matter in kilograms per hectare								
Site & Date Component	n	1 RG	2 RYE	3 TRIT	4 RG/V	5 R/V	6 T/V	7 RG/C	8 R/C	9 T/C
Ferg July 30	3									
GRASS		1992	1077	1060	1188	1262	883	1522	824	1056
WEEDS		395	354	459	463	646	406	771	646	819
LEGUME		0	0	0	93	120	120	0	0	0
TOTAL		2388	1432	1519	1744	1987	1409	2294	1470	1875
Ferg Sept 9	1									
GRASS		1938	508	868	1814	420	498	2500	846	604
WEEDS		130	76	210	40	180	150	120	226	160
LEGUME		0	0	0	200	60	106	0	80	134
TOTAL		2068	584	1078	2054	660	754	2620	1152	898
Firth July 28	3									
GRASS		2110	1449	1319	1941	1364	941	1274	951	1134
WEEDS		779	829	774	686	1289	1197	1026	1144	1376
LEGUME		0	0	0	80	47	113	0	0	0
TOTAL		2889	2278	2093	2707	2700	2251	2300	2096	2510
Firth Aug 22	3									
GRASS		957	440	478	943	293	262	809	327	278
WEED		0	11	11	0	158	94	0	108	136
LEGUME		0	0	0	0	31	0	0	0	0
TOTAL		957	451	490	942	482	356	809	435	414
Firth Oct 8	1									
TOTAL		1890	1170	1390	1750	1130	1300	1500	1210	1220
estimated weeds%		10%	30%	40%	2%	25%	30%	10%	20%	40%
estimated leg%		0%	0%	0%	8%	5%	20%	10%	10%	10%
estimated % gr		90%	70%	60%	90%	70%	50%	80%	70%	60%
Hubbard Aug 1	1									
GRASS		2380	1616	1192	1592	720	1648	1708	934	1084
WEEDS		554	500	646	368	666	320	520	518	442
LEGUMES		0	0	0	1488	925	657	0	0	40
TOTAL		2934	2116	1838	3488	2311	2625	2228	1452	1566
Hubbard Aug 28	1									
GRASS		1000	656	1404	1036	560	936	1264	612	1244
WEED		0	0	0	0	0	0	0	0	0
LEGUMES		0	0	0	0	332	68	0	0	0
TOTAL		1000	656	1404	1036	892	1004	1264	612	1244
TOTAL		1000	656	1404	1036	892	1004	1264	612	1244

Table 39 (concluded).Post-hoc statistical tests . (* =0.05, + =0.10)

COMPARISON	FERG Jy 30	FIRTH Jy 28	FIRTH Ag 22	HUBB Ag 1	HUBB Ag 22	FERG Sp 9	FIRTH Oct 8
GRASS							
RG vs RG + vetch	*	.	*				
RG vs RG + Persian	*	+	*				
RYE vs RYE + vetch	.	.	.				
RYE VS RYE + Persian	.	.	.				
TRIT vs TRIT + vetch	.	.	.				
TRIT vs TRIT + Persian	.	.	.				
all RG treatments versus all RYE treatments	*	*	*	+	*	*	
all RG treatments versus all TRIT treatments	*	*	*	.	*	*	
all RYE versus all TRIT	.	.	.	.	.	.	
WEEDS							
RG vs RG + vetch	.	.	.				
RG vs RG + Persian	.	.	.				
.							
RYE vs RYE + vetch	.	.	+				
RYE vs RYE + Persian		.	.	.			
TRIT vs TRIT + vetch		.	.	.			
TRIT vs TRIT + Persian		.	.	+			
all RG treatments versus all RYE treatments	.	.	*	.	.	.	
all RG treatments versus all TRIT treatments		.	.	+	.	.	.
all RYE versus all TRIT		.	.	.	.	.	.
TOTAL BIOMASS							
all vetch treatments versus all treatments w.out legumes			.	.	.	.	.
	.						
all RG versus all RYE	*	.	*	*	+	*	*
all RG versus all TRIT		*	.	*	*	*	*
	*						
all RYE versus all TRIT		.	.	.	.	.	.
	+						

Table 40. Crude Protein, Acid Digestible Fibre and nitrate contents of composite samples from Experiment V.

Sample	CP	ADF	Nitrate
	(Percent of dry weight)		
Ferguson July 30			
Ryegrass (Marshall)	21.7	27.5	0.96
Rye	24.5	23.1	1.04
Triticale	23.0	26.5	0.53
Weeds	21.1	19.3	0.52
Hairy vetch	30.2	23.7	0.21
Firth July 28			
Ryegrass (Marshall)	22.1	27.6	1.48
Ryegrass (Maris Ledger)	28.8	24.1	3.15
Triticale	27.9	26.5	2.34
Rye	29.5	23.5	2.01
Weeds	27.3	20.9	1.34
Hubbard Aug 1			
Ryegrass Lost			
Rye	21.7	26.4	0.31
Triticale	17.2	29.9	0.18
Vetch	24.9	32.1	0.10
Weeds	14.1	23.1	____
Hubbard Aug 28			
Ryegrass	14.6	25.1	0.08
Rye	20.1	24.5	
Triticale	17.0	29.7	
Vetch	31.6	19.2	
Firth Aug 22			
Ryegrass (Marshall)	28.0	19.6	1.24
Ryegrass (Maris Ledger)	30.1	18.2	2.32
Rye	29.3	15.8	0.45
Triticale	28.3	19.0	0.87
Weeds	25.3	19.9	0.76
Firth Oct 8			
Ryegrass (Marshall	22.4	20.5	0.12
Ryegrass (Maris Ledger)	24.8	20.0	0.14
Rye	26.9	18.7	
Triticale	24.1	19.9	

At all 3 sites, the biomass of ryegrass was higher than that of the cereals on the first cut, and also on the second cut except at Hubbards where the triticale biomass was approximately the same as that of ryegrass on the second cut. (Fig. 12, Table 39).

The biomass of ryegrass in the pure stands was higher at all 3 sites on the first cut than in the ryegrass-legume stands where the ryegrass seeding rate was reduced by 1/3; however on second cut, there was little difference. Differences in seeding rate seemed to have less effect on the cereals (Fig 12, Table 39).

Ryegrass and total yields were higher on first cut than second at Firth and Hubbard, but were more or less equivalent on the 2 cuts at Ferguson. The third cut at Firths was much higher than the second (Fig. 14).

<u>Nitrates</u>
Nitrates in the ryegrass and cereals at the Firth and Ferguson sites reached values above 1% (Table 40).

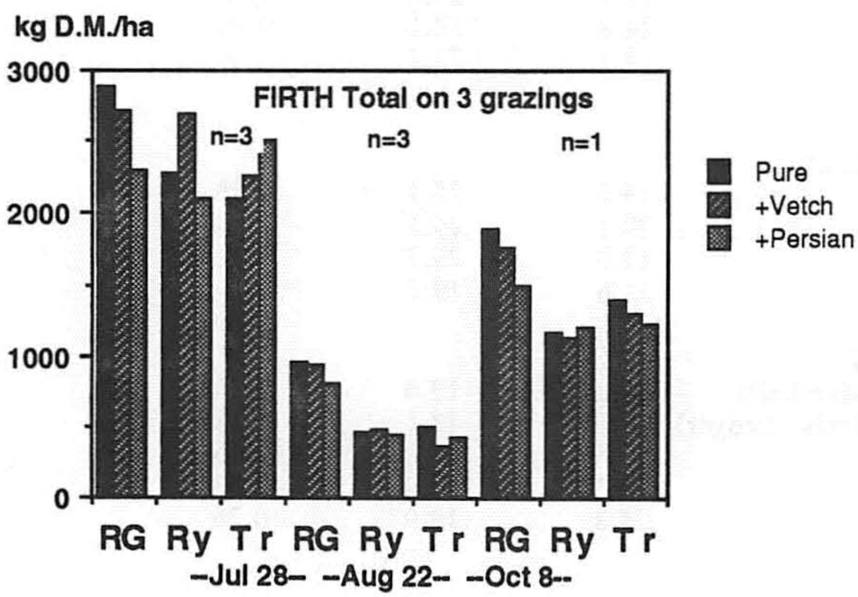


Figure 14. Total biomass yield at successive harvests at Firth site. RG, Ry Tr refer respectively to plots with ryegrass, rye and triticale.

Comparison of Marshall and Maris Leger ryegrasses
At the Firth site, side by side comparisons were made between the farmer's ryegrass (Maris Ledger) and the Marshall ryegrass:

Table 41. Biomass of Marshall ryegrass in plots, and adjacent Maris Ledger ryegrass at Firth site.

Date	Treatment	Maris Ledger (adjacent to plots) (kg/ha)	Marshall RG (in plots) (kg/ha)	P value[a]
July 28	pure RG	921	2110	0.35
	RG-Persian	1070	1274	0.25
Aug 22	pure RG	1046	809	0.05
	RG-Persian	1160	957	0.14
Oct 8	all RG plots	1263[b]	1713[b]	0.02

[a]Probability that the differences arose by chance as assessed by paired t-tests. n=3 for each comparison.
[b]Total biomass, estimated as 95-100% ryegrass

Marshall ryegrass had greater biomass on the first and third grazings, but was less than Firth's on the second. It had lower percent protein and lower percent nitrate on all 3 cuts (Table 41).

Weeds
The weed biomass on first cut made up a significant portion of the total biomass, especially at the Firth farm on the first cut, but was not very significant on the second cut (Fig. 12, Table 39)

The predominant weeds at the Firth farm were Lady's Thumb, Lambsquarter, Hemp Nettle, Wild Radish and Plantain. The first 4 were in flowering stage. The following observations were made after the sheep had grazed the field:

Lady's thumb: 75-100% of leaves and up to 50% of stems (top parts) eaten
Lambsquarter: 85-100% of leaves and up to 30% of stems (top parts) eaten
Hempnettle: Most leaves eaten and half of stems
Wild Mustard: upper leaves, flowers, some seed pods eaten and tops of stems

At Ferguson's, the main weeds were Lambsquarter, Hempnettle, Corn Spurry and Lady's Thumb. The cattle ate more of the stems than we observed for sheep at Firth's.

At Hubbard's the dominant weeds were Lambsquarter and Hempnettle.

Soil fertility at the three sites
Soil data indicate roughly equivalent levels (M- to H) of P, K, Ca and Mg at the 3 sites.

Table 42. Soil data for Experiment V sites.

Site	LOI (%)	ph	P_2O_5	K_2O (kilograms/hectare)	Ca	Mg
Ferguson	6.1	6.1	159M	398H	2499M-	649H
Firth	6.7	6.0	245H-	336H	2882M-	560H-
Hubbard 1[a]	6.1	6.6	114M-	106L+	1395L	461M+
Hubbard 2b	6.7	6.3	340H	355H	2643M-	610H-

[a]Sample in June 1990, whole experimental field
[b]sample in May 1991, in Experiment V region only

V. 4. Conclusions

Cereal yields were disappointingly low compared to the ryegrass. Persian clover performed very poorly; seed germination was slow. Possibly it was not a good batch of seed. Vetch showed more promise, and produced very significant amount of biomass at the Hubbard site. The difference may be related to difference in available N at the three sites, which on the basis of the fertilization would likely be lowest at the Hubbard site. This is suggested also by lower %protein in plants tissues than at the other two sites (Table 40). Unlike the sections of the field where experiments I and IIB were conducted, calcium appears to be adequate in the Experiment V region which is near the top of the field.

There were high levels of nitrates in the ryegrass and some of the cereals at the Ferguson and Firth sites on the first and second samplings (David Firth and Eric Bosveld had suggsted that we look at the nitrate levels). The Marshall ryegrass had somewhat lower levels than the Maris Ledger, but the cereals were also relatively high. Weeds formed a significant part of the biomass at first grazing at the Firth site, and were grazed down by the sheep.

The annual pasture at the Firth farm was very weedy at first grazing. One visitor suggested that it be ploughed in. However, it was clearly evident that the weeds made good forage, and in any case, their proportion in the biomass dropped markedly after the first grazing. There is some evidence that the weeds contained higher levels of selenium (J. Scott, thesis).

Following up on these experiments, two of the farmers experimented with ryegrass/Alsike clover mixes and ryegrass/forage peas mixtures in 1991 (see J. Scott, thesis).

Appendix A.

Monthly rainfall and temperature data for 1990 and 1991 growing seasons at Nappan

Month	Avg. Temp (°C) 1991	1990	1989	Last 30 years	Total Precip (mm) 1991	1990	1989	Last 30 years
May	10.1	8.4	13.5	9.2	91	238	91	76
June	14.8	15.9	15.8	14.7	50	41	108	78
July	18.4	18.8	17.4	18.0	57	113	86	84
Aug	18.4	19.4	18.1	17.4	198	101	56	91
Sept	13.1	13.3	13.7	13.4	127	106	102	81
Oct	9.8	10.8	7.5	8.3	99	161	44	101

Weekly Rainfall at Nappan

Week	1991	1990	Last 30 Years
May 3-9	25.9	28.5	16.8
10-16	7.7	63.2	16.8
17-23	29.3	70.5	16.8
24-30	20.7	74.8	16.8
31-**Jn** 5	3.8	11.4	18.0
7-13	15.0	0.0	18.2
14-20	10.7	4.2	18.2
21-27	8.8	22.7	18.2
28-**Jy** 4	11.8	5.5	18.6
5-11	1.1	1.4	18.9
12-18	27.1	0.0	18.9
19-25	0.5	85.1	18.9
26-**Aug** 1	36.6	50.5	19.1
2-8	64.4	12.4	20.3
9-15	32.4	50.5	20.3
16-23	51.6	11.0	20.3
23-29	28.5	9.2	19.3
30-**Sept** 5	20.3	0.8	20.3
6-12	N/A	24.9	18.9
13-19	35.6	2.3	18.9

Appendix B INFORMAL TRIALS OF WINTER RYES

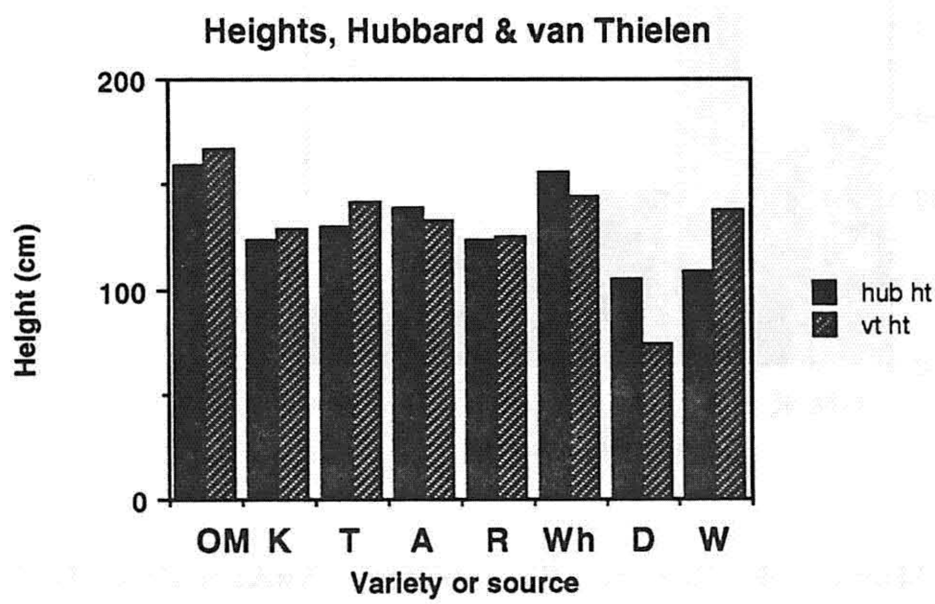
In 1989, an informal experiment was conducted to test 8 winter ryes. Single plots of each type were set up at the Hubbard and van Thielen farms.

Methods:

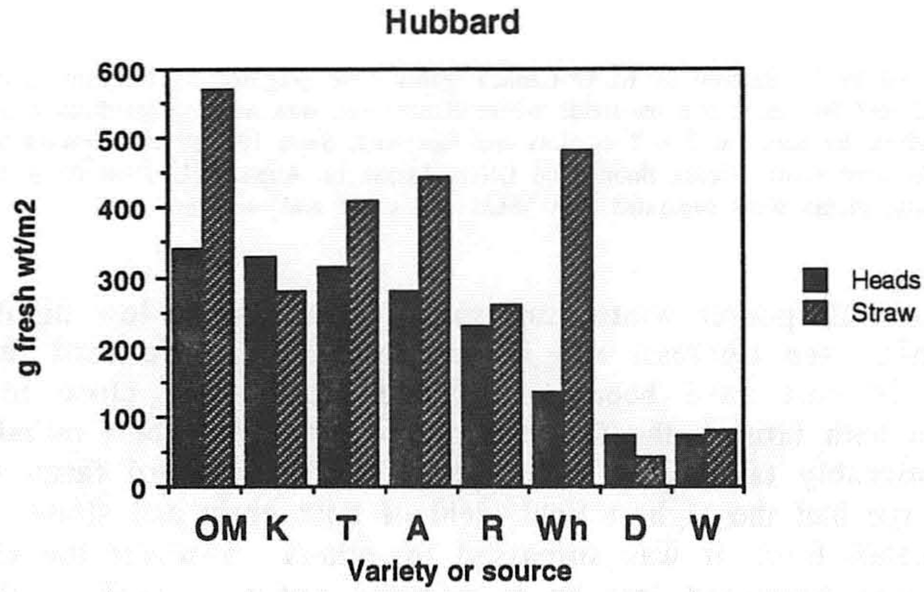
Seed was provided by R. Samson of REAP-Canada. Plots were prepared by Suzanne, Judith, Charles Hubbard and Nicola Boone on fields where Kustro rye was being planted as a crop. Seed was broadcast by hand on 7 x 7 m plots and harrowed, Sept. 10, 1989. Harvests were made by by Jennifer Scott, Nicola Boone and Oliver Maass on August 11, 1990 from three 50 x 50 quadrats. Plants were separated into heads and straw and weighed

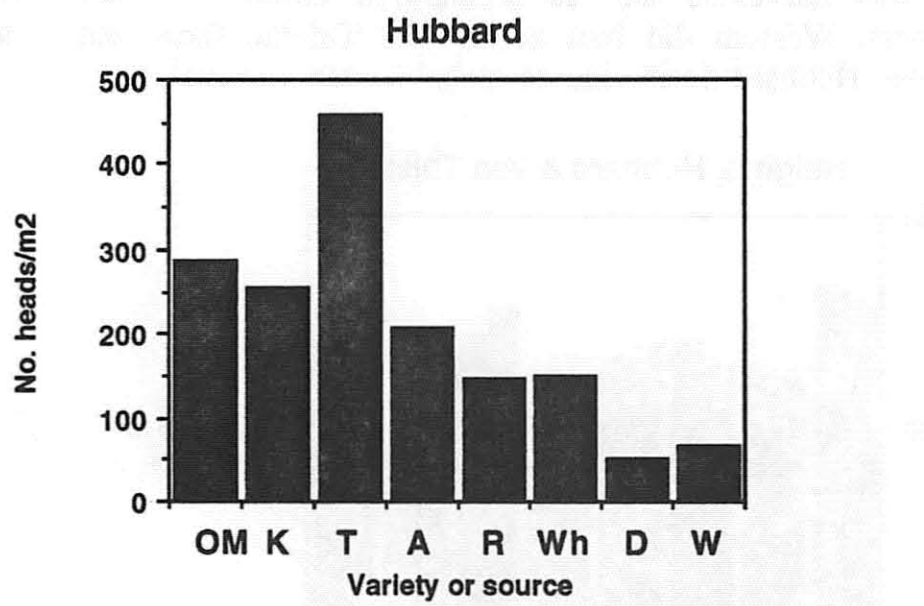
Results:

There was overall poorer winter survival (indicated by a low number of heads/m^2; see figures), and lower yields at the Hubbard farm which may in part have been due to the plots being close to a highway. On both farms, the Oak Manor rye looked the best initially, and was noticeably taller than other types. At the Hubbard farm, the Oak Manor rye had the highest final yield of both grain and straw At the van Thielan farm, it was surpassed by others however the Oak manor rye was harvested late as it matured about 2 weeks earlier than the others. Western did best at the van Thielan farm, but it was poorest at the Hubbard farm due to poor winter survival.

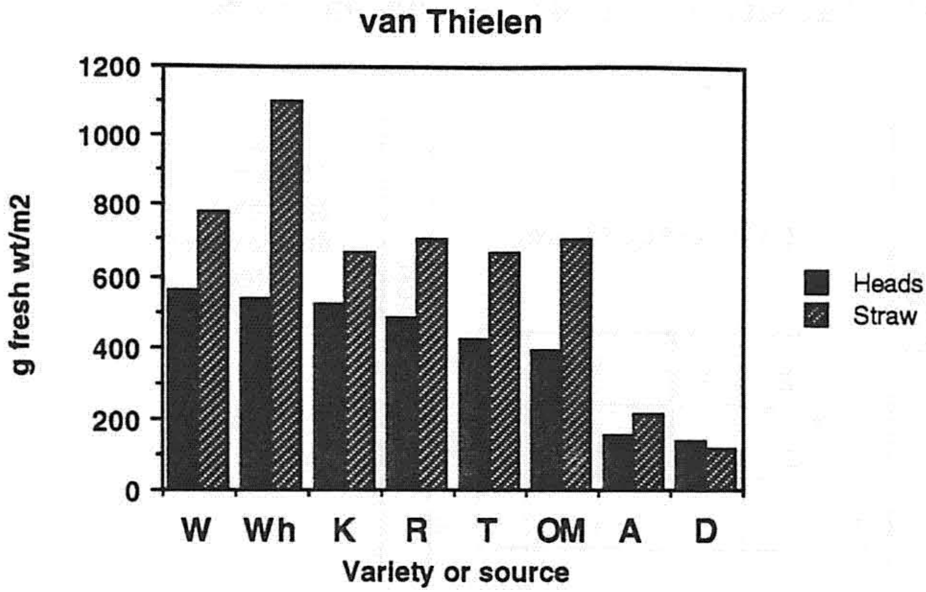


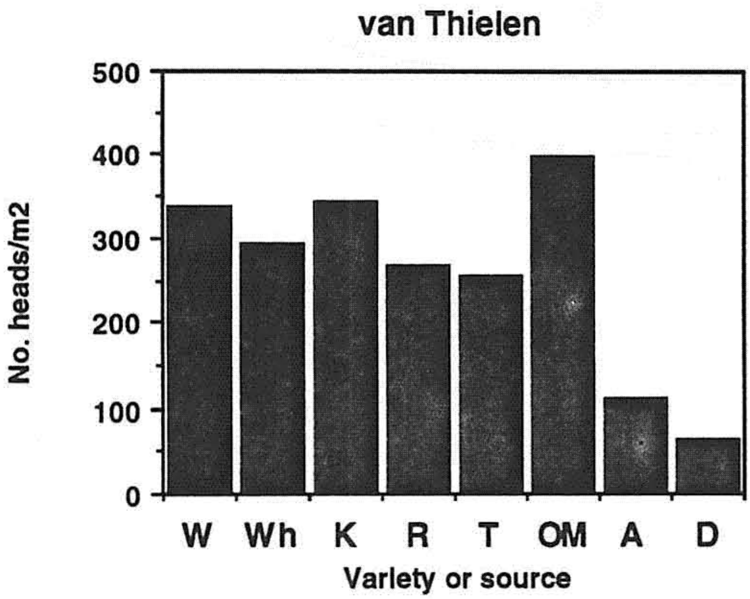
OM=Oak Manor, K=Kustro. T=Tobacco, A=Aroostik, R=Ryeman W= Wheeler, D=Danko, W=Western





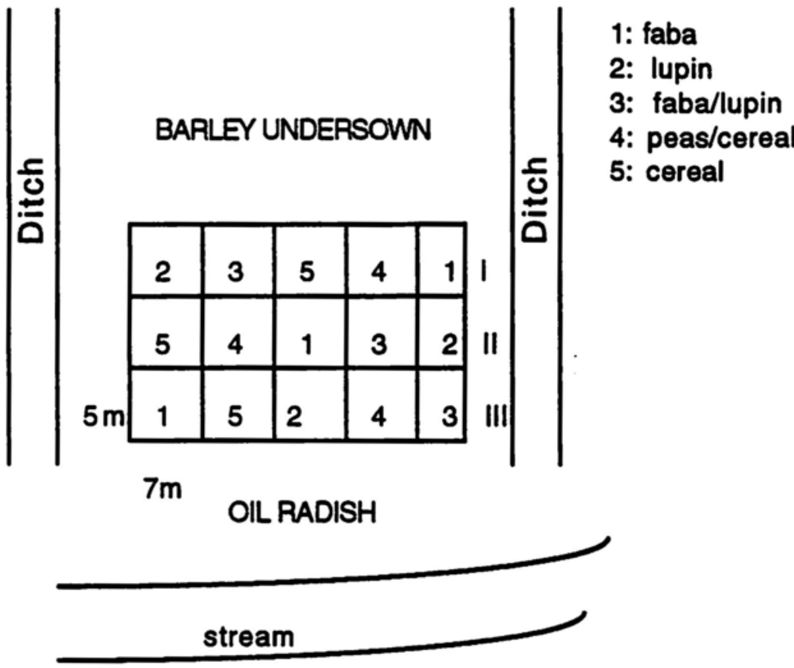
OM=Oak Manor, K=Kustro. T=Tobacco, A=Aroostik, R=Ryeman W= Wheeler, D=Danko, W=Western



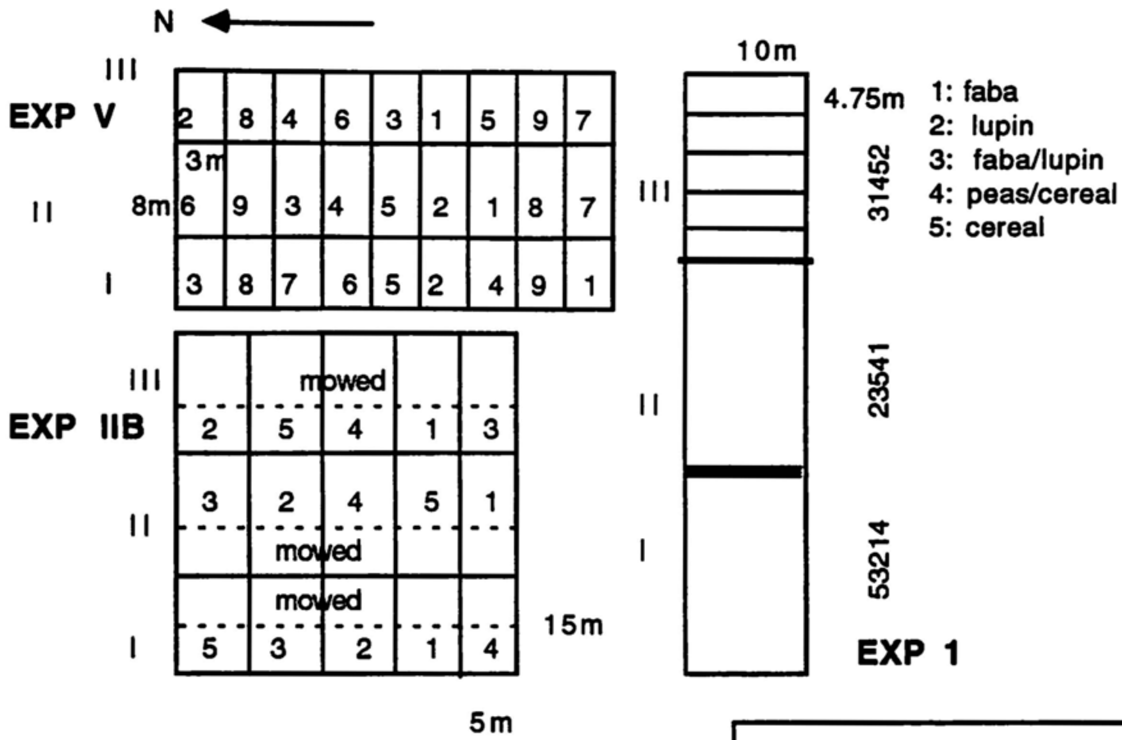


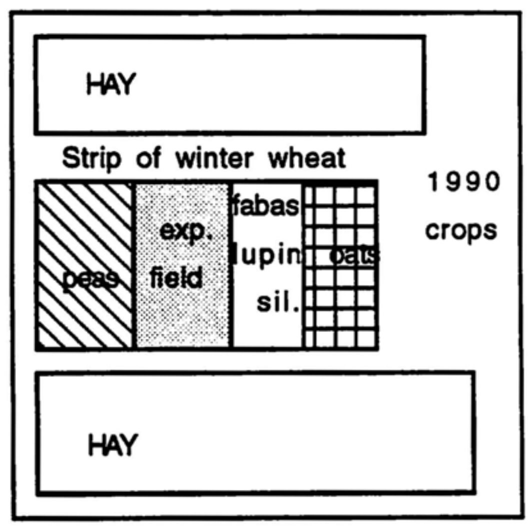
OM=Oak Manor, K=Kustro. T=Tobacco, A=Aroostik, R=Ryeman W= Wheeler, D=Danko, W=Western

Appendix C: Layouts out plots set up in 1990



EXP I van Thielan

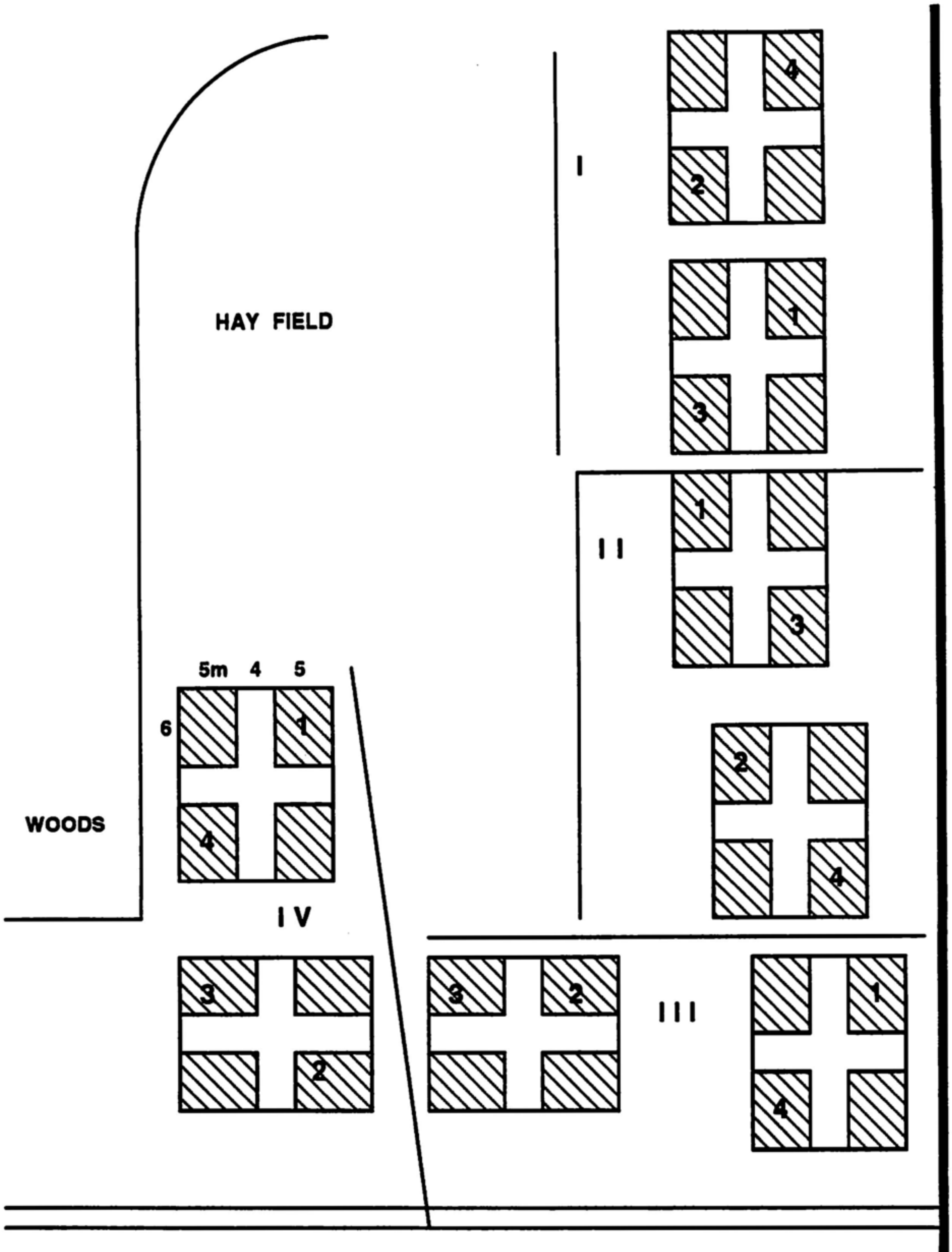




Exp V.
1= ryegrass
2=rye
3=triticale
4=ryegrass + vetch
5=rye + vetch
6=triticale + vetch
7= ryegrass + P. clover
8= rye + P. clover
9= triticale + P. clover

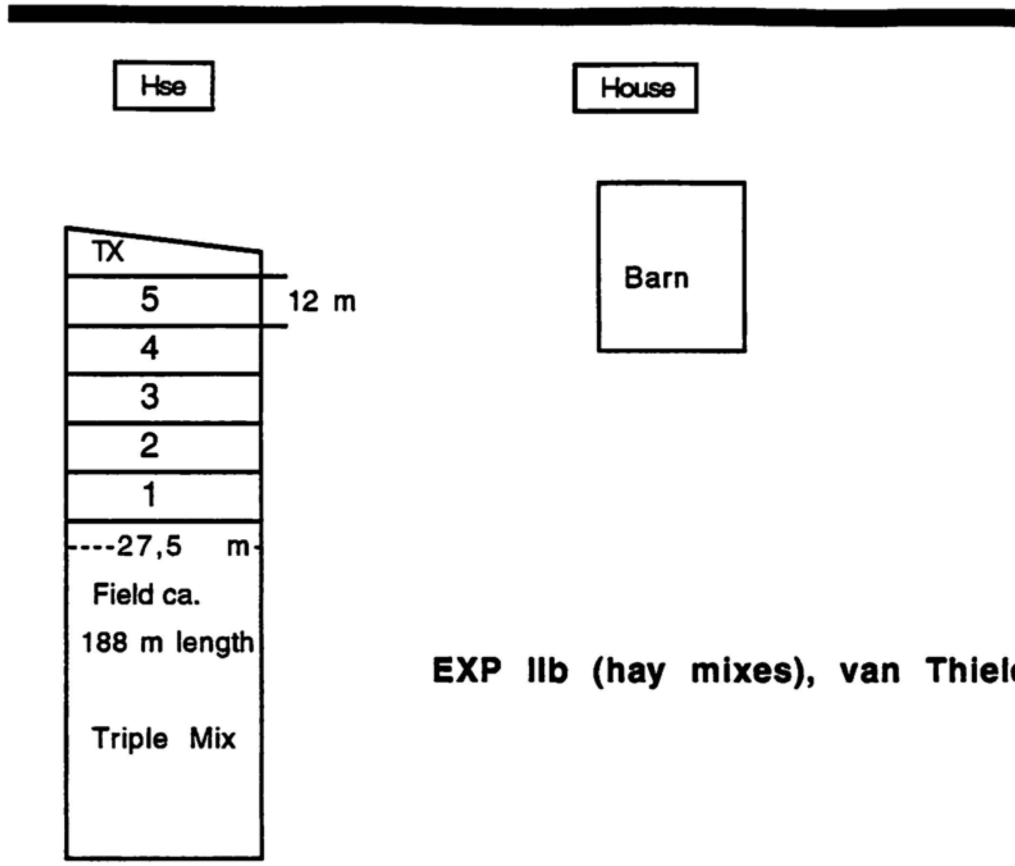
Exp. IIb: 1 = RC/T; 2= A/T; 3=RC/WC/T; 4: RC/WC/A/T/B; 5: Triple Mix

"Experimental Field" at Hubbard Farm with experiments I, IIB, V

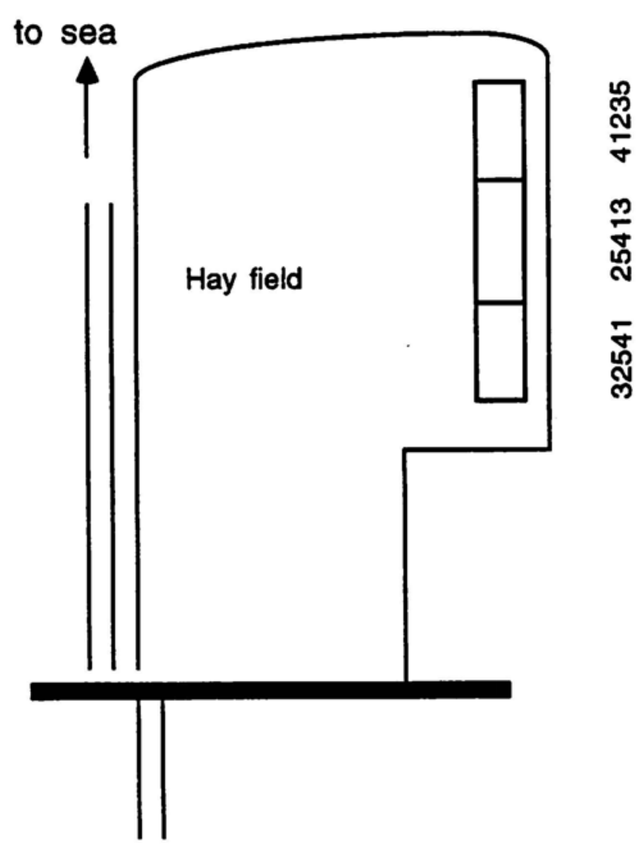


EXP IIa. Fertilization of hay. Hubbard, 1990
(plots with no numbers to be set up in 1991)

1=control, 2=manure, 3=compost, 4=N-P-K



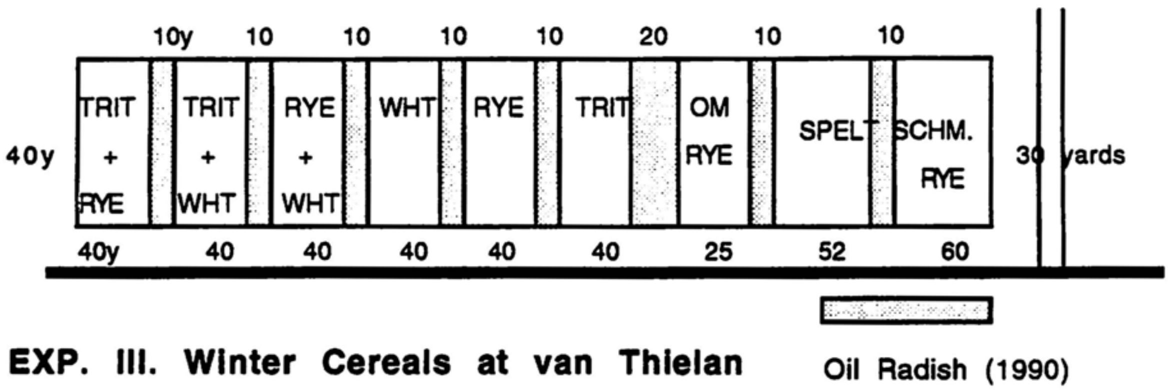
EXP IIb (hay mixes), van Thielen



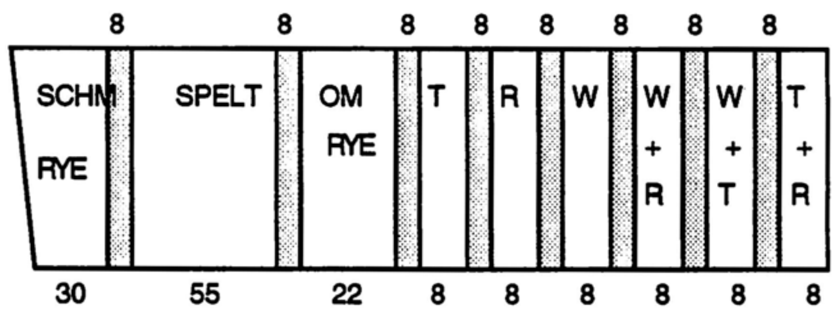
EXP IIb (hay mixes)
Firth

Each plot is 3 m wide, 11 m long

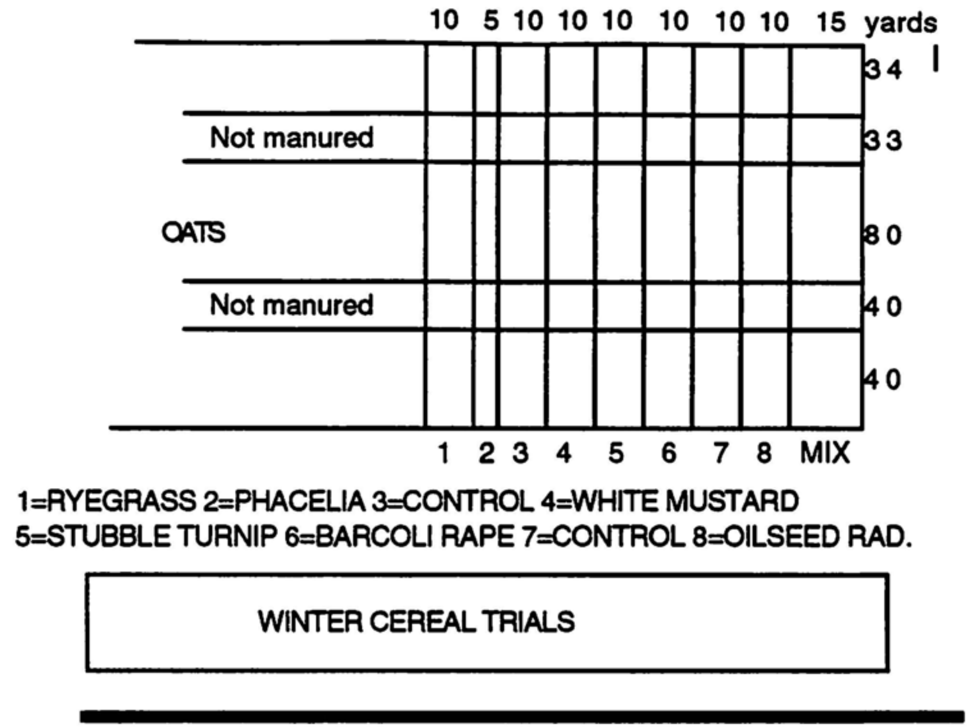
Exp. IIb: 1 = RC/T; 2= A/T; 3=RC/WC/T; 4: RC/WC/A/T/B; 5: Trople Mix



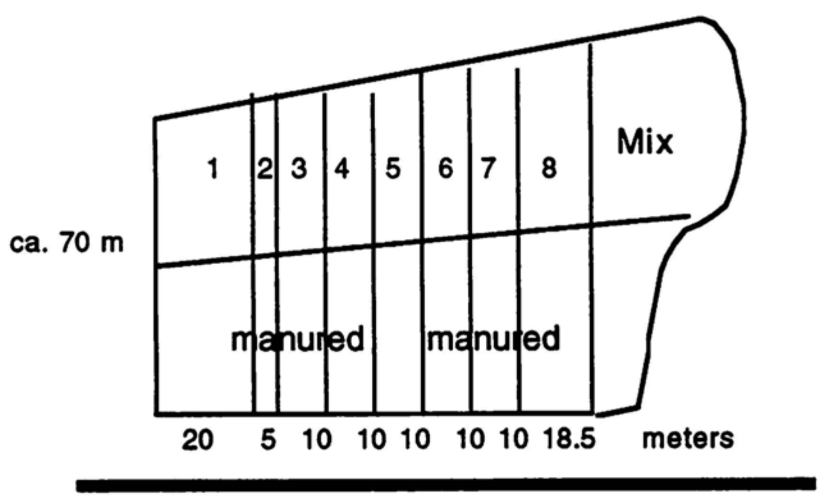
EXP. III. Winter Cereals at van Thielan



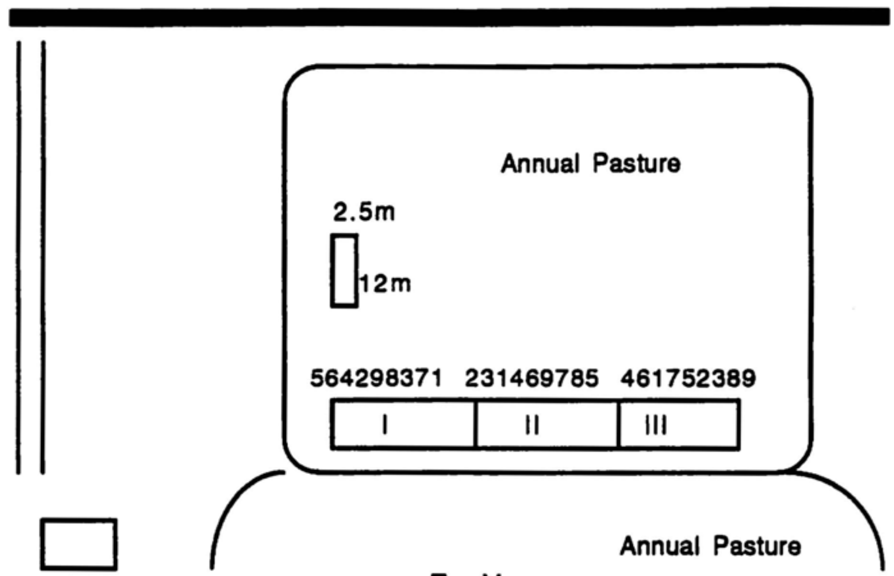
EXP III. Winter Cereals at Hubbard



EXP IV Catch Crops, van Thielan

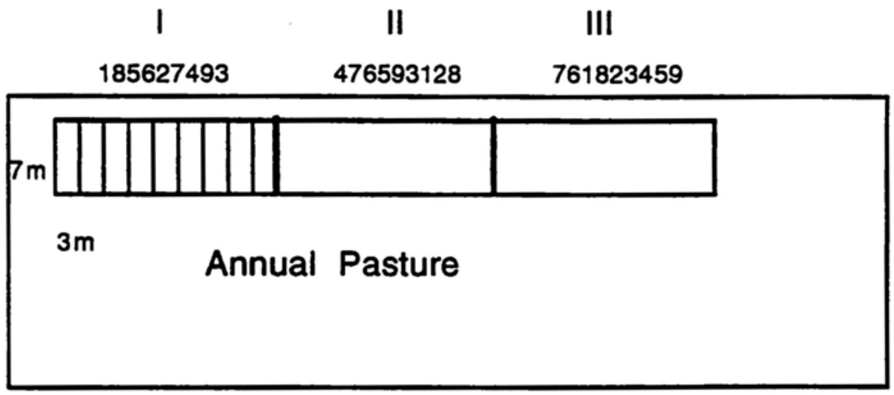


EXP IV Catch Crops, Hubbard



EXP V, Ferguson

Exp V.
1= ryegrass
2=rye
3=triticale
4=ryegrass + vetch
5=rye + vetch
6=triticale + vetch
7= ryegrass + P. clover
8= rye + P. clover
9= triticale + P. clover



EXP V. Firth Farm

Exp V.
1= ryegrass
2=rye
3=triticale
4=ryegrass + vetch
5=rye + vetch
6=triticale + vetch
7= ryegrass + P. clover
8= rye + P. clover
9= triticale + P. clover

Appendix D. Informal experiment to develop a labor efficient system for residue and weed management in organic vegetable production.

The weed problem in organic vegetable production. Control of weeds is commonly a major labor requirement for organic vegetable producers. Many producers use rototillers or rotovators, to prepare seedbeds, and cultivate between rows. In the course of certification visits to farms in Nova Scotia, New Brunswick and Maine, D.P. had the opportunity to observe many organic vegetable operations. Consistently, the most intense weed pressure was observed in the rotovated or rototilled systems (Plate 3, A). The rotovation turns seed banks over, exposing them to light and stimulating germination, as well as burying the current seed rain. Between the rows, rotovation controls weeds adequately, but requires energy. Also, the rotovation likely stimulates release of nutrients which could be lost readily by leaching, and it pulverizes the soil.

REAP's Experimental Garden In 1990, an experimental garden was established on the Hubbard farm for the purpose of testing effects of seaweed extracts on vegetable production (for Acadian Seaplants Ltd.) It provided as well an opportunity to test a system for organic vegetable production with the objectives of (i) minimizing requirements for weeding (ii) allowing as much of the preparation as possible to be done during the fall, so as to minimize work required in the spring when soil is wet, and (iii) facilitating in-place handling of plant residues (as opposed to collecting and composting them).

The field had been cleared from forest 4 years previously. It had grains growing on it the first 2 years (to improve soil), and in 1989, experimental crops of lupins, fababeans and vetch. The only fertilizer applied was manure; no fertilizers were applied to the legumes in 1989. The soil is a loam.

In May of 1990, the field was ploughed and 30 m length raised beds of 50 cm width and 20 cm height with 50 cm between beds were prepared using a hilling implement behind a small tractor. The raised beds were narrower than wished, but with the field equipment at hand, the best that could be done. The field slopes gently to the north; beds were oriented perpendicular to the slope. The areas between beds were mulched with approx. 5cm of straw from the legume crops or old hay (Plate III: B). Fertilizers were incorporated into the raised beds using hoes and rakes. The fertilizers used were crab meal (5-8-0), fish bone meal (6-12-1), usually a mixture of the two. Potassium sulfate and hard rock phosphate were applied to some plots. Typical rates for high fertility plots were: 300 g mixed fish/crab, and 20 g potassium sulfate per 2 meter length of raised bed; 100 g of hard rock phosphate was applied in some of the 2 meter plots.

For the purposes of providing mulching and green manure materials, serving as windbreaks, diversifying the environment and providing nectar for natural enemies, and to suppress weeds on unused ground, several annual species were grown on roughly 1/3 of the raised bed area (Plate III: C, D). These included oat/vetch mixture, Persian clover, Crimson Clover, and buckwheat

The straw or hay mulches provided excellent weed control between the rows. High yields were obtained for most crops; they were reduced by about 50% where no fertilizers were applied.

In one row, bean seeds were dropped loose into the straw mulch; these germinated and grew as well or better than the beans on the raised beds (Plate III: B) Enhanced growth is attributed to better moisture retention in the straw covered depressions, than on the more exposed raised beds.

Fall management for residue digestion, addition of fertilizers and weed control

In early September, three sets of 2 adjacent rows and the intervening depressions were selected for a fall management trial. Residues from the crops, and the green manure/mulch crops were placed in the depressions. Soil from the 2 adjacent raised beds was hoed over the residues (Plate III: E) and ryegrass or oilseed radish (Plate III: F) planted. It is suggested that fertilizers could also be applied at this time, to the residues. It was hypothesized that the cover crops would absorb free nutrients, preventing leaching; and suppress weeds. Being annuals, they would be winter killed. Then in the spring it would be necessary only to till precisely where crops were to be planted, which would minimize soil disturbance. The well raised beds would facilitate good drainage, and early warming. The incorporated plant residues would begin decomposition in the fall, continue in the spring and summer, allowing a slow release of nutrients to crops which would increase though the season. By varying the mixtures of different residue types, manures and fertilizers incorporated in the beds, it should be possible to devise systems with different patterns of nutrient release to suit different crops.

We had intended to reestablish a regular garden at this site in 1991, but pressure of work prevented us doing so, and the garden, except for the experimental fall tillage was completely undisturbed. Vegetables were planted only in the experimental rows, and in rows where Crimson clover had been grown and died back during the winter forming a natural mulch. No weeding was conducted. Remarkably, the fall prepared beds and the undisturbed Crimson clover beds (but not those of other mulch crops) remained almost totally weed-free though the season, while there was heavy weed growth elsewhere (Plate III: G).

The fall prepared beds were approximately twice as large as the original, 50 cm width beds, which was desired, as the original beds were smaller than wished. It is proposed that this system could be maintained by applying straw mulch between the enlarged, (roughly 1 meter wide) beds during the growing season, applying residues and manure over the straw in the fall, and then hoeing one adjacent bed on top of the residues; immobilizing residues might be applied to the newly exposed depression.

In summary, the main features of the proposed and partially tested system are:

(1) Establishment of annual raised beds, ca 1 m in width with 1 meter between beds.

(2) The depressions between raised beds are mulched with immobilizing residues to control weeds, retain nutrients. Some leguminous crops might be seeded directly into the residues (as they will not suffer and may even benefit from immobilization of N).

(3) Annual green manure/cover crops are grown on a portion of the raised beds, to provide mulch, green manure, or immobilizing materials, keep weeds down, function as windbreaks, and diversify habitat.

(4) As crops are harvested, the crop residues are turned into the adjacent depression together with manures, other residues, or other fertilizing materials; the old raised bed is hoed over the depression, and a cool season, but winter-kill annual planted to provide fall cover, take up soluble nutrients, and suppress weeds.

(5) In spring or summer, the raised bed is cultivated only where seeds are to be placed. By the time roots have grown down into the layer of residues, decomposition is releasing adequate nutrients for maximum crop growth. In principle, by varying the mixtures of residues and manures, it should be possible to vary the pattern and intensity of nutrient release to suit different crops.

Potential Benefits of this system are:

- low weed pressure.
- desirable seasonal labor distribution;
- minimal soil disturbance in spring;
- raised beds for good drainage and rapid warming up in spring;
- in place production of mulch, green manures with minimal distance involved in moving residues; incorporated residues are decomposed in place (at the site where the nutrients will be taken up by the crop);
- diversification;
- with manipulation of ratios of fibrous and succulent materials, manures etc. incorporated in the raised beds, it should be possible to provide varied patterns and quantites of nutrient release to suit different crops.

The system could probably be handled on the scale of about 1/2 acre to 1 acre by one to two persons without mechanization, or on a larger scale with appropriate modifications and mechanization of some operations.