IPC SEMINAR AGENDA

Agriculture and the Environment in the 21st Century

How Can Agriculture Feed the World Without Harming the Environment?

Tuesday, October 17, 1995
Hotel New York • Disneyland Paris

9:00-10:00 ***Is Agriculture a Threat to the Environment?***

What is the relationship between agriculture and the environment in the current policy climate? Are the two in a state of conflict or cooperation?

Opening remarks: **Georges-Pierre Malpel** (Director General, Unigrains)
Introduction: **Lord Plumb of Coleshill** (Member, European Parliament & IPC Chairman)
Keynote address: **Henri de Benoist** (Chairman, Céréaliers de France)

10:30-12:15 ***Impact of Agricultural Policies on the Environment -- The Farmers' Perspective***

How are farmers responding to environmental concerns? Should governments employ policies to encourage environmentally friendly production and, if so, which policies?

Moderator: **Georges-Pierre Malpel** (Director General, Unigrains)
Panelists: **André Grammont** (Director for Rural Land, Ministry of Agriculture, France)
Dean Kleckner (President, American Farm Bureau Federation)
Jiro Shiwaku (President, Livestock Industry Promotion Corporation, Japan)
Tadeusz Hunek (Polish Academy of Sciences)

12:30-1:45 Luncheon - Luncheon Speaker: **Peter Williams** (Director, Products and Services, Rhône-Poulenc)

1:45-3:00 ***How is Agribusiness Responding to the Environmental Challenge?***

What constraints are businesses facing? What policies should be employed to encourage safe products while allowing businesses to remain competitive? How can national governments employ policies that encourage the development of new, environmentally sound agricultural products?

Moderator: **Bernard Auxenfans** (Group Vice President, International Division, Monsanto)
Panelists: **Georges Vermeersch** (Director of Innovation & Prospective Studies, Sofiproteol)
André d'Olne (consultant)
Rob Johnson (Corporate Vice President, Public Affairs, Cargill)
Claudio Rocchietta (Administrative Delegate, Novaol)

3:15-5:00 ***How is the World Trade Organization Addressing Environmental Concerns?***

What are the WTO's plans for multilateral reform of agriculture? Will the WTO be "green?" What mechanisms and modalities should be implemented?

Moderator: **Aart de Zeeuw** (Former Chairman, Agricultural Negotiations, GATT)
Presenter: **Richard Eglin** (Trade and Environment Division, WTO)
Reactors: **Dale Hathaway** (Exec. Director, National Center for Food and Agric. Policy, USA)
Pedro de Camargo (Vice President, Brazilian Rural Society)
Julio Garcia-Burgues (European Commission, DG XI)

5:00-5:30 ***Implications and Conclusions***

Claude Villain (Inspector General, Ministry of Finance, France)

L'AGRICULTURE MENACE-T-ELLE L'ENVIRONNEMENT?

Henri de Benoist
Céréaliers de France

C'est au moment où la France se trouve être le deuxième exportateur mondial de produits agricoles et agro-alimentaires et où la recherche agronomique explore tout ce qui est techniquement possible pour rester compétitif, que des voix s'élèvent régulièrement pour dénoncer publiquement les impacts écologiques défavorables de l'agriculture, et se demandent si l'agriculture est une menace pour l'environnement.

Cette question est légitime parce que le risque existe. Et, en cela, notre agriculture n'est pas différente de notre industrie ou de nos concentrations urbaines. L'important est d'être à même d'évaluer ce risque et de faire en sorte qu'il soit réduit au minimum. C'est ce à quoi les agriculteurs se sont attachés comme nous allons le voir.

A la question y a-t-il, en France, conflit à ce sujet entre partenaires, on peut d'entrée répondre "non". Je n'aurais peut-être pas répondu aussi nettement il y a quelques années. Mais aujourd'hui, entre les représentants de la filière agricole, l'Administration et les collectivités territoriales, des actions communes sont en cours avec la volonté d'avancer. Je crois que c'est du solide et du sérieux, et que c'est la seule voie payante à long terme. Nous en donnerons des exemples.

Mais, me direz-vous, vous avez tous lu récemment un article, vu une émission, entendu la déclaration tonitruante d'un homme politique stigmatisant le "comportement irresponsable des agriculteurs"! Il est vrai en effet que cette situation est fragile et que le conflit reste latent car il y aura toujours des gens qui chercheront l'occasion de mettre de l'huile sur le feu parce que c'est leur intérêt immédiat. Mais c'est du court terme, cela n'est pas sérieux et je crois que le complexe problème des relations entre l'agriculture et l'environnement mérite d'être mieux traité.

Dans un premier point, je voudrais justement aborder brièvement cette question de l'interdépendance des relations entre l'Agriculture et l'environnement.

L'interdépendance des relations Agriculture-Environnement

Nourrir l'homme

La nation a accédé à la sécurité alimentaire et, déjà, elle oublie que c'est là un privilège! En effet, jusqu'à ces dernières années encore, la prééminence des préoccupations concernait l'approvisionnement en denrées alimentaires.

Il s'agissait de développer et d'assurer notre capacité de production. Ce fut l'objectif essentiel de la première Politique Agricole Commune mise en place par le Marché Commun dans les années soixante.

Les agriculteurs, aidés en particulier par les apports de la recherche scientifique et technique, ont sû remplir cette mission durant les fameuses "trente glorieuses". L'indépendance alimentaire a été non seulement atteinte, mais dépassée. Cette réussite a eu deux conséquences:

1 - D'abord, l'amélioration de la productivité agricole qui a très largement profité au consommateurs que nous sommes tous. Ainsi, en France, la part du budget des ménages consacrée à l'alimentation qui était de 34% en 1960 n'était plus que de 18% en 1990.

2 - Seconde conséquence du succès de la première Politique Agricole Commune: la mise en place, à partir de 1993, d'une nouvelle PAC dont l'objectif est la maîtrise des productions. Cette politique, que vous connaissez tous, est caractérisée par une baisse des prix qui est compensée partiellement dans la mesure où l'agriculteur accepte de mettre en jachère un pourcentage de sa surface. Mais il a bien été décidé que cette surface retirée de la production devait être modulée en fonction des besoins des marchés.

Il faut en effet dire et redire que la mission fondamentale de l'agriculture a toujours été, est, et doit rester, de nourrir l'homme.

Rappelons que l'on considère que, pour les trente ans à venir, il sera nécessaire d'accroître de 50% les ressources alimentaires pour couvrir à la fois les besoins des nouveaux venus et compléter la ration du milliard d'individus qui, actuellement, ne mange pas à leur faim.

Il faut dire aussi que la production agricole est au service de l'homme, non seulement pour le nourrir mais également pour être une source de matières premières industrielles appelées "renouvelables." Nous reviendrons plus loin sur l'exemple des biocarburants. On pourrait parler aussi de la "Chimie Verte."

L'Europe, et spécialement la France, ont la capacité de répondre à cette demande mondiale dès lors qu'elle se manifeste. Les agriculteurs français et tout particulièrement les céréaliers, ont bien l'intention, dans le cadre des accords du GATT signés en avril 1994, de maintenir et de développer leur présence sur ces marchés très convoités et que certains disent même stratégiques pour les années à venir.

Protéger l'environnement

Mais restons sur les aspects alimentaires. Les risques ancestraux de pénuries, pour ne pas dire de famines, s'étant évanouis dans nos pays, une nouvelle demande sociale est peu à peu apparue vis à vis de l'agriculture. Elle concerne à la fois la qualité des produits (absence de risques pour la santé, goût...) et la préservation de l'environnement et des ressources naturelles (eau, atmosphère, cadre de vie dans l'espace rural,...).

L'agriculture, comme toute activité économique, a ainsi ses exigences et celles-ci évoluent: produire pour produire n'est déjà plus un objectif. Il s'agit désormais de mettre

sur le marché des denrées présentant des caractéristiques qualitatives adaptées à une demande qui se fait de plus en plus précise.

Cette activité agricole, comme toute activité humaine, peut avoir ses excès, mais l'agriculteur a déjà montré qu'il était capable de s'adapter aux nécessités et aux exigences de la société. Il ne se résignera pas en tout cas à servir de bouc émissaire. L'environnement, il le connaît d'ailleurs sans doute mieux que la plupart des citadins car c'est à la fois son lieu de travail et le milieu dans lequel il vit tous les jours! Il est donc tout naturel qu'il ait le souci de sa sauvegarde, puisqu'il en est le premier bénéficiaire. Vous comprendrez facilement que nous ne souhaitons pas transmettre à nos successeurs, qui sont souvent nos enfants, un patrimoine déprécié! La protection de l'environnement est donc un objectif que nous partageons totalement. Comment pourrait-il en être autrement puisque, pour revenir à la question posée au départ, si l'agriculture devait devenir une menace pour l'environnement elle deviendrait immédiatement une menace pour l'agriculteur lui même!

La première condition pour que cette mission de préservation de l'environnement soit remplie par l'agriculture, c'est que la compétitivité des entreprises agricoles permette leur survie. Quelle pourrait être en effet la qualité de l'environnement dans une région désertée par ses agriculteurs ?

Une agriculture toujours plus raisonnée

Ainsi donc l'agriculture est-elle confrontée aujourd'hui à des demandes qui peuvent paraître contradictoires:

D'une part celles des agriculteurs, rejoignant d'ailleurs celles des marchés, qui cherchent à produire en quantité suffisante des denrées d'une qualité toujours accrue et à des prix toujours plus bas.

D'autre part, les attentes croissantes de la société dans son ensemble vis à vis de la préservation du territoire rural et de l'environnement.

Y a-t-il alors conflit? Il est vrai que selon, la position que l'on occupe, (agriculteur, responsable politique, simple consommateur, défenseur de l'environnement) et l'importance que l'on attache à chacune de ces demandes, on peut estimer que le secteur qui nous concerne le plus reste le parent pauvre et qu'il est moins bien pris en compte que les autres.

En réalité, un domaine aussi complexe que celui des relations agriculture-environnement plaide en faveur d'une concertation toujours plus grande entre partenaires. Si, à une certaine époque chacun a pu voir midi à sa porte, cette concertation s'est beaucoup améliorée ces dernières années et des mesures que l'on peut considérer comme raisonnables ont été décidées puis mises en oeuvre avec l'agrément de toutes les parties concernées.

Mais d'abord, le problème fondamental est de savoir si l'on peut produire de façon efficace et rentable, c'est-à-dire jouer un rôle économique, tout en limitant la pollution. Autrement dit, la préservation de l'environnement peut-elle mettre en péril la pérennité de l'entreprise agricole?

Je pense qu'il n'en est rien et que les deux objectifs de production et de limitation des pollutions sont conciliables. Ce postulat est d'ailleurs à la base de l'actuel partenariat actif et constructif qui se développe en France. Cest le second point que je vais maintenant illustrer.

Un partenariat constructif et déjà actif

Ce partenariat est déjà actif. L'expérience a montré et montre encore tous les jours que c'est en faisant valoir nos points de vue que l'on peut, ensemble, progresser. Pour concilier les exigences de productivité, de qualité et de respect de l'environnement, les agriculteurs développent depuis plusieurs années une agriculture raisonnée qui bénéficie des avancées régulières des sciences et des techniques. Les producteurs

français ont toujours participé activement aux travaux de recherche grâce, en particulier, à leurs Instituts Techniques qui collaborent étroitement avec les Institutions publiques et privées de recherche, en France et, de plus en plus aujourd'hui, en Europe.

Il faut tout d'abord mentionner le CORPEN. En 1979, le Ministère de l'Agriculture et le Ministère de l'Environnement ont demandé au Professeur S. HENIN de préparer un rapport sur la qualité de l'eau en liaison avec l'activité agricole. Suite à ce travail, ces deux Ministères ont créé, en 1984, le Comité d'Orientation pour la Réduction de la Pollution des Eaux par les Nitrates et les phosphates provenant des activités agricoles (CORPEN). Les activités de cet organisme ont été étendues aux produits Phytosanitaires en 1993. Le CORPEN réunit, outre les deux Ministères fondateurs, l'Agriculture et l'Environnement, les Ministères de la Mer, de l'Industrie, de la Santé, des Finances, des élus, les Agences de l'Eau, des chercheurs (INRA, Cémagref), des industriels de l'Agrofourniture et aussi des responsables professionnels agricoles et leurs instituts techniques (ITCF, CETIOM...). Le CORPEN est ainsi une structure de concertation officielle, reconnue par tous, au sein de laquelle sont discutées toutes les mesures susceptibles de maintenir la qualité des eaux.

Les mots clés qui caractérisent son action, sont: "réunir les informations", "valoriser les compétences", "faire des propositions" et"éviter les conflits". Cet organisme est ainsi impliqué dans la préparation des réglementations, dans le soutien méthodologique des programmes d'action régionaux ou nationaux et dans la publication de synthèses techniques.

C'est aussi le CORPEN qui a élaboré le code de bonnes pratiques agricoles, dans le cadre de la directive Nitrates de la CEE, et qui a défini des recommandations générales sur l'emploi des produits phytosanitaires.

Les producteurs, de colza et de céréales, notamment, désirant développer cette dynamique et marquer leur engagement pour intégrer dans leurs pratiques les enjeux de la protection de l'environnement, tout spécialement dans le domaine de la protection des

eaux, ont défini un certain nombre de techniques à mettre en oeuvre et d'autres à éviter. Sont ainsi parus successivement une charte pour la conduite du colza d'hiver sur jachère énergétique (préparée par le CETIOM) et un guide environnement pour la culture du blé tendre d'hiver (préparé par l'ITCF). Le CORPEN a eu à analyser en détail les projets initiaux et a proposé des améliorations qui ont été approuvées.

Autre exemple de partenariat : l'ACCORD CADRE passé entre Ministères, et Organisations Professionnelles: Reconnaissant l'effort des agriculteurs en vue de protéger les réserves en eau, le Ministère de l'Agriculture et le Ministère de l'Environnement ont souhaité établir un accord cadre avec les organisations professionnelles agricoles afin d'engager un programme complet de maîtrise des pollutions concernant à la fois les produits phytosanitaires et les fertilisants, qu'ils soient d'origine minérale ou organique. Cet accord mobilise les agences de l'eau, les comités de bassin ainsi que les collectivités territoriales qui le souhaitent.

Parmi les enjeux majeurs qui motivent cet accord, et selon ses termes mêmes, figure à la fois la revitalisation du milieu rural, qui repose sur une agriculture dynamique, et la protection de l'environnement.

Cet accord a été mis en place en janvier 1994. Le CORPEN a été chargé d'élaborer un programme d'action concernant les produits phytosanitaires (le premier du genre) et un nouveau programme concernant les risques de pollution par les nitrates et intégrant les objectifs de la directive nitrates de Bruxelles et les opérations de labellisation Ferti-Mieux - que nous verrons plus loin - mises en oeuvre par les organisations professionnelles agricoles.

Concernant l'amélioration des bâtiments d'élevage, un programme d'investissement a été défini: Il doit s'étaler jusqu'en 2002 et porte sur un montant évalué à 7 milliards de francs avec un plan de financement concernant les éleveurs pour 1/3, l'agence de l'eau pour 1/3 et le Ministère de l'Agriculture et les collectivités territoriales à parité, pour le troisième tiers.

Les Ministres et les Présidents des Organismes Agricoles constituent une conférence nationale des programmes d'action à laquelle sont associés les Présidents d'agences de bassin.

Un comité de suivi est également constitué qui, de la même façon, réunit des représentants du Ministère de l'Agriculture ainsi que les organisations professionnelles représentées au CORPEN.

Citons aussi les actions FERTI-MIEUX, animées par la profession agricole elle-même. Les actions Ferti-Mieux attribuent un label officiel garantissant la valeur scientifique et technique de programmes régionaux destinés à conseiller les agriculteurs en matière de fertilisation azotée. Ces actions doivent ainsi amener peu à peu les agriculteurs des régions concernées à prendre pleinement en compte les problèmes d'environnement et, éventuellement, à changer leur comportement. Ces opérations sont dirigées par l'Association Nationale de Développement Agricole (ANDA), c'est-à-dire par les agriculteurs eux mêmes. Ces actions ont également l'intérêt d'encourager le partenariat entre agriculteurs et organismes non-agricoles. Enfin, les actions Ferti-Mieux manifestent au grand public la volonté des agriculteurs d'agir pour réduire les risques de pollution ; 43 sites ont ainsi été labellisés en 1995, ce qui représente plus d'un million d'hectares.

Il s'agit aussi de faire connaître cette approche de l'agriculture raisonnée dont nous parlions à l'instant à la fois à un public d'agriculteurs, de non agriculteurs et de citadins.

Je pense, pour la France, à l'association FARRE (Forum de l'Agriculture Raisonnée Respectueuse de l'Environnement), qui regroupe les principaux acteurs de l'agriculture française : syndicats, organisations de développement, entreprises d'agro-fourniture, de collecte et de distribution. FARRE entend promouvoir une agriculture raisonnée, compétitive, qui tienne compte à la fois des contraintes écologiques des producteurs, des attentes des consommateurs et de l'environnement. L'agriculture

raisonnée nécessite une parfaite maîtrise technique. L'objectif est de gérer, le plus finement possible, et selon les techniques mises au point par la recherche, la conduite des cultures, l'alimentation de la plante et sa protection contre les nuisibles.

Ces techniques présentent à la fois l'avantage de réduire les coûts et d'éviter que les moyens de production que sont les engrais et les produits phytosanitaires ne soient en excès dans les sols et qu'ils ne soient entraînés dans les eaux. FARRE met aussi en place un réseau de fermes de rencontres ouvertes aux visites d'autres agriculteurs, ce qui permet de confronter les expériences, et aussi, aux représentants du monde non agricole ayant un rôle dans la circulation de l'information (enseignants, élus, journalistes...).

Des initiatives de ce type, qui existent dans cinq autres pays de l'Union Européenne, manifestent notre volonté et notre détermination en vue de valoriser toutes les ressources des sciences et des techniques pour répondre aux attentes fondamentales de la Société, tout en le faisant savoir.

Pour un partenariat renouvelé

Comme on vient de le voir avec ces quelques exemples, et on pourrait en donner d'autres, les rapports entre agriculture et environnement en France sont donc très largement caractérisés par le partenariat.

Cela à été possible, parce que les agriculteurs sont conscients qu'une activité économique n'est complètement performante que si elle prend en compte toutes les attentes de la société et que, de leur côté, les pouvoirs publics et l'Union Européenne ont le souci de la pérennité économique des exploitations agricoles.

On peut dire aussi qu'en France il y a consensus sur les moyens: la priorité est donnée à la prévention et à l'action à la source pour réduire les dommages à l'environnement. Le principe non pollueur-non payeur doit l'emporter sur le principe pollueur-payeur. La préférence est aussi donnée aux incitations plutôt qu'à la voie

réglementaire, dominante dans certains pays. Enfin, nous mettons l'accent sur la subsidiarité et la responsabilité des niveaux régionaux.

Ainsi, jusqu'à aujourd'hui, nous avons essentiellement géré les problèmes de relations agriculture environnement tels qu'ils se posaient; nous avons bien avancé et nous poursuivons sur cette voie.

Mais nous souhaitons être plus ambitieux et valoriser les aspects positifs de l'agriculture pour faire face aux défis de demain.

L'environnement peut être en effet une formidable source d'opportunités pour l'agriculture du XXIe siècle et il est de notre devoir de positionner définitivement l'agriculture comme fournisseur d'environnement.

Cependant, ce ne sont pas les 5% d'actifs que représente l'agriculture qui pourront, seuls, s'atteler à ces tâches. Nous aurons à nous engager, avec les autres acteurs concernés, dans une politique renouvelée de partenariat plus volontariste, à la dimension des enjeux du siècle prochain. Je voudrais maintenant donner quelques aperçus de ces enjeux.

Prenons l'exemple de l'aménagement de l'espace rural. Ayant en charge en France 30 millions d'hectares, soit 56% de la surface du pays, les agriculteurs ont naturellement un rôle de production de biens paysagers. Ce rôle a été reconnu dès 1985 par un règlement de la CEE (article 19). Il a été assuré gratuitement jusqu'à présent, comme un prolongement de l'activité de production de biens alimentaires.

Compte tenu des contraintes techniques et économiques subies par les agriculteurs aujourd'hui, l'entretien des paysages, tel qu'il est souhaité par la collectivité, doit être considéré comme une prestation de services qui pourrait faire l'objet de contrats spécifiques.

La solution qui consisterait à passer par des prix artificiellement élevés à la production ne nous parait pas adaptée car elle engendrerait des distorsions et notamment un manque de compétitivité de nos produits sur les marchés aussi bien intérieurs qu'à l'exportation.

Un autre problème beaucoup plus aigu auquel l'agriculture est prête à apporter sa contribution est celui de la réduction de la pollution de l'air dont le principal responsable est la circulation automobile.

Ce problème a d'ailleurs été sous les feux de l'actualité dans plusieurs de nos grandes cités cet été.

De nombreux débats ont lieu sur les meilleures solutions à mettre en oeuvre. Cependant, il est reconnu, notamment à la suite de la mise en place du "Clean Air Act" en 1990 aux Etats-Unis, que la présence de composés oxygénés dans les carburants peut améliorer notablement la situation.

Or, l'agriculture est à même de fournir des biocarburants qui sont des composés oxygénés.

Des actions de partenariat entre nos organismes agricoles et les compagnies pétrolières sont déjà engagées pour développer ces technologies nouvelles et créer les bases de nouvelles filières. On sait qu'elles ne seront rentables qu'à terme, mais c'est la raison pour laquelle nous ne devons pas attendre si nous voulons être prêts au début du siècle prochain. C'est ainsi que nous cofinançons avec les pétroliers deux usines de production d'un biocarburant, l'ETBE. Une troisième usine est en cours de construction.

Un autre domaine dans lequel le partenariat devrait être dès maintenant accentué est celui du devenir des boues d'origine urbaine ou industrielle. Grâce au pouvoir épurateur des sols, l'agriculture peut en effet assurer un recyclage de ces "co-produits"

d'autres secteurs d'activité. Mais il faut d'abord se mettre d'accord sur le statut de ces boues.

Sont elles des engrais, auquel cas l'agriculteur devrait les acheter, mais ces soit disant engrais répondent ils bien aux normes des engrais classiques (composition constante, absence de métaux lourds...)? Ce n'est pas le cas actuellement. Alors ces boues sont elles des déchets? auquel cas leur utilisation en agriculture éviterait leur incinération. C'est donc un service que l'agriculteur rendrait à la société et qui devrait être rémunéré.

Là aussi, on peut faire confiance à la vertu du dialogue pour trouver des solutions acceptables. Encore faut-il que des négociations s'engagent à ce sujet avec tous les partenaires et, notamment, avec les agriculteurs !

Je voudrais mentionner encore un point à propos duquel les agriculteurs demandent à être entendus. Si nous nous obligeons en Europe à respecter certaines contraintes environnementales dans nos processus de production, il est équitable que cela soit reconnu d'une manière ou d'une autre, face à des produits concurrents qui n'ont peut être pas été obtenus avec la même rigueur en ce qui concerne le respect de l'environnement. Certains pays considèrent même ces contraintes comme un luxe de pays riches qu'ils ne peuvent se payer.

Si l'on veut éviter de graves distorsions de concurrence, il nous faudra beaucoup progresser dans la définition de règles sur le développement durable et dans l'harmonisation des législations, aussi bien à l'intérieur de l'Union Européenne, qu'au niveau international dans le cadre de l'Organisation Commune des Marchés.

Conclusion

Finalement, on peut considérer qu'il y a deux manières de gérer les risques d'atteintes à l'environnement.

La première consiste à s'abstenir de produire en prenant des mesures arbitraires, telles l'interdiction de telle technique ou de tel produit. Cette voie n'est pas sans efficacité, mais elle est génératrice d'effets négatifs et pervers.

Prenons par exemple ce qui se passe à propos du taux de jachère. Le maintien d'une jachère à un taux élevé est dû, en partie, aux préoccupations environnementalistes d'un certain nombre d'états membres de l'Union Européenne. Ceux-ci estiment que, si l'Europe se limite à produire ce dont elle a besoin, l'environnement ne s'en portera que mieux. Les pays qui prônent le "tout environnement", quitte à augmenter les jachères, sont justement ceux qui ne manquent d'aliments ni en quantité ni en qualité. N'y a-t-il pas là un comportement d'enfant gâté?

Et ne faudrait il pas rechercher une position plus équilibrée tenant compte des attentes de pays moins favorisés? D'ailleurs, à quoi a abouti ce type de raisonnement?

C'est avec de telles approches que l'Europe a contribué à la modestie de la récolte mondiale en blé cette année. Cela a entraîné une hausse des prix qui a conduit les pays en développement à revoir à la baisse ces derniers mois leurs prévisions d'importations. Voici donc une manière de gérer les risques environnementaux liés à l'activité agricole dont nous ne pouvons pas être fiers.

Une seconde voie me paraît plus avisée. C'est celle dont nous assurons la promotion en France avec de nombreux autres acteurs. Elle consiste à maîtriser ces risques en faisant confiance au progrès des sciences et des techniques, au dialogue entre partenaires et à la capacité d'adaptation des agriculteurs.

Pour terminer, je dirai qu'il ne faut pas perdre de vue que la gestion de l'environnement est l'affaire de tous, et que, si les agriculteurs acceptent d'en assurer leur part, celle-ci devra être partagée avec le reste de la collectivité. Produire dans les conditions exigées par la Société est possible techniquement, mais cela a un coût qui ne

peut être supporté par les seuls agriculteurs. Cela n'enlève rien à la détermination des agriculteurs, décidés à ne pas se laisser aller à d'illusoires solutions de facilité. Les agriculteurs ont plus que jamais la volonté d'agir en responsables aujourd'hui pour ne pas être coupables de pollution demain.

Bien plus, nous avons la volonté de positionner l'agriculture en tant que producteur de biens environnementaux, de biens renouvelables, ceux que la société attend pour ce XXIe siècle qui est à notre porte.

THE EFFECTS OF AGRICULTURAL POLICIES ON THE ENVIRONMENT AND THE POINT OF VIEW OF FARMERS

André Grammont
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Through its historical, cultural and economical evolutions, the territory of France as a whole bears the marks of agriculture, even though it now numbers less than one million farmers.

The Weight of Agriculture:

- Rural areas include 31 million hectares of useful farm land and 15 million hectares of woodlands, which have fashioned the french landscape over the centuries.
- Agricultural production and related activities such as food-processing hold an important place in the french economy: France is the second largest exporting country world-wide for raw food-products, and the first for processed food-products (particularly high-quality products labelled as origin-controlled).

The Questions at Stake for Agriculture:

As concerns heritage, the French territory provides a great variety of fauna and flora, a diversity which is threatened by certain farming practices. However, agriculture is obviously the only activity likely to achieve, at a national level, a comprehensive management of the land, especially sensitive areas.

In the future, agricultural policies will have to reconcile a two-fold requirement: To maintain a competitive and viable agriculture and to take into account the conservation of the environment.

Two types of interventions are necessary:

- On land management, in relation to the maintainance of agricultural activities;
- On farming practices, in order to reduce their impact on the environment in highly-productive areas.

Land Use Policy for Agriculture and Forestry

Adequate land management can be ensured only by maintaining farmers through income support and actions in favour of new farming practices.

1. Income support

Regulations

The system of community support in favour of agriculture in rural areas is based on European directives. These rules aim to compensate for the effects of permanent handicaps on incomes that are a natural result of farming and to maintain a minimum of viable farming operations in such areas.

Mode of implementation of the CANH: The CANH is a yearly allowance which aims to compensate the handicaps suffered by farms in unfavoured agricultural areas.

2. Actions in favour of farming practices

Agro-environmental measures

The agro-environmental measures set up in Rule CEE 2078/92 by the European Council on June 30, 1992 aim to encourage farmers to maintain or resume farming methods that are compatible with environment requirements, including landscape conservation. Those measures are as follows:

- Aids for the maintenance of extensive breeding, more commonly called the “grass premium,” which will help maintain grass surfaces. This will impact 5.8 milliion hectares from 1993 to 1997;
- Aids towards extensification through extension;
- Incentive support to reconvert arable lands into extensive pastures;
- Local operations, based on a more comprehensive approach to a given territory, will undoubtedly effect landscape conservation.

Programs for Sustainable Development (PSD)

The PSD are based on a comprehensive approach to each farm operation. Currently, 1,228 farms are experimenting with the program. Regardless of specific regions, the PSD offers farmers an organization of farming systems in which production, environmental conservation and land management are all taken into account.

3. Actions in favour of rural land management: the Fund for Rural Land Management.

Under agriculture’s current operating conditions, the maintenance and management of rural land are no longer a free by-product of farming activities; they require a specific payment.

The Fund for Rural Land Management (Rural code, article L. 112 - 16) provides financial support for the maintenance or rehabilitation of agricultural areas that are being deserted, important natural landscapes, and areas exposed to natural hazards.

The Rational and Sustainable Management of Rural Land

This qualitative aspect of management is particularly designed to check the deterioration of water quality in relation to the rate of nitrate contents. As for the maintenance of population, the implementation of voluntary actions through dialogue and persuasion is preferred to an enforcement of regulations. On that basis, the following operations have been set up:

1. CORPEN -- A counselling committee for the reduction of water pollution via nitrates and pesticide residues, the CORPEN was created in 1984. It gathers the representatives of all groups involved. It is three main purposes are:

- To design and approve the tools to be used by farmers in order to improve their practices that impact water quality;
- To provide th eadministration with the means of better adaptating regulations to local needs (i.e., implementation of the directive on nitrates);
- To prepare technical information for experts in international negociations.

2. FERTI-MIEUX -- This program aims to change the farmers' attitude and more particularly their fertilization methods. The network now includes 48 actions, of which 19 are in the process of being quality-stamped and 29 are already quality-stamped. Altogether they cover over 1.2 million hectares.

3. The Program for the Control of Farming-originated Pollution -- This program was initiated on January 1, 1994 by both the ministers of agriculture and environment in collaboration with professional organizations. Actions against water pollution are conducted on all types of productions: animal husbandry as well as crop-growing. The purposes are as follows :

- To set up a plan of action against water pollution caused by nitrates and pesticide residues;

- To control pollution originating from breeding activities (equipment and manure-spreading methods).

After showing some reluctance to any change in the practice of their activities, farmers now realize the validity of the measures taken in the new CAP, they accept the back-up measures and are becoming involved in the “Fund for the Rural Land Management.”

It is too early to review the situation, but the obviously favorable and positive attitude of farmers allows us to think that solidarity between agriculture and the environment is about to be resumed.

IS AGRICULTURE A THREAT TO THE ENVIRONMENT?

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American Farm Bureau Federation

Is agriculture a threat to the environment? It certainly can be, but to too many people in the U.S., at least, there is a mindset that farmers are out to ruin the countryside, which is a misconception.

I am to address the impact of agricultural policies on the environment. It is probably not much different in my country than it is in yours. Through one incentive or another, farmers are encouraged to get the highest yield possible, and frequently this production is dictated to be a certain crop, which restricts the farmer's ability to rotate crops to rest or improve the soil. Other policies take fertile land out of production, which limits our output and provides opportunities for our competitors.

To me, though, the real question we should address at this convention, the one progressive farmers in the U.S. are fighting with, is "how do we deal with the impact of environmental policies on agriculture?"

If you've been around me long enough, you've heard me tell of some of the problems U.S. farmers face, dealing with environmental zealots inside and outside of our government. There is a continuing debate over preserving wetlands which we've been embroiled in for 10 years, and scientists still can't even come up with a definition that people can agree with. We've got an endangered species act that is meant to ruin entrepreneurs for the purpose of protecting plants and animals that no one's ever heard of or cared about. We've got laws that eliminate needed crop protection chemicals because they cause cancer in lab rats that were forced to eat mega-doses of the stuff over a long period of time. It's really crazy.

Farmers in the U.S. wonder what is our purpose? Is it to produce food and fiber to benefit mankind the world over? Or is it to enhance habitat for critters? Am I exaggerating? I do not think so. Let me tell you a horror story.

Some people want to eliminate a very effective crop protection chemical because it might cause cancer. The chemical is atrazine, a weed killer that is very effective. Now, farmers everywhere believe that if a chemical is determined by scientists to be a hazard, then get rid of it, but the major manufacturer of atrazine has submitted 15,000 pages documenting the testing of the chemical and is confident it is safe. Banning this chemical would greatly increase farm costs and lower production. Substitutes for atrazine are, but they're more expensive and not as good. Such a ban would clearly hurt the environment. We'd have to use more of something else to get the same weed knockdown. Most important, we're seeing a tremendous increase of conservation tillage which reduces erosion by leaving various degrees of residue on the field. This can be done best only when we have effective, efficient herbicides.

One chore the U.S. Producers have is convincing the non-farming public that we use chemicals responsibly. Herbicide use in the U.S. has hovered around 500 million pounds of active ingredient for the last 15 years. Insecticide use has dropped significantly, from more than 300 million pounds to about 170 million pounds. Our nation as a whole has made tremendous progress in cleaning our environment. The air contains nearly 30 percent less sulfur dioxide, 40 percent fewer reactive volatile organic compounds, less than half as much carbon dioxide, 60 percent fewer suspended particulates and 98 percent less lead. Our water supplies are swimmable and fishable. Moreover, land is conserved.

There are a variety of conservation programs incorporated into our federal farm law. The environmental conservation acreage reserve program is comprised of a conservation reserve program, a wetlands reserve program, a water quality protection program and an environmental easement program. The greatest progress is being made

voluntarily, however. U.S. farmers are doing their part, producing more food on fewer acres, leaving more open space for wildlife habitat.

Many of our newer pesticides have shorter residual periods. You apply the chemical, it does what it's supposed to and then it safely degrades. We use integrated pest management techniques, working with nature to decrease the use of expensive chemicals.

We conserve our soil. Erosion has been cut more than 90 percent, to less than one ton per acre per year, on highly erodible soils enrolled in government programs. Most soils naturally regenerate at rates of 2 to 12 tons per acre per year. Today's new farming methods and tillage techniques have made erosion negligible. A growing number of farmers are now using some form of crop residue management program, leaving old crop stalks and leaves in place to lessen soil erosion from wind and run-off.

More than 100 million acres are produced with conservation tillage procedures, about 26 million acres are contour farmed, about one million acres are idled to protect true wetlands. Approximately 135 million acres are managed under specific individual conservation plans, formally approved by government soil scientists. U.S. farmers maintain about 170,000 miles of windbreaks and we plant millions of trees on our land every year. We must be doing something right because wildlife numbers are booming. Our private lands provide habitat for between 75 and 85 percent of the nation's wildlife.

Finally, we encourage the use of environmentally friendly products made from our crops. Examples are ethanol in place of imported petroleum; a calcium magnesium acetate made from corn that replaces salt as a road deicer and ink made from soybeans instead of crude oil.

To conclude, we readily admit that agriculture alters the environment. Some say that to live is to pollute. We don't have to feel shame or guilt that we as producers use such basic resources as soil, water and air to feed and clothe a global population.

Farmers in the U.S. and elsewhere are proud of our accomplishments and achievements. We will be just as proud next year, and the year after, and the year after that.

Working with nature, enhancing the resources we find provided to us by a benevolent god, farmers will continue to feed and clothe a growing global population, whether they appreciate it or not.

Thank you for this opportunity to speak, to report the views and actions of farmers and ranchers in the United States.

AGRICULTURE AND THE ENVIRONMENT IN JAPAN

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Characteristics of the Relationship between Agriculture and the Environment in Japan

Japan is located in the northeastern part of the Asian monsoon belt and has an average annual rainfall of 1,800mm -- almost twice the world average. This geographic condition poses serious problems of potential flooding and water shortages due to several factors: mountain ranges over 2,000-3,000 meters in height running through the Japanese archipelago which produces very steep rivers; heavy rainfall tends to concentrate at the time of typhoons or in the summer rainy season; and a large population of 124 million in a tiny national land area raises large demands for water.

Under these circumstances, an agricultural system predominantly depending on rice cultivation in paddy fields was developed during Japan's history of more than two thousand years as an important system which performs crucial roles of not only producing vital food but also of mitigating severe terrestrial and meteorological conditions and preserving the natural environment.

Paddy fields have been well maintained by artificially surrounding the paddies with embankments to make them suitable for cultivating rice. This maintenance/management system ensures the water storage capacity of the fields and allows water to permeate into the ground.

Although Japan has more than 2,200 dams, the paddy fields themselves also provide functions to prevent flooding and preserve water resources without significantly altering nature, a fact that can be compared to the water storage capacity of these large dams.

Moreover, paddy fields are highly effective in preventing soil erosion under Japan's natural conditions, including the need for cultivation on very steep hills.

During the period of high economic growth from the 1950s up to the 70s, however, the development of manufacturing and mining industries caused serious contamination of agricultural land and water resources by the discharge and accumulation of cadmium, mercury and other harmful chemicals, polluting both agricultural products and soil. As damage to agricultural products and the human body has increased, regulations on factory discharges were strengthened and contaminated agricultural fields have been improved by soil replacement.

The Need for Promoting Environment-Preserving Agriculture

In recent years, although the situation differs somewhat from that in Europe and the United States, Japan is now seeing inappropriate cases of agricultural practices, including the excessive input or ill-adapted use of fertilizers and agricultural chemicals. In some cases, inadequate processing of livestock manure has caused negative effects to the environment. These problems call for more specific efforts by producers themselves to enhance their recognition of environmental importance and to reduce environmental burdens.

Japanese governments and other related parties have also made significant efforts to assist producers in promoting programs to produce healthy cultivated soil by improving soil quality, to actively introduce advanced technologies and farm management systems, and to meeting consumer needs. More specifically, agriculture in Japan is now aiming at promoting nationwide "Sustainable Agriculture" which actively utilizes the recycling functions of agriculture, and takes various measures -- including those for soil improvement -- to reduce environmental burdens due to the use of agricultural chemicals and fertilizers, giving due account to the harmonization with productivity. For this purpose, along with technological developments and their

dissemination, campaign activities are now being pursued to promote these efforts throughout the country in cooperation with consumers and the distribution sector.

Specifically, this includes assistance and financial measures for technological developments and their dissemination. Such technologies are focused on soil management and fertilization technology (fertilization based on soil and growth diagnoses, use of compost, transplanting with sideline type fertilizer application, utilization of slow-release fertilizer), planting technology (establishment of crop rotation systems including introduction of cleaning crops), and pest-control technology (development of advanced and accurate pest occurrence forecast information system, utilization of natural enemies, sex pheromones, attenuated viruses).

Moreover, meetings promoting “Sustainable Agriculture” have been instituted at the national and local level by agricultural organizations, consumer organizations, distribution services, scientists and administrators, and movements aimed at continuing education in sustainable agriculture and food production are also being carried out. Additionally, a contest focused on “Sustainable Agriculture” has been scheduled for this year, sponsored by the Council of National Sustainable Agriculture Promotion. The ministry of agriculture, Forestry and Fisheries is cooperating in this undertaking through the establishment of some Ministerial Awards.

We believe that these endeavors aimed at "Sustainable Agriculture" will result in the maintenance and improvement of the functions provided by agriculture, especially by paddy fields, to preserve the national land and environment, and contribute to the activation of local communities through exchanges between consumers and producers.

However, even today in our country, as the degree of agricultural chemicals and nitrates in the natural environment and drinking water exceed environmental and water safety standards by only 0 - 0.02 percent, environmental contamination attributable to agriculture has not yet reached a degree for which measures to directly restrict input of these chemicals are required.

As for the generation of global warming gas such as methane from paddy fields in Japan about which concern was expressed in discussions with the IPC, it was found from actual measurements that the amount of these gases was smaller than expected. Reducing the generation of these gases is believed possible by measures including non-tilling cultivation.

As a result of recent changes in farm communities, such as the rapid aging of farmers and the increasing depopulation of remote communities in mountainous and sub-mountainous areas, agricultural fields are often neglected or abandoned and forests surrounding the farmland are also deserted due to the inability to continue adequate maintenance work indispensable to these forests -- including selective felling, leading to environmental problems in such agricultural communities.

Accordingly, it has become increasingly important to maintain healthy environments in these communities through the settlement of successors for farming activity by assisting efforts in the development of viable farming operations and manufacturing of processed agricultural products, as well as the promotion of "green tourism" which provides a healthy environment for urban sightseers.

The Outlook for Future Policies on Agriculture and the Environment

In the past, discussions regarding the relationship between agriculture and the environment in such international forums as OECD and WTO have largely focused on how to reduce environmental burdens stemming from agriculture. We fully recognize the importance of measures to reduce the negative effects on water quality and human health caused by the overuse of agricultural chemicals and fertilizers as well as inappropriate discharge of livestock manure to achieve the target of developing sustainable agricultural practices.

As an agricultural country depending on paddy fields under a monsoon climate, however, we consider it is also important for the international community to recognize equitable evaluation of the positive environmental functions of such agricultural practices which have been recognized as natural in the face of the various geographical and climatic conditions in Japan.

As part of monsoon Asia, Japan expects and would like to contribute to deepening the international understanding of the impact of agriculture on the environment through the development of well-balanced discussions on the relationship between environment and agriculture at international forums.

The relationship between the environment and trade is a theme on which many countries have a great deal of interest and is expected to be discussed further in OECD and WTO. The review process, in the agricultural sector, to be undertaken on the sixth year of the implementation period of the UR, has already been agreed upon. We believe that it is important that trade measures or national agricultural support policies should be given legitimate positions in rules as a result of these review processes reflecting positive, multi-faceted role of agriculture, particularly in terms of environmental preservation.

POLICIES FOR ENVIRONMENTAL ISSUES IN KOREAN AGRICULTURE

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A large part of Korea is mountainous, only about 20.5% of the land area is arable. Limited arable land, small-sized farming and a very high man-land ratio have caused chronic shortage of food supply from domestic production. Moreover, the demand for food grains has risen continuously as population and income levels have risen.

Government has placed high priority on the task of increasing grain production through programs of raising output from the existing arable land by improving irrigation, developing higher yielding varieties and encouraging the application of fertilizer and pesticides. As a result, considerable success has been achieved to increase agricultural production. However, total production is not sufficient to meet demand for even a subsistence level. In order to cover the shortage, a large volume of grains have been imported. In 1994, this accounted for 13,172,000 tons.

However, a variety of unexpected problems arose from greater use of agricultural inputs including chemical fertilizer, pesticides, machine oils, etc. In fact, the total consumption of fertilizer in 1994 was 970,000 tons on a nutrient base, a 72.3% increase over 1970. As shown in Table 1, the average annual increase during this period was 4.8%. At this level, fertilizer use per hectare must be the highest in Asia.

Table 1. Fertilizer Consumption by Year in Tons

Item	1970	1975	1980	1985	1990	1994
Total consumption	563	886	828	807	1,104	970
kg/ha	245	396	377	376	523	447

Along with increased use of fertilizers, the total application of pesticides has increased rapidly. In 1994, this reached 26,391 tons, an increase of 206.2% as compared with 8,619 tons in 1975.

Table 2. Pesticide Consumption by Year (Unit: Nutrient basis, ton)

Item	1980	1975	1985	1990	1994
Total consumption	886	828	807	1,104	970
kg/ha	396	377	376	523	447

Moreover, the demand for meat and livestock products has increased substantially. This increasing demand led to an increase in the number of animals. For instance, the total number of cattle increased from 1,642,000 head in 1975 to 2,945,000 in 1994, a 79.4% increase over 1975.

The number of hogs raised has increased to 5,955,000 head in 1994, 4.8 times the growth over the last 20 years. The number of chickens raised was also increased about 2.6 times from 30 million to 81 million during the same period.

In the case of cattle farms, the manure obtained is used in crop farming to improve soil fertility since these farms are raising only one or two head of cattle. However, poultry and hog farms using commercial feeds in areas adjacent to cities mostly do not use animal manure for soil improvement, and thus manure must be disposed of in other ways.

This may lead to environmental pollution due to the generation of offensive effluents and consequent water contamination. This means that an increase in large-scale hog and poultry farms has inevitably brought about pollution problems.

In order to prevent this potential increase in pollution from the farming sector, it was necessary to provide some financial aids to construct a kind of sewage treatment at the individual farm level.

In addition, the rapid expansion of the urban population let to enormous volumes of municipal sewage being discharged directly into rivers. Moreover, numerous types of pollution are generated from construction work, road cleaning, factory disposal, cooking remains, air pollution, and so on. All of these are serious causes of water pollution which can substantially affect the quality of human life.

In order to tackle these current issues to some extent, the government initially set up the Administration of Environment at the national level in 1980. Thereafter, it has implemented some ambitious programs including identification of various sources of problems. However, the Administration has experienced great difficulty in achieving the planned targets because very large investments from the budget were needed.

In 1990, the Administration was reorganized into a Ministry level to implement the programs successfully. As the first step, the Ministry started to construct large size sewage treatment plants in cities and provided a financial support for farmers to install sewage and waste disposal.

Nevertheless, the protection of the environment is not yet sufficient to solve a variety of types of pollution. It cannot be solved by enacting any rigid laws and through asking for voluntary cooperation by the people.

Thus, the control prevention of environmental damages must be mainly the concern of the government. The success of keeping a natural environment depends largely on additional investment for facilitating clean air, fresh water, comfortable living spaces, etc. So, there is a need to develop appropriate policy measures in the coming years.

ANIMAL PRODUCTION AND POLLUTION PROBLEMS

Peter Williams
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Introduction

In 1900, manure made in open yards was worth three shillings and six pence per ton, and that made in covered yards five shillings and three pence (Fream 1900). Any liquid that flowed out from a dung heap was considered to involve exceptionally great waste, particularly if the heap had entered into the fermenting stage. Wheat was valued at £7 per tonne, but the manure from animals fed wheat also had a specific value. The total original manure value per tonne of wheat consumed was eighteen shillings and eleven pence, nearly 14% of the value of the original feedstuff. The odors that emanated from livestock production were also recognized. It was stated that, "the house should overlook the homestead,- not to encourage the occupant to farm indoors... still it is desirable that the house should not be too close to the homestead, lest unpleasant odors should find their way in from the livestock" (Fream 1900). In one respect, as we approach the twenty first century, agriculture has dramatically changed, farmers are now being taxed according to the amount of slurry and manure they produce. The material apparently no longer possesses a positive value. On the second point, there is very little change; it is not desirable for urban dwellings to overlook agricultural production, unpleasant odors from livestock are a major source of complaint (Nielsen 1990) and the writings of 1900 have not been heeded.

Pollution of the environment from agricultural activity does not exist solely in terms of nitrogen (N) and phosphorus (P) pollution of land and water courses. The pollution that exists within animal housing is of equal if not greater importance as a result of its direct impact on health and production.

The objectives of this manuscript are to review issues of environmental pollution arising from animal production, to consider how legislation is being adopted to control the

pollution and to address how modern agricultural practices can be employed to reduce the problem.

The Sources of Environmental Pollution From Livestock Production

Nitrogen and phosphorus pollution

The two sources of pollution presently receiving the greatest attention are the N and P which take on the mantle of pollutants when they exist in the excreta of livestock. Recently, interest has been paid to the use of N budgets of whole farm enterprises, taking into account N balance of both animals and crops in order to predict the potential losses of nitrates from the system. The N budget can be formulated so that a positive balance indicates the amount of N available for leaching. The basic relationship for the N budget of a farm can be summarized as:

N_{inputs} = $N_{outputs}$ + change in the N contents of the soil, livestock and other components

The main components of the N inputs to agricultural systems are derived from direct purchases from off-farm supplies (e.g. animals, seeds, fertilizer and feed), and from natural processes that occur during the growth of crops (e.g. symbiotic N fixation) or from natural processes that are influenced by anthropogenic activity (e.g. atmospheric deposition). The main components of N outputs from agricultural systems are derived from direct sales of plant and animal products and from gaseous and leaching losses. Goss et al. (1993) made a study of the N budgets of a number of farms in Canada, the results of the budgets were compared with the measured N values in water leaching from the farm. The main conclusions of their study were that 37% of the wells tested on farms contained one or more of the target contaminants at levels above the provincial drinking water regulations.

Goss et al. (1993) found that for a well established orchard, under circumstances where the farming practice had reached equilibrium, the simplified budgetary approach

gave close agreement between the concentration of nitrate predicted in the ground water (13.5 mg N/L) and the value measured in the well water (13.6 mg N/L). This gave confidence to the balance approach. Many livestock farms however, appeared to give large imbalances of N which could be due to the fact that the system was not in equilibrium, but calculations of the N budgets for livestock enterprises identified the major discrepancy between the import and exports of N into the system (Goss et al. 1993; Goss personal communication 1993) (Table 1). In the two examples given, the import of N via fertilizer represented 44 and 63 percent of the N input into the system for the mixed farm raising cattle and pigs and the beef enterprise respectively. The simple budgetary approach identified the potential for N leaching and nitrate pollution of water sources from these livestock enterprises. In contrast, the N input component from livestock which includes both purchase of animals and manure represented less than 10 percent. Using the budgetary approach a number of model systems were compared. In one cash crop farming system there was a true balance, the rotation included corn, soybeans and wheat, with two years of soybeans always being grown before corn. No nitrate was found in the well and no nitrate was predicted (Goss et al. 1993).

Table 1. Nitrogen budgets of mixed livestock farms and one cash crop farm (all values given are kg N/ha/year)

N Inputs			
	Beef[1]	Dairy Cattle and Pigs[2]	Cash Crop[3]
Seeds	0.9	0.6	5.4
Feed	27.9	3.0	50.2
Fertilizers	153.6	51.9	
Livestock	21.2	0.6	
Fixation	22.6	41.8	88.7
Atmospheric deposition	18.4	18.4	18.4
Total N_{in}	244.6	116.3	162.7
Predicted ground water (mg/L)	24.0	31.8	18.1
N Outputs			
Plant/plant products		19.1	163.0
Plant/animal products	28.7	6.3	
Gaseous Loss	49.9	12.4	
Grain	28.6		
Total N_{out}	107.2	41.3	163.0
Predicted ground water (mg/L)	30.8	11.6	10.4
Imbalance (Total N_{in} - Total N_{out})	137.4	75.0	-0.3

The above calculations indicate the scale of the problem. Fertilizers are used to achieve the maximum growth of plant material, however the blame for N pollution is often placed on the wastes from livestock production. In the above example, N from livestock sources was comparably a very minor component of the problem source.

Depending on the soil type, topography, rainfall and a complex of micro-biological reactions N applied to the soil can either be assimilated by plants or is lost from the soil by

leaching or volatilization. If the rate of nitrate application or degradation is in excess of plant assimilation then there is the potential for nitrate pollution. Nitrates leached through the soil eventually reach groundwater supplies whereas degradation of nitrates with the production of NH_3 can lead to atmospheric pollution. The World Health Organization (WHO) has set a limit of 50 mg/litre (11.3 mg N/l) in drinking water as the concentration of nitrates which is likely to cause harm to humans. In the United Kingdom (UK), nitrate levels in rivers and bore holes remained relatively stable up until the mid 60's. However, in some areas of the UK and in other European Economic Community (EEC) countries, there has been recently a gradual rise in nitrate levels in drinking water and levels are approaching the maximum recommended limit set by the WHO. It has been the National Rivers Authority and the water supply companies that have been able to gauge the scale of the problem. High levels of nitrates in drinking water are known to be carcinogenic and have been associated with blue baby syndrome (methaemoglobinaemia).

Pollution from manure and slurry after spreading

Experiments have shown that applications of laying-hen manure to loamy sand in October and November resulted in 40 to 50% nitrate leaching (Shepherd, 1990). In this experiment, the nitrate leaching from cattle farm-yard manure (FYM) similarly applied was only 3 to 8%. It was suggested that the increased composting of the FYM stabilized the N. However there is also the possibility that a proportion of the volatile N was lost from the FYM during the composting process. Several reports have indicated a positive correlation between the moisture content of the slurry or manure and the N loss via volatilization of ammonia (Voorburg, 1986 ; Gleadthorpe contract report 1989). There is also evidence that growth promoters and coccidiostats in the feed of poultry may affect micro-organisms in the soil which may limit the use of certain types of manure as a source of organic fertilizer (Strauch, 1987). There is presently considerable consumer opposition to the use of antibiotics in poultry feed. If antibiotics were also considered to contribute to environmental pollution arguments against their use would be considerably strengthened.

There are several alternative methods of applying slurry to land ranging from direct injection to less expensive and more widely adopted spray techniques. Even under the most stringent application conditions a large proportion of the N in the slurry is lost via either leaching from the soil or volatilization. Pain et al. (1989) reported that the concentration of ammonia in air after spreading pig slurry tended to be higher than that from cattle slurry. Total N loss via ammonia volatilization, as a percent of N applied was approximately 5 and 20% when the mean total solids in the slurry were 46 and 142 g/kg respectively. The loss of ammonia N via volatilization occurs very rapidly after the slurry is spread. Between 24 and 39% of the total N loss occurred within 1 h of application and up to 85% within 12 h (Pain et al. 1989; Pain et al. 1990). The rate of ammonia emission was increased by faster wind speed and by warmer daytime temperatures. Pain et al. (1989) suggested that the problem of ammonia volatilization was reduced when more dilute slurries were applied which percolated into the sward, compared with thicker slurries which remained on the grass sward for a longer period. These results were recently confirmed by Moal (1994), in trials to test the factors affecting volatilization of N from pig slurry, after application of 163, 319 and 534 Kg N/ha, 50.5, 41.0 and 29.4% of total ammonia N applied was lost via volatilization, seventy five percent of this volatilization occurred in the first 24 h. The loss of ammonia in the first six hours was highly correlated with the level of N applied (r^2 = 0.999) and also with ambient temperature, peaks in ammonia volatilization followed peaks in ambient temperature. Furthermore, water addition to the slurry equivalent to 60% of the slurry volume reduced ammonia volatilization by 32%.

Loss of N from slurry applied to swards can be reduced. Pain et al. (1990) reported that ammonia volatilization accounted for between 31 and 84% of the NH_4^+-N applied in cattle slurry to grassland but acidifying the slurry to approximately pH 5 prior to application reduced this loss by half. Reducing ammonia volatilization by acidification however, increased losses of N through denitrification by approximately 40%.

Ammonia loss via volatilization constitutes the loss of a valuable commodity. It may also have a significant influence on the perception of the smell of slurry by neighbors living adjacent to livestock enterprises. The smell of pig slurry has four times the initial

impact compared with cattle, broiler and poultry manure (Pain as cited in Stock, 1990). Surveys have identified that where the initial spike of smell is particularly concentrated, there are more likely to be complaints. It is interesting to compare the measurement of odor with the volatilization curves for ammonia. Both curves show a spike within the first 24 h. This may indicate that the high odor threshold for pig slurry is correlated with the initial high release of ammonia, emphasizing the need to control ammonia volatilization.

The production of noxious gases from animal excreta has been stressed. However, in terms of odor control these gases may play only a contributory role. In a review of the literature Spoelstra (1978) documented 86 volatile components in the air of pig confinement units. Schaefer (1977) correlated odor intensify with the concentrations of volatile fatty acids (C_2-C_5), phenol, p-cresol, indole, skatole and ammonia. The highest correlations were obtained with p-cresol whereas correlations with other components were non-significant. Thus control of noxious gases and particularly ammonia released from excreta will not completely eliminate the odor of livestock but may reduce the pungency of the smell and will result in a healthier environment.

Methane emission from ruminants

Global warming and the greenhouse affect are considered to be of major importance to the future of the ecosystem. The presence of CO_2 in the atmosphere in increasing concentrations results in a higher retention of solar radiation, but on a molecular basis, CH_4 is sixty-five times more efficient in absorbing infra red radiation than CO_2. The build up of CH_4 in the atmosphere is considered to contribute 15% to the greenhouse effect and digestive CH_4 of human and animal origin (varying from 80 to 110 million tonnes produced per annum) represents one fifth of the total biogenic CH_4 emission (Jouany 1994). In ruminants, CH_4 is produced as a result of fermentation in the rumen. None of the carbohydrate-fermenting bacteria and protozoa produce CH_4 but many produce formate, H_2 and CO_2 as fermentation end products. Methanogenic bacteria transform the H_2 and CO_2 into CH_4, formate is converted into H_2 and CO_2 by methanogens that use formate as the primary substrate for the production of CH_4 (Wolin and Miller 1988). Inter-species

hydrogen transfer and production of CH_4 in the rumen results in a significant improvement in energy metabolism in the rumen. Wolin and Miller (1988) calculated that molar ATP yields for monoculture fermentation of *Ruminococcus albus* and with inter-species H_2 transfer were 3 and 4, respectively.

Depending on the type of diet, up to 10% of the gross energy of a diet can be lost through CH_4 formation in the rumen. However, inhibition of CH_4 production does not necessarily result in improvements in production. van Nevel and Demeyer (1988) concluded that positive effects of CH_4 inhibitors were related to the use of high-roughage rations which normally give rise to large quantities of CH_4 and low proportions of propionate in the rumen, while growth rates of the animals are low. Several scenarios for reducing CH_4 production from ruminants have been proposed (Johnson 1991; Jouany 1994). Blaxter (1962) demonstrated that in ruminants, raising the feeding level from 1 to 3 times maintenance gave a thirty percent reduction in CH_4 production. For the same digestible energy intake, fibrous diets produce more CH_4 than diets supplemented with starch, and supplementation of the diet with fat tends to reduce CH_4 production. Fat is also a source of energy which does not ferment in the rumen. Johnson (1991) reported that distillers and brewers feeds appear to be markedly different in their fermentation patterns such that much less CH_4 (2% of gross energy intake [GEI]) is produced than would be predicted (7% of GEI). It was postulated that low sugar and starch levels in the distillers and brewers grains, coupled with relatively high levels of unsaturated fatty acids, resulted in lower CH_4 production. The use of ionophore antibiotics has on occasion been associated with a reduction in CH_4 production (van Nevel and Demeyer 1988).

In general, the more intensive the system, the less CH_4 is produced. Jouany (1994) calculated that for an annual production of 240000 L of milk, 60 cows would produce 6550 kg of CH_4 whereas with an intensive system, 24 cows would only produce 3500 kg. Options do exist for reducing CH_4 production from ruminants. Jouany (1994) considered that future likely developments could lie in the transfer of H_2-utilizers like acetogens from other microbial ecosystems or the genetic engineering of rumen micro-organisms and defaunation which can reduce CH_4 production by 30%. Potential also exists to reduce CH_4

production via modification of diet formulation, but at present little attention has been paid to the specific interaction between diet composition and CH_4 production. Studies to address the issue of reducing CH_4 production from domestic ruminants are therefore merited since it is an issue perceived by the consumer as a further example of the pollution of the environment caused by livestock production.

Pollution Of The Environment Within Animal Housing

The environment in livestock housing has an impact on both the livestock that occupy the housing and the stockmen who work in the buildings. Pollutants in the air adversely effect human health and the productivity of animals. Nitrogen is volatilized from slurry in the form of ammonia, and as indicated earlier, it can contribute to the obnoxious smell of slurry, and when it is released in livestock buildings the concentration can rise to levels that are injurious to health.

Human health

Increased attention is now being paid to the health of workers exposed to the environment in livestock housing. Regulations introduced in Great Britain limit the exposure of humans to atmospheric ammonia to a mean level of 25 ppm over an 8h work shift and 35 ppm for 10 minute exposure (Control of Substances Hazardous to Health [COSHH], 1986). Donham (1989) listed exposure thresholds; contaminants in excess of values given were associated with a higher proportion of work related or pig diseases or lower productive parameters. Ammonia thresholds were 7.0 and 11.0/25.0 ppm for human and pig health respectively. Published survey data indicated that the air in livestock buildings can seriously endanger the health of livestock and stock-persons (Donham et al. 1985). Donham (1989) reported that air quality may affect illness in parts of the body other than the respiratory tract; arthritis was correlated with ammonia levels above 25 ppm. Ammonia has been specifically shown to reduce base-line pulmonary function with decrements in flow rates (Donham, 1990).

Dust was considered to be the most important contaminant, but ammonia and other toxic, irritating gases may be absorbed onto the surface of the dust and drawn deeper into the alveoli of the lungs, compounding the inflammatory response (Donham, 1989). Dust produces acute and chronic inflammation of the airways, and in three studies dose response relationships were suggested (Rylander et al. 1989). In this working-group report it was also noted that one epidemiological study of pig workers suggested that the swine confinement environment might lower the resistance of the respiratory tract to infections. If livestock are similarly affected, then there are important consequences in terms of profitability.

The most common symptoms of respiratory impairment of workers in pig buildings all relate to disease of the airways, (e.g. bronchitis often associated with increased reactivity of the airways, cough, sputum production, chest tightness, shortness of breath and wheezing). Crook et al. (1991) observed in a survey of 29 farmers who worked on pig units that work related respiratory symptoms, typically chest tightness, wheeze and nasal and eye irritation were reported in 80% of the individuals. Three farmers had specific IgE to pig squames or urine and eight to feed components. Specific IgG responses to pig squames or urine and to feed were demonstrated in 14 and 9 workers respectively. The majority of workers had work-related upper respiratory tract symptoms, mainly nasal irritation, however, the presence of specific IgE in some workers with wheeze suggested the possibility of their having an allergic response. The authors conclude that there is no documented evidence of the additive effects of dust and ammonia on human health but mucosal irritants such as cigarette smoke increased sensitization to aeroallergens (Venables et al. 1985) and ammonia is to be considered as one of the airborne contaminants that cause respiratory irritation and sensitization in pig farmers.

Whyte (1993) reviewed aerial pollutants and the health of poultry farmers. In line with conclusions drawn from the health of pig farmers, it was concluded that dust and ammonia represent the two most significant respiratory hazards to the health of poultry stockmen. It is noticeable that ammonia levels reported in poultry buildings were considerably higher than those reported in pig buildings, with levels in excess of 50 ppm

often being cited, and concentrations ranging from 23 to 42 ppm with a mean of 33 ppm and from 17 to 123 ppm with a mean of 78 ppm for pig and poultry buildings respectively. Major seasonal variations were recorded as a result of reduction in ventilation rates to conserve heat during the winter. Whyte (1993) concluded that the best method of ammonia control was by proper litter management with the aim of maintaining the litter dry.

Animal health and productivity

In poultry, the irritant effect of ammonia was demonstrated by Anderson et al. (1964). Chicks were exposed to Newcastle Disease virus, with or without exposure for 72 hours to 20 ppm ammonia. In the absence of ammonia, approximately 40% of the chicks were infected, however prior exposure to only 20 ppm ammonia resulted in 100% infection. Similar results were obtained when 4-week old chickens were exposed to sterile dust, ammonia and *E. Coli* separately and in combination for 4 weeks continuously (Oyetunde et al. 1976). *E. Coli* alone had no ill effects but gave pathogenic effects on the respiratory system when combined with dust or ammonia or both together. These results confirm that dust and ammonia can compromise the respiratory system and render it more vulnerable to damage by an otherwise harmless bacterium.

Infectious atrophic rhinitis is a disease of the upper respiratory tract of pigs characterized by the atrophy of the nasal conchae. Pathogenic bacteria are involved in the pathogenesis of the disease but environmental factors also play an important mediating role (Robertson et al. 1990). In a survey of pig farms, it was found that in 49 buildings on 12 farms there were significant positive correlations between the severity of conchal atrophy at commercial slaughter weights and the increased aerial concentrations of dust ($P<0.05$), bacterial counts ($P<0.01$) and ammonia ($P<0.05$) (Robertson et al. 1990). In an extension of this study the lungs of the pigs were examined for pneumonic lesions and the relationship between pneumonic lesions and environmental factors analyzed (Robertson 1992). There were no correlations between environmental factors and severity of pneumonic lesions in the farrowing or first stage weaner houses. This was considered consistent with the accepted pathogenesis of the disease i.e. primarily a disease of growing

and finishing pigs and the environment in the farrowing and weaner accommodation is unlikely to have an opportunity to influence the disease. There were positive correlations between the severity of lung lesions and airborne concentrations of respirable dust and respirable bacteria in the second stage weaner house which is in close agreement with similar studies in humans (Crook et al. 1991). There were however, significant relationships between both dust and ammonia and the mean lung score of animals from the finishing house. Individually the correlations between dust and ammonia and lung score were weak ($P<0.10$ in both instances) however the combined effect of these two weak associations was highly significant ($P<0.002$). The results support the theory that concentrations of airborne dust, ammonia and bacteria compromise the defense mechanisms of the lung.

The authors concluded that atmospheric ammonia in pig houses facilitates the onset of respiratory problems. Also that ammonia, together with the presence of the relevant pathogens and an aerial burden of dust and non-specific micro-organisms, can have a detrimental effect on the pigs at concentrations lower than 50 ppm as has previously been suggested.

Effects on production parameters

There are few reports which relate specific air pollutants to effects on production parameters, probably due to the difficulty of manipulating one parameter at a time.

Feed consumption and average daily gain of pigs, growing over the weight range 45 to 62 kg, were reduced ($P<0,05$) when the pigs were exposed for five-week periods to levels of 12 to 145 ppm ammonia (Stombaugh et al. 1969). Feed intake was reduced by a mean of 5.2% when the pigs were exposed to 61 ppm ammonia and 15.6 % reduction when exposed to higher levels. The incidence of coughing was also increased at all ammonia levels above 10 ppm. Curtis et al. (1974) examined the effects of ammonia, hydrogen sulfide and combinations of these two gases with dust on the performance of pigs. The number of pigs used was small but there was a tendency for rate of weight gain to be reduced with 50 ppm ammonia in the atmosphere. A combination of 50 ppm ammonia plus 300 mg/m^3 dust for 57 days significantly reduced weight gains from 0.52 to 0.42 kg/day.

Removal of dust from an environment which did not carry a high bacterial load did not result in a consistent improvement in the performance of broilers. However, filtration did result in a detectable decrease in the severity of lung damage (Carpenter et al. 1986).

Acute enzootic and haemophilus pneumonia in pigs, both caused by infectious agents, reduce feed conversion efficiency by up to 0.4 and increase days to slaughter by up to 21 and 30 days respectively (Muirhead, 1986 cited in English et al. 1988).

It is difficult to identify whether the effects of ammonia pollution on production parameters arise from a direct effect on the animal or whether it is via an interaction with sub-clinical disease. However, the results are indisputable in that the presence of dust in particular and/or ammonia will impair both health and production efficiency. The results which indicate the build-up of nitrates in water courses from agricultural run-off and the adverse effects of volatilized N in livestock housing indicate that N in the excreta of livestock is causing a major environmental hazard and has the potential to cause a major

risk to health. The recognition of this situation has resulted in the drafting of legislation to control sources of animal pollution. Such legislation is relatively new on the statute books, but examples may be found extensively in Europe, North America and Asia.

Legislation To Control Environmental Pollution

Throughout the world, legislation to protect the environment has become increasingly important since the early 1970s. In agriculture, legislation to control the impact of agricultural production on environmental pollution will be an additional cost levied against the producer. Hacker and Du (1993) prepared a comprehensive listing of different forms of legislation regarding the control of animal waste disposal from agricultural animal production being used around the globe. An EEC Directive (COM [88] 708) limits the number of manure

Table 2. Maximum number of manure producing animals per hectare of land available for manure spreading.

Species	Maximum number of animals per hectare
Dairy cows	2
Young stock/beef	4
Fattening pigs	16
Sows with piglets	5
Turkeys, ducks	100
Laying hens	133
Young hens, 0-16 weeks	285

producing animals per hectare of land available for manure spreading (Table 2) equivalent to a limit of 170 kg/ha/year total N (including that deposited while grazing) in zones deemed vulnerable as regards nitrate leaching. Land available for spreading will be specified and different limits will be set for zones vulnerable to water pollution from N

compounds. The future code of good agricultural practice for England and Wales will recommend to farmers a general limit of N application of 250 kg/ha/yr. This figure does not include N deposited while grazing or that applied as fertilizer. There is also likely to be a requirement for a closed season to be established for manure application but this will be left to national discretion.

The problem is being approached in various ways with some countries adopting very strict measures in the control of animal waste disposal. Table 3 lists several countries where such legislation has been enacted and summarizes the restrictions that have been imposed. The data in the table is not meant to cover all existing legislation but the examples given are presented to indicate the form that the laws are taking and the few instances were contingencies are included to account for the benefits that can be achieved from anti-pollution measures. Of note is the fact that much of the legislation is based on livestock numbers or livestock units, a fact which fails to take into consideration the nutritional regime being practiced or the efficiency of any particular breed.

Table 3. European international legislation controlling N and P pollution

Country	Date	Law	Basic Legislation	Norms		
Netherlands	1984	Ecological law	Limit on expansion of agricultural enterprises			
	1987	Soil Protection law	Slurry quota system	7.1 kg $P_2 0_5$ per growing pig		
	1990	Registration of input of minerals	Norms of manure spreading - maximum $P_2 0_5$ period of manure spreading;		$P_2 0_5$ (kg/ha/yr)	
			mandatory slurry soil injection;		95 Jan	2000Jan
			record keeping; allocation of manure spreading;	Grassland	155	110
			tax on surplus application;	Silage maize	155	75
			concessions to use environmentally Friendly Feeds;	Arable	125	70
			maximum ratio of N:P in manure 2:1			
					$P_2 0_5$ (kg/ha/yr)	
	1991	Mestdecreet	Maximum levels of fertilizer application.		1991	
	1993	Vlaren II	Norms of manure spreading; periods when manure application permissible.	Grassland	200	125
			Commissioning of manure banks to coordinate distribution of excess manure.	Silage maize	200	125
			Concessions given to farmers who use reduced N & P inputs in feed formulations.	Arable	125	125
Denmark	1987	Action Plan	Control water pollution by N&P	2.3 animals units/ha, cattle		
	1988	Detailed guidelines	Norms for storage and application; periods when manure application is forbidden; minimum storage capacity.	1.7 animal units/ha, pigs		
Germany		Federal law - water catchment areas	The "Landers" are able to define "a unit of slurry" in terms of animal numbers and unit applied/ha.	1 unit = 80 kg N/ha/yr and 60 kg $P_2 0_5$/ha/yr		
		Regional law - treatment of overflows	Rohprotein Abgeschickte Mischfutter (RAM system) a contract between farmer, local administration, feed producer and Chamber of Agriculture, the use of low protein feed gives a 25% concession on norms.	Minimum levels of lysine for pigs combined with maximum protein levels.		
France	1992	Protection of the environment	Regulations specific to pig farms Class A - Authorized - pig farms housing over 450 pigs. Class D - Declared - open air units up to 450 pigs.			

There are a number of measures available to livestock producers to reduce the excretion of N and P from livestock and which can reduce the potential pollution from livestock production. These measures were recently highlighted in a position paper written on behalf of the Fédération Européenne des Fabricants d'Adjuvants pour la Nutrition Animale (FEFANA 1992) which was written with a view to influence the formation of new European legislation to incorporate the benefits which can be achieved. The specific opportunities identified in the FEFANA (1992) position paper were as in Table 4.

Table 4. FEFANA (1992) recognized opportunities for reducing animal pollutant output.

Feed Supplements	Extended use of amino acids and related compounds.
	Use of enzymes.
	Use of growth promoters.
Feed Systems	Formulation closer to requirements
	Phase feeding
	Increased use of high digestible raw materials
Animals	Breeding and selection for better feed conversion and N retention.
N & P in Manure	Reduction by better conversion using all influencing factors including housing
Manure Processing	Improvement of distribution and handling of manure on farming land

This list was not intended to be exclusive, but represented a consensus of opinion of the European feed industry of "those feed related measures which could be quickly implemented as they do not require significant structural changes, heavy investment or any time consuming process whilst their impact is significant" (FEFANA, 1992). The potential reductions in N and P pollution that could be achieved by employing the various measures are shown in Table 5 although it was emphasized that the reductions that could be achieved were not cumulative.

Table 5 Potential effects of various strategies to reduce the N and P content of manure.

Factors		Estimated % reduction in manure	
		N	**P**
SUPPLEMENTS			
Synthetic amino acids and reduced protein levels in feeds		20 - 25	
Enzymes :	Cellulases	5	
	Phytases		25 - 30
Growth promoting substances		5	5
SYSTEMS			
Formulation closer to requirements		10 - 15	10 - 15
Phase feeding		10	10
Use of highly digestible raw materials		5	5

Adapted from FEFANA 1992

Methods Of Reducing The Pollution Of The Environment By Animal Production

Reduction in the protein content of diets offered to livestock

Formulation of diets to supply protein for both monogastric and ruminant livestock is carried out in most instances to achieve intakes of several essential amino acids in quantities that do not limit growth. To achieve this goal the ration must be accurately formulated based on knowledge of the amino acid composition of the raw materials. Furthermore since the essential amino acids may be present only in limited quantities it is acknowledged and accepted that under such circumstances the total dietary protein intake may be in excess of requirements. In theory, the availability and inclusion of industrially produced essential amino acids to supply a range of limiting amino acids should offer the opportunity to more accurately formulate diets and also reduce the overall protein content of the diet. There are two approaches to achieving greater precision in the supply of dietary protein for monogastric animals. Attention should be paid to matching dietary protein content to the needs of the animal according to stage of growth, and also to the amino acid content of the protein to match the needs of the animal. The two approaches are not exclusive of each other and need to be used in combination.

Techniques to improve the precision in estimation of the protein available for digestion in feedstuff raw materials

The use of protein in a feedstuff is limited by the availability of the protein in the material and the contribution of the amino acids in the feedstuff to the overall amino acid composition of the diet. If the protein is in a form that it cannot be digested or the amino acids that are contributed are in excess of requirement, the N will be excreted. Ileal digestibility is a concept that has been used to increase the accuracy of ration formulation in meeting the requirements of monogastric animals. The system relates to a specific component of the digestive process, however, it does not take into account the supply of nutrients to the tissues or tissue uptake of the nutrients.

The theory behind the isolation of the caecum and rectum where the major part of microbial activity occurs is that once proteins reach the hind gut they cannot be absorbed. Further microbial transformation or production of amino acids can lead to erroneous estimates of absorption. The use of ileal rather than fecal digestibility overcomes the inaccuracy incurred as a result of hind gut microbial fermentation in the caecum of the pig or caeca of the fowl. The effects of hind-gut microbial fermentation on amino acid digestibility is not the same for all materials. As a generalization, results indicate that the lower the digestibility of the protein supplement i.e. the more undigested protein that reaches the hind-gut, the more the value of digestibility can be affected by microbial fermentation. Using intact and caecectomized cockerels it was shown that there was little difference between fecal and ileal digestibility of amino acids for cereals, slight differences for oilseed meals, but significant differences for some animal meals; the N digestibility coefficients for the three meals being 0.92, 0.91 and 0.83 respectively (Green et al. 1987a, b; Green and Kiener 1989). This effect of undigested N reaching the hind gut on the difference between fecal and ileal digestibility is confirmed by the work of Johns et al. (1986). Lysine digestibility of meat and bone meal in intact and caecetomized birds was 0.88 and 0.82 respectively in meal without heat treatment and 0.58 and 0.45 respectively in 5h heat treated meal. The more undigested protein reaching the hind gut, the greater the discrepancy between the two measures of digestibility.

The advantage of ileal digestibility values to total amino acid values was demonstrated by Tanksley and Knabe (1984). In diet formulations in which meat and bone meal or cottonseed meal were used individually to replace half the soya-bean meal in diets for growing pigs, the pigs given diets formulated on an ileal digestible amino acid basis performed better than those given the diets formulated on the basis of total amino acids. However, even then the performance of pigs given the cottonseed meal diet did not equal that of pigs given the soya control. Ileal digestibility of protein cannot be considered to give an all-encompassing value of protein digestibility. Factors which influence ileal digestibility include level of feeding, associative effects between feeds such that values are non additive, particle size, starch type, non-starch polysaccharides and the effects of feed processing.

Low and Longland (1990) concluded that despite the considerable practical interest in using ileal digestibility values there was relatively little validation of the approach in terms of the extent to which the values obtained were accurate predictors of rates of lean tissue accretion. Results of published studies presented a conflicting picture. Recently some doubt has been expressed as to the correlation between ileal digestibility values and availability of amino acids (Batterham et al. 1990, 1993). Batterham (1992) identified that a difference exists between ileal digestibility and availability. He concluded that the differences relate mainly to heat damaged meals. The differences were significant for lysine, methionine, threonine and tryptophan but not for the branched chain amino acids. Furthermore, he concluded that, particularly for cereals, ileal digestibility values were the most appropriate as they account for losses in digestibility.

Dietary supplementation with individual amino acids

Poultry

Considerable work has been carried out to determine the levels to which dietary protein in diets can be reduced without adverse effects on animal performance. The possibilities of reducing N excretion and environmental pollution from poultry by dietary supplementation with individual amino acids was reviewed by Leclercq and Tesseraud (1993). These authors calculated that poultry used feed protein with an overall efficiency approaching 45 percent, but that the conversion by poultry of dietary protein to human consumable protein is of the order of 27 percent. They calculated that in theory, by the use of pure amino acids and reducing the protein content of a grower diet from 22 to 16%, it is possible to achieve a 72.5 percent efficiency of utilization of protein with a concurrent reduction in N excretion by a factor of 1.7. Results indicate that it is difficult to achieve this level of improvement in practice.

From the data (Table 6), Leclercq and Tesseraud (1993) concluded that early results obtained with animals exhibiting relatively slow rates of growth yielded results which suggested that dietary supplementation with individual amino acids has the potential to

reduce the level of protein required in the diet and hence reduce N excretion. However, on the contrary, more recently with large numbers of birds and with birds exhibiting high rates of growth it has proven difficult to fully compensate for dietary protein reduction with supplementary amino acids. In particular, the birds given the low protein diets have exhibited increased carcass fat and increased feed intake suggesting that a better equilibrium in amino acid profile has resulted in overall improved energetic efficiency.

Table 6. Comparison of responses of broilers to a reduction in protein content of the diet and supplementation with individual amino acids.

	Waldroup et al. 1976		Schutte 1987		Edmonds et al. 1985		Fancher and Jensen 1989	
	Cont.	+ Supp	Cont.	+ Supp	Cont.	+ Supp	Cont.	+ Supp
Age (days)	0-21		7-28		8-22		21-42	
CP %	22.7	18.9	20.0	16.0	24.0	16.0	21.9	17.9
Lysine	1.23	1.23	1.25	1.25	-	+0.74		+0.03
Methionine	0.80	0.80	0.86	0.86	-	+0.38		+0.13
Energy (kcal/kg)	3080	3080	-	-				
ME (kcal/kg)					2970	2970	3300	3300
Live-weight gain (g/d)	218	222	810	813	260	227	944	922
FCE	1.65	1.69	1.61	1.59	1.49	1.74	2.079	2.105
Abdominal fat pad	-	-	-	-	-	-	1.92	2.20

FCE - Feed conversion efficiency

Adapted from Leclercq and Tesseraud, 1993.

Pigs

The use of dietary supplementation with individual amino acids and concomitant reduction in protein content has also been tested in pigs. In a trial at the Ilob-Institute (The Netherlands) the crude protein (CP) content was lowered from 13.9% to 11% and the low

protein diet was supplemented with methionine, threonine, lysine and tryptophan. On the low protein diet there was no reduction in live-weight gain or feed conversion efficiency but N excretion was reduced by nearly 30% (Koch, 1990). Kies et al. (1992) carried out a series of growth and N balance experiments specifically to address the potential reduction in N excretion that could be obtained by lowering the N content of the diet and supplementation with individual amino acids. Diets were prepared equal in digestible energy, lysine and total sulfur bearing amino acids, but with CP levels ranging from 12.7 to 18.6% in the grower ration and 10.8 to 16.5% in the respective finisher rations. The results are shown in Table 7. The different levels of protein had no effect on performance during the growing phase but growth rate and feed conversion efficiency were significantly poorer for pigs given the low protein ration during the finisher phase. During the grower phase, overall N excretion was reduced by 50% with the use of the 13% CP ration, whereas if the minimum of 13.5% protein is accepted as the minimum level acceptable without reducing performance in the finisher phase, a 27% reduction in N excretion is attainable.

Recent studies (Quiniou et al. 1994) have confirmed the data that, compared with a control CP level of 17.8%, dietary CP can be reduced to 13.6% plus supplementation with lysine, methionine, threonine and tryptophan without any adverse effects on performance or carcass composition of growing and finishing pigs (Table 8). These authors compared two genotypes (Large White and Large White x Piétran) and two sexes (females and castrates). There were significant differences between the genotypes and sexes but no significant interaction between dietary treatment and either genotype or sex. The dietary treatments had no effect on performance or carcass composition of the pigs and when the energy intake was expressed in terms of net energy there were no significant differences in the efficiency of utilization of net energy.

Table 7. Effects of level of protein in the diet on the performance and N excretion of growing and finishing pigs.

	Ration 1	Ration 2	Ration 3	Significance

Grower ration (CP %)		18.6	15.6	12.7	
Finisher ration (CP %)		16.5	13.4	10.8	
20-60 kg	Intake (g/kg)	1742	1714	1746	
Average daily gain (g/d)		806	784	799	NS
Feed conversion ratio		2.17	2.19	2.20	NS
60-95 kg	Intake (g/kg)	2343	2284	2282	
Average daily gain (g/d)		898	904	846	*
Feed conversion ratio		2.62	2.53	2.70	*
N Utilization					
Grower ration					
Apparent biological value		0.59^{b}	0.64^{ab}	0.74^{a}	05*
Apparent efficiency of utilization - dietary N		0.51	0.55	0.62	NS
Finisher ration					
Apparent biological value		0.60^{b}	0.70^{c}	0.76^{a}	01**
Apparent efficiency of utilization - dietary N		0.53^{b}	0.61^{ab}	0.65^{a}	01**

The two low protein diets reduced overall N excretion by 18 and 33% compared with the control 17.8% CP diet (Figure 1). Comparing their results with those of Kies et al. (1992), Quiniou et al. (1994) concluded that the reduced performance experienced with a diet of 10.5% CP was probably due to an inadequacy of non-essential amino acids, and that the minimum level of CP that could be achieved is limited by a threshold level of ideal protein. This threshold they consider corresponds to 12.5% CP, a ratio of lysine/protein of 6.5% and a ratio of essential to non-essential amino acids approaching 1 (Chung and Baker 1992). Quiniou et al. (1994) also stress the point that in their work there was no effect on carcass composition when the level of protein in the diet was reduced. However, in earlier work in which the energy content of the diets was based on digestible energy, the net energy content of the diets rich in protein was always lower than that in the low protein diets. This was accompanied by catabolism of excess protein and energy loss via the urine. The reduction in protein content of the diet in fact represented an energy economy which could, under certain circumstances, result in an important deposition of fat in the carcass. Therefore, it is

important therefore that formulation of diets with reduced levels of protein is carried out on the basis of net energy to avoid negative effects on carcass composition. The authors conclude that with the combination of both the ideal protein concept and the matching of protein supply to the needs of the pig, it is possible to reduce excretion of dietary protein intake to less than 54%, whereas with high levels of dietary protein intake, nearly 70% of the ingested protein is excreted.

Table 8. Effects of level of protein in the diet on the performance of growing and finishing pigs (Large White and Pietran x Large White).

	1	2	3	Significance
CP (%)	17.8	15.5	13.6	
Digestible energy (kcal/kg)	3378	3324	3286	
Net energy (kcal/kg)	2438	2438	2438	
Initial live weight	29.3	29.5	29.4	NS
Final live weight	102.9	103.2	102.8	NS
Average daily gain (g/d)	846	867	852	NS
FCE (kcal NE/kg)	6588	6560	6599	NS
% muscle	51.3	52.3	51.6	NS
% fat	19.1	18.4	19.3	NS

FCE - Feed conversion efficiency

1. Control ration.
2. Supplemented with lysine, methionine and threonine.
3. Supplemented with lysine, methionine, threonine and tryptophan.

Adapted from Quiniou et al. (1994).

The N excretion of pigs over a range of weights and different dietary protein concentrations and composition are shown in Figure 2. Data used to construct these figures was generated from a pig modeling program (D. Charles; personal communication, 1991). Several very important points can be gained from the data. In Figure 1, the lysine content of the diet is constant at 10 g/kg and the CP concentration has been increased from 140 to 230 g/kg. At the three weights of pig shown (50, 70 and 100 kg live weight), N excretion

increases as the level of protein in the diet is increased. At no point was protein limiting as would be shown by a curvilinear relationship. The main reason for this is that the diets were offered *ad libitum* and since the pigs were eating to satisfy their appetite for energy, at the levels of protein used in the diet, protein intake was always in excess of requirement. Most noticeable is the higher N excretion in pigs weighing 100 kg compared with those weighing 50 kg, and also, the rate of N excretion with increasing protein level in the diet is higher for the heavier pig.

There is a tendency for finishing pigs to be offered the same diet over the weight range 50 to 100 kg. A major reduction in N excretion by pigs could be achieved by adopting a diet strategy with greater emphasis on the weight of pig being fed. A reduction in dietary protein content as the live weight of the pig increases would have environmental and financial benefits. Koch (1990) calculated that a two phase feeding system, using a grower (165 g/kg CP) and a finisher ration (140 g/kg CP) was capable of reducing N excretion by 13% compared with feeding a single 160 g/kg CP diet.

Ruminants

The concept of feeding individual amino acids to ruminants to balance amino acid supply in the small intestine has only recently become possible. This has resulted from research which has yielded data on the requirements for individual amino acids, specifically for milk production (Rulquin et al. 1994 in press) systems to predict amino acid supply to the small intestine from dietary protein and microbially synthesized protein (e.g. the Cornell Net Carbohydrate and Protein System, O'Connor et al. 1993; INRA PDI system, Verité and Peyraud 1989). In the dairy cow supplementation with 12 g of rumen protected, duodenally available methionine has resulted in increases in the protein content of the milk in mid lactation, without any response in milk yield (Rulquin et al. 1993; Robert et al. 1994). The mean increase in three trials carried out using cows post peak lactation was 42 g of protein per head per day (6.84 g of N, Robert, J. C., personal communication 1994). Thus, there was very close agreement between the 7.04 g of additional N obtained from the supplementary methionine and the additional N appearing in the milk. In later experiments with cows in early lactation, increases in milk yield of 1.73 l (Robert, J. C., personal

communication 1994) and 1.9 l (Chilliard, personal communication 1993) were obtained together with increases in the protein concentration of the milk of 1.54 and 2.7 g/kg respectively. In these trials the addition of supplementary methionine resulted in 4.5 and 13.8 g of extra N secreted in the milk respectively over and above that added to the diet in the form of methionine. Complete N balances have not been carried out in these experiments, but the results strongly suggest that by balancing the supply of dietary protein given to dairy cows with the first limiting amino acid, reductions in N excretion can be obtained.

The effects of animal genotype on N excretion

Genetic selection offers the opportunity to select within a species, traits which have specific value, with the selection pressure imposed being dependent on the trait selected. Selection of animal genotypes which transform feed proteins into body protein with optimum efficiency is of value in the present context. The monongastric species selection for lean tissue growth has been a goal for several years, the specific benefits in terms of N balance is a benefit which to date may have been underestimated. Leclercq (1989) suggested that selection of poultry for improved efficiency of feed utilization and reduced adiposity resulted in improved efficiency of N utilization. Research on the efficiency of N utilization comparing poultry genotypes bred to produce lean or fat genotypes has demonstrated the advantage of genotype selection which could contribute to a reduction in N excretion. Geraert et al. (1990) demonstrated that excretion of uric acid was higher in genetically fat birds compared with lean genotypes when both received the same levels of protein. The difference did not exist when the birds were young but was of the order of 0.5 g/d uric acid less for the lean line when the fat line were excreting between 1 and 2 g/d uric acid. The conclusions drawn from this study were that 1) the maintenance requirement of the two lines was the same 2) the efficiency of conversion of dietary protein into muscle was higher in the lean line (73.7%) compared with the fat line (57.2%) and 3) this difference was observed over a range of protein intakes from 13 to 25% CP in the diet. Further comparison of fat and lean genotypes indicated that the lean genotype had a slightly higher efficiency of utilization of sulfur bearing amino acids than the fat line but that this

difference was insufficient to explain the total metabolic difference between the genotypes and that efficiency of utilization of other amino acids should be considered. It was concluded that in terms of ideal protein, particularly with respect to sulfur bearing amino acids, different genotypes had different requirements and that selection for reduced adiposity was likely to modify the requirement in terms of quantity and composition of a defined ideal protein. Leclercq and Tesseraud (1993) concluded that it was possible that selection could be used to produce animals with an increased level of efficiency, and utilize feeds high in essential amino acids and low in total protein. Secondly, it was found that lean genotypes inherently had a lower level of N excretion than fat genotypes at any given level of protein intake, and finally, that selection for reduced fat deposition could at one and the same time reduce N excretion by 14.3% (Leclercq and Tesseraud 1993).

Similar effects can be inferred with pigs although direct comparisons between different genotypes in terms of N economy are less evident. Campbell (1989) citing Campbell and Taverner (1985) demonstrated the influence of genotype on protein accretion in a comparison of lean genotype Large White x Landrace pigs with a conventional genotype. Protein retention of the pigs over a range of digestible energy intakes was compared over the weight range 45 to 90 Kg live weight. Protein retention of the lean genotype over the range of energy intakes studied was not effected by the level of concentration of energy in the diet and protein retention was limited by intake. Protein retention in the conventional genotype plateaued at an energy intake of 33 kJ digestible energy per day. Above this value increased protein intake would have been excreted in comparison with the lean genotype which continued to retain protein.

The effects of genotype on N retention demonstrate that in both pigs and poultry genotype can play a major role in the response of the animal to the quantity and quality of protein in the diet. The results obtained with poultry signal caution in that raising the efficiency of N retention can have consequences in terms of overall efficiency and in this instance resulted in negative effects on carcass composition.

Addition of growth promoters to the diet to reduce pollutant excretion

For many years growth promoters in the form of antibiotics or hormones have been administered to livestock in order to improve either the efficiency or the rate of growth and also to yield benefits in terms of carcass composition. Growth promoters (antibiotics, hormones and b-agonists) have effects on N accretion which result in improvements both in the efficiency of N retention and in the rate of live-weight gain. Both factors have positive effects in terms of the reduction in N excretion. Williams (1992) demonstrated that in growing pigs, in terms of reductions in N excretion, the metabolic effects of using anabolic growth promoters (b-agonists or recombinant porcine somatotropin) in terms of increased N retention in the carcass at equal slaughter weight were relatively small (14% of the reduced N excretion was accounted for by N retention in the carcass) compared with the major reduction in N intake resulting from increased growth rate and the reduction in time to slaughter. The situation was somewhat different in cattle where 60% of the reduced N excretion is accounted for by carcass N retention. Easter et al. (1993) reviewed data on the use of b-agonists in pigs and concluded that daily N deposition was increased by 19.4% and N retention was increased by 8.8%, at the same time live-weight gain was increased by 5%.

From a series of growth experiments using pigs and cattle where growth promotants were administered, the data in Table 9 has been calculated. For swine, ractopamine (b-agonist; Adeola et al. 1990) and recombinant porcine somatotropin (rpST; Campbell et al. 1987, Campbell 1988) and for cattle, monensin sodium (ionophore; Chalupa 1980 data applied to Early et al. 1990 data) and recombinant bovine somatotropin (rbST; Early et al. 1990) were the growth promotants examined. Two scenarios were chosen for each growth promotant, either the animals were reared for an equal number of days and therefore the animals treated with the growth promotant were heavier, or the animals were slaughtered at equal final live weight and those receiving the growth promoter reached slaughter weight in a shorter period of time. Since N balance data were not available, the results have been calculated in terms of manure saving. Assumptions used in the determination of these data include the use of constant digestibilities and dry matter concentration of manure (from Ensminger and Olentine 1978) within each scenario. In most instances, as would be expected, rearing the animals to constant slaughter weight produced the greatest saving in

manure excretion. Assuming equal N and P content of the manure calculated from these scenarios, the use of growth promotants may result in reductions in pollutant output ranging from 11.6 to 33.5% in swine and 4.2 to 11.7% in growing cattle.

The use of rbST to increase milk yield in the dairy cow can have a similar beneficial environmental impact. Williams (1993) calculated that while overall N excretion is increased in rbST treated cows, as a result of the increased feed intake, the N excretion per litre of milk produced is reduced by 15%. Under a situation where the quantity of milk produced is limited by a quota, N excretion would be reduced by reducing the number of cows.

Table 9. Use of growth promotants to reduce N and P excretion of pigs and cattle

	Scenario	Initial Wt (kg)	Rearing period (days)	ADG (kg/d)	Final Wt (kg)	DMI (kg/d)	Feed Saved/hd (kg DM)	Manure-saving/hd (kg DM)	% of control
1. b-agonists and porcine somatotropin to reduce N excretion of pigs									
[1]***b-agonist (ractopamine)***									
Control	Equal days	64.4	28	0.99	91.9	2.41			
+ b-agonist		64.4	28	1.10	95.1	2.08	9.32	0.68	86.0
Control	Equal final Lwt	64.4	31	0.99	95.0	2.41			
+ b-agonist		64.4	28	1.10	95.0	2.08	17.80	0.34	76.1
[2]***Porcine somatotropin****									
Control	Equal days	25.0	33	0.91	55.0	2.13			
+ PST		25.0	33	1.10	60.0	1.90	8.95	0.56	88.4
Control	Equal final Lwt	25.0	33	0.91	55.0	2.13			
+ PST		25.0	28	1.10	55.0	1.90	18.4	1.15	76.1
[3]***Porcine somatotropin****									
Control	Equal days	60.0	31	1.06	93.0	3.38			
+ PST		60.0	31	1.22	98.0	2.61	25.73	1.61	77.4
Control	Equal final Lwt	60.0	36	1.06	98.0	3.38			
+ PST		60.0	31	1.22	98.0	2.61	43.7	2.18	66.8
2. Ionophores and recombinant bovine somatotropin (rbST) to reduce N excretion of beef cattle									
[4]***Ionophore (monensin sodium)***									
Control	Equal days	231	112	1.30	377	7.90			
+ ionophore			112	1.33	380	7.57	37.3	14.0	95.8
Control	Equal final Lwt	231	114	1.30	380	7.90			
+ ionophore			112	1.33	380	7.57	54.9	20.6	93.9
[5]***Recombinant bovine somatotropin***									
Control	Equal days	231	112	1.30	377	7.90			
+ rbST			112	1.50	399	8.05	-16.8	-1.26	101.9
Control	Equal final Lwt	231	129	1.30	399	7.90			
+ rbST			112	1.50	399	8.05	119.3	44.8	88.3

[1] Adeola et al. (1990) [2] Campbell et al. (1987) [3] Campbell (1988) [4] Chalupa (1980) [5] Early et al. (1990)*

assumes feed dry matter of 92%

Note: negative number in feed and manure savings columns represents greater input and output

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Reduction of N pollution by a decrease in the excretion of endogenous N

Huisman et al. (1993) took an additional approach to the reduction in N excretion by considering the part played by endogenous excretion. As they summarized, reduction in N excretion in the feces can be achieved by increasing N digestibility and by removing anti-nutritional factors from the diet, a decrease in urinary N is achieved by reducing protein content or by improving the efficiency of N retention using hormonal growth promoters or b-agonists. There remains the N excretion resulting from the loss of the endogenous component. They conclude that a considerable part of urinary N is of endogenous origin. From a series of experiments the authors concluded that the true digestibility of a range of feedstuffs is above 90% whereas the apparent digestibility is of the order of 13% lower, this value representing N associated with endogenous loss. However, since the reabsorption rate for the endogenous N up to the terminal ileum is estimated at approximately 73%, this implies that three quarters of the secreted endogenous N is digested and reabsorbed before the terminal ileum. During this N turnover, it is estimated that a 30% loss occurs in the urine. In conclusion Huisman et al. (1993) calculate that with a 100g intake of feed N, the N losses in feces and urine are 62 g of which 33.5 g originate from the feed and 28.5 from endogenous loss. The data underline the important point that achieving means of reducing endogenous N losses can have an equivalent effect to the readily accepted solution of reductions in feed N intake or improved utilization of dietary N.

Enzyme supplementation of diets for pigs and poultry

The concept of using enzymes in diets for pigs or poultry is now well established. Chesson (1987) established the principle that enzymes are used either to supplement an endogenous supply or to supply a digestive capacity non-existent in the host animal. Although the current impetus to the use of enzymes is one of economics it follows that since their use results in an improvement in the digestibility of components in the diet and improvements in growth, in the context of the present discussion the use of enzymes results in a reduction in undigested food excreted. There are many excellent literature reviews describing the use of enzymes for monogastric animals which cover the relevant nutritional

concepts (Chesson, 1987; Dierick, 1989; Inborr, 1989; Rotter et al. 1989; Rotter 1990; Classen and Campbell, 1990; Campbell and Bedford, 1992; Johnson et al. 1993). The present review will therefore be restricted to the concepts as they relate to environmental pollution.

Polysaccharidases.

Plant polysaccharides are major components of animal feedstuffs, the most important being starch (95% digestion in the small intestine of pigs). However, non-starch polysaccharides pass through the animals gut largely untouched unless they are exposed to enzymes produced by the microbial flora. The microbial population which develops in the crop of poultry and in the hind gut of pigs is capable of digesting mixed b-glucans. The presence of non-starch polysaccharides in the food can either block digestion of other important nutrients e.g. protein and starch, or the presence of b-glucans in the lumen of the gut can seriously inhibit absorptive capacity.

White et al. (1983) found that the results of using b-glucanase do not stem from complete hydrolysis of the b-glucan, but that relatively minor hydrolysis alters the ability of the b-glucan to form viscous solutions and act as a barrier to endogenous enzyme activity. The age of the pig affects b-glucanase activity (Inborr 1989). The apparent digestibility of b-glucans was reported to be 68% in pigs of 30-50 kg live-weight and approximately 80% in pigs over 58 kg live weight. The addition of a mixture of b-glucanase, a-amylase and gluco-amylase to diets given to piglets between 2 and 5 weeks of age improved daily live-weight gain and feed conversion efficiency by 10.9 and 13.3% respectively (Inborr and Ogle 1988). The improved digestibility of the feed also resulted in a lower incidence of scouring. Low and Longland (1990) reported that N retention of pigs was slightly increased by enzyme supplementation.

This work also demonstrated the potential of enzyme preparations to improve the health status of pigs (Table 10). The combination of the two enzyme preparations containing carbohydrase activity plus the cellulose, amylolytic and proteolytic activity significantly reduced the severity of diarrhea in the pigs. The effects could be interpreted as

a result of the increase in digestibility of materials in the small intestine following the activity of the enzyme preparations which resulted in a reduction of substrates for pathogenic bacteria in the lower gut.

Table 10. Effect of a b-glucanase preparation on the health of young pigs fed barley-based diets.

Parameter	Control	Enzyme Combination
Severity of diarrhea 2 - 9 weeks*	4.7	1.5
Antibiotic treatments (piglets/days)	6	0

* Scale of diarrhea severity 1 = slight diarrhea, 2 = moderate diarrhea, 3 = severe diarrhea requiring antibiotic treatment.

Adapted from Inborr and Ogle (1988)

The use of enzymes in diets for poultry can have additional benefits to the improved growth of the birds. The main factors influencing ammonia production from litter are pH and moisture content of the litter, and environmental temperature (Elliot and Collins 1982). Recent measurements of moisture and N content of litter following the use of enzyme supplementation of diets given to broilers has indicated that litter moisture content and N content were lower in the litter of the birds given diets supplemented with b-glucanase (Williams, unpublished data). Measurement of ammonia release from the litter indicated that when a second flock of birds was raised on the same litter, the presence of a b-glucanase in the diet reduced the level of ammonia release by 80%.

Digestion of plant derived P

Approximately 0.66 of the P in plant tissue is in the form of phytate-P (myo-inositol hexabisphosphate) which has a low availability in simple stomached animals. The excretion of this P contributes to P pollution in areas of intensive livestock production. Furthermore, the addition of mineral P to the ration in order to supply the animals' requirement utilizes space in the formulation which could potentially be used for the inclusion of cheaper raw materials. Phytase is an example of a specific enzyme which is used to target phytate to release free P with excellent results (Simmons et al. 1990; Ketaren et al. 1992). There are several options available for increasing the phytase activity of diets for pigs, either the diet can be supplemented with phytase-rich cereals or phytase can be added from microbial sources.

Cereals that contain phytase such as wheat, triticale, rye or their by-products when included in diets for pigs result in better phytase utilization. Pointillart et al. (1993) designed diets which contained decreasing amounts of inorganic P and increasing dietary phytase activity by altering the dietary proportions of wheat, wheat by-products (bran and shorts) and rye bran. The proportion of inorganic P in the diet ranged from 0.30 to 0. There was no effect on pig performance in the period to slaughter and no effect on bone density or strength at slaughter in pigs given the diet with low inorganic P supplemented with cereals containing phytase compared with the pigs given a standard diet supplemented with inorganic P. A recent study (Campbell, R.G. unpublished) clearly demonstrates the effect of supplementary microbial phytase in P deficient and adequate diets which contained a range of dietary available P (AP) (1.5, 3.0, 4.5, and 6.0 g/kg). Results from pigs fed diets with and without added phytase commencing at 25 kg live weight showed that supplementation with phytase resulted in significant improvements in growth performance only at the lower levels of AP.

Although the use of phytase is targeted specifically at the availability of P the presence of the enzyme can have effects on the digestibility of other dietary components. N digestibility (%) was significantly higher in pigs receiving diets without inorganic P supplementation (+ 2.8%.; Nasi 1990); a number of other investigations have indicated that

there is often strong binding between phytic acid and protein (Zhu et al. 1990). Results also suggest that the digestibility of a number of other mineral components may be improved by the addition of phytase. Calcium digestibility and calcium retention was improved by supplementation with phytase (Nasi 1990; Simmons et al. 1990) and Nasi (1990) reported that the digestibility of magnesium also tended to be higher. Mroz et al. (1994) reported that the inclusion of phytase in a diet for pigs significantly improved the apparent total tract digestibility of dry matter (+1.8%), organic matter (+1.6%), CP (+2.3%), Ca (+4.3%), total P and amino acids. The authors concluded that the effects on CP and amino acid digestibility may indicate that phytate-protein bindings were to some extent cleaved by phytase activity or by reducing the activity of phytic acid its inhibitory influence on trypsin and pepsin was diminished.

The presence of Ca and vitamin D in the diet strongly interact with P utilization and may affect phytate-P utilization. The presence of additional vitamin D in the diet can directly affect phytate-P utilization; chicks supplemented with 10 mg of 1,25-dihydroxycholecalciferol in the diet had reduced incidence of P rickets and markedly reduced amounts of phytate-P in the feces (Edwards 1993). A second experiment with 5 mg 1,25-dihydroxycholecalciferol confirmed the results with a 30% increase in P retention compared with the unsupplemented diet. Recently, Lei et al. (1994) have confirmed the interaction between the presence of Ca, vitamin D and the effects of phytase in weaning pigs. A normal level of Ca in the diet (8 g/kg as fed) greatly reduced the efficacy of supplemental phytase. Raising vitamin D in the diet partially offset this effect but did not produce further improvement when the Ca level was low. The authors concluded that the introduction of high levels of vitamin D into the diet may enhance Ca absorption thereby removing the possible Ca-phytate interaction in the gut and resulting in improved phytate P availability.

To date experiments on the effects of phytase have been carried out using a microbial form of phytase supplied by either *Aspergillus Ficuum* (Simmons et al. 1990; Nasi 1990*)* or *Aspergillus niger* (Beers and Jongbloed 1992). A problem with this preparation has been the sensitivity of the organism and the enzyme to temperature and

hence the loss of activity above 80°C, a temperature often experienced during the process of feed pelleting. An interesting development which may herald a new era in the use of enzymes in animal feed was recently reported when the gene coding for phytase activity in *Aspergillus niger* was engineered into tobacco seeds (Pen et al. 1993). The enzyme was expressed as 1 percent of the soluble protein in mature seeds. In *in vitro* tests that simulated chicken crop and stomach conditions, release of phosphate from feed by addition of transgenic seeds was demonstrated. Supplementation of broiler diets with transgenic seeds resulted in an improved growth rate, comparable to diets supplemented with fungal phytase or P. Although at this stage the sensitivity of this enzyme to temperature has not been tested these results demonstrate that there is perhaps the potential to engineer the phytase producing gene into a wide range of plant materials that could be included in diets without the need for supplementary microbial enzyme.

Conclusions

Pollution arising from animal production is a major problem facing livestock producers. Where pollution exists, other than in isolated instances, it is a problem associated with the intensification of livestock production, although such intensification is essential for the economies of scale which enable food to be economically produced. The nuisance caused to neighbors by environmental pollution has recently caused the State of California to draw up an ordinance acceptable to both residents and the poultry industry which would establish guidelines for the citing of poultry production units (Voris, 1992). Three separate citing standards were established and it was also agreed that each new unit would have to develop a management plan describing the operational practices necessary to control nuisances. The goal of the management guidelines was to give County Environmental Departments a set of rules to use to determine when a producer is in compliance with acceptable industry standards. It could also be argued that in the future, only large scale operations will be able to withstand the cost of responding to anti-pollution measures. It is obvious, however, from reference to N budgets described earlier in this paper that in present farming practices the import of N into the system from feed and fertilizer greatly exceeds that which is exported. Furthermore, once in the system there are

few opportunities to export N from the system and presently there is only one opportunity for major recycling i.e. the production of fertilizer. Nitrogen in excreta does have the potential to replace feed N. Poultry manure can be used as a source of non-protein N for ruminants (Arave et al. 1990), and attempts have been made to ferment slurry to produce an energy source or on a limited scale the amino acid lysine (J. Sanders personal communication 1992). This latter innovation is interesting since it does represent, together with the feeding of poultry manure to ruminants, one of the few means of recycling N within the system with an added value to the final product. Moreover, the separation of the N component from the phosphate and potassium in the manure removes the constraint of the fixed N:P:K ratios which limit the use of manure as fertilizer.

These statements apart, management of feeding practices and methods of feed formulation offer considerable opportunity to reduce N and P excretion of livestock. Sufficient research has been carried out to validate the systems, the aim must be to transfer these technologies into practice at the earliest opportunity. There is undoubtedly a cost to these advanced technologies. This cost must be shared by the livestock producer, if he wishes to continue without restriction at the same or increased levels of production, and the consumer if they wish affordable quality food. However, it is the cost which must be paid by the livestock industry and the consumer for the protection of the environment.

Literature

Adeola, O., Darko, E.A., Ping He and Young, L.G. 1990. Manipulation of porcine carcass composition by ractopamine. J. Anim Sci. 68:3633-3641.

Anderson, D.P., Beard, C.W. and Hanson, R.P. 1964. The adverse effects of ammonia on chickens including resistance to infection with Newcastle Disease virus. Avian Dis. 8:369-379.

Arave, C.W., Dobson, D.C., Arambel, M.J., Purcell, D. and Walters, J.L. 1990. Effect of poultry waste feeding on intake, body weight and milk yield of Holstein cows. J. Dairy Sci. 73:129-134.

Batterham, E.S., Anderson, L.M. and Baigent, D.R. 1993. Utilization of ileal digestible amino acids by growing pigs: Methionine. Br. J. Nutr. 65:711-720.

Batterham, E.S., Anderson, L.M., Baigent, D.R., Beech, S.A. and Elliott, R. 1990. Utilization of ileal digestible amino acids by pigs: Lysine. Br. J. Nutr. 64:679-690.

Batterham, E.S. 1992. Availability and utilization of amino acids for growing pigs. Nutr. Res. Rev. 5:1-18.

Beers, S., and Jongbloed, A.W. 1992. Effect of supplementary *Aspergillus niger* phytase in diets for piglets on their performance and apparent digestibility of phosphorus. Anim. Prod. 55:425-430.

Blaxter, K.L. 1962. The energy metabolism of ruminants. Hutchinson Scientific and Technical. London.

Blaxter, K.L. 1991. Animal production and food: real problems and paranoia. Anim. Prod. 53:261-269.

Campbell, G.L. and Bedford, M.R. 1992. Enzyme applications for monogastric feeds: A review. Can. J. Anim. Sci. 72:449-466.

Campbell, G.L., and Classen, H.L. 1989. Commercial application of enzyme technology in feeding barley to poultry. Proc. 24th Pacific Northwest Animal Nutrition Conference. Boise ID. pp 65-73.

Campbell, R.G. 1988. Nutritional constraints to lean tissue accretion in farm animals. Nutr. Res. Rev. 1:233-253.

Campbell, R.G. 1989. Protein accretion and the nutrition of growing animals. In Pork Talk 2000. ed Johnson, R. Rhône-Poulenc Animal Nutrition, Australia.

Campbell, R.G., Caperna, T.J., Steele, N.C. and Mitchell, A.D. 1987. Effects of porcine pituitary growth hormone (pGH) administration and energy intake on growth performance of pigs from 25-55 kg body weight. J. Anim. Sci. 65(Suppl. 1):244 (abstr).

Campbell, R.G., Taverner, M.R. and Curic, D.M. 1985. Effects of sex and energy intake between 48 and 90 kg live weight on protein deposition in growing pigs. Anim. Prod. 40:489-496.

Carpenter G.A., Smith, W.K., MacLaren, A.P.C. and Spackman, D. 1986. Effects of internal air filtration on the performance of broilers and the aerial concentration of dust and bacteria. Brit. Poultry Sci. 27:471-480.

Chalupa, W.C. 1980. Chemical control of rumen microbial metabolism. In Digestive Physiology and Metabolism in Ruminants. ed Y. Ruckebusch and P. Thivend. AVI Publishing Company, Inc. Westport CT. pp. 325-347.

Chesson, A. 1987. Supplementary enzymes to improve the utilisation of pig and poultry diets. In Recent Advances in Animal Nutrition. eds Haresign, W. and Cole, D. J. A. pp. 71-89. Butterworths. London.

Classen, H.L. and Campbell, G.L. 1990. Improvement of feed utilization through the use of enzyme products. In Australian Poultry Science Symposium. University of Sydney. ed D. Balnave. pp 1-8.

Chilliard, Y. 1989. Long term effects of recombinant bovine somatotrophin (rBST) on dairy cow performances: a review. Pages 61-87 *in* K. Serjrsen, M. Vestergaard and A. Neimann-Sorensen, eds. Use of somatotrophin in livestock production. Commission of the European Communities. Elsevier Scientific Publishers Ltd., England. .

Chung, T.K. and Baker, D.H. 1992. Apparent and true amino acid digestibility of a crystalline amino acid mixture and of casein: comparison of values obtained with ileal cumulated pigs and caecectomised cockerels. J. Anim. Sci. 70 : 3781-3790.

Classen, H.L. and Campbell, G.L. 1990. Improvement of feed utilization through the use of enzyme products. Pages 1-8 *in* D. Balnave, ed. Australian Poultry Science Symposium. University of Sydney.

Crook, B., Robertson, J.F., Travers-Glass, S.A., Botheroyd, E.M., Lacey, J. and Topping, M.D. 1991. Airborne dust, ammonia, microorganisms and antigens in pig confinement houses and the respiratory health of exposed farm workers. Am. Ind. Hygiene Assoc. 52:271-279.

Curtis, S.E., Hensen, A.H., Simon, J., and Day, D. 1974. Effects of aerial ammonia, hydrogen sulphide and swine house dust, alone and combined on swine health and performance. Proc. of the International Livestock Environment Symposium. Lincoln NE, American Society of Agricultural Engineers. 31:50.

Davis, M. 1991. Enzyme addition to barley based broiler diets. Scottish Agricultural Colleges Poultry Newsletter. January.

Dierick, N.A. 1989. Biotechnology aids to improve feed and feed digestion: Enzymes and fermentation. Arch. Anim. Nutr. 39:241-261.

Donham, K.J. 1989. Relationship of air quality and productivity in intensive swine housing. Agri-Practice. Vol. 10, N° 6 : 15-26

Donham, K.J. 1990. Health effects from work in swine confinement buildings. Amer. J. Indust. Med. 17:17-25.

Donham, K. J., Yeggy, J. and Dague, R. R. 1985. Productions rates of toxic gases from liquid swine manure: Health implications for workers and animals in swine confinement buildings. Biol. Wastes. 24:161-173.

Early, R.J., McBride, B.W. and Ball, R.O. 1990. Growth and Metabolism in somatotropin-treated steers: I. Growth, serum chemistry and carcass weights. J. Anim. Sci. 68:4134-4143.

Easter, R.A. Stein, H.H. and Trottier, N.L. 1993. Use of biotechnology and feed additives. in Nitrogen Flow in Pig Production and Environmental Consequences. Pages 169-182 *in* Proc. First International Symposium on Nitrogen Flow in Pig Production and Environmental Consequences. Wageningen (Doorwerth), The Netherlands.

Edmonds, M.S., Parsons, C.M. and Baker, D.H. 1985. Limiting amino acids in low protein corn soybean meal diets fed to growing chickens. Poult. Sci. 64:1519-1526.

Edwards, H.M.J. 1993. Dietary 1,25-dihydroxycholecalciferol supplementation increases natural phytate phosphorus utilization in chickens. J. Nutr. 103: 567-577.

Elliot, H.A. and Collins, N.E. 1982. Factors affecting ammonia release in broiler houses. Trans. Am. Soc. Agric. Eng. 25:413-418.

Ensminger, M.E. and Olentine, C.G. 1978. Feeds and Nutrition - Complete. The Ensminger Publishing Company. Clovis, CA.

Fancher, B.I. and Jensen, L.S. 1989. Influence on performance of three to six-week-old broilers of varying protein contents with supplementation of essential amino acid requirements. Poult. Sci 68:113-123.

Fédération Européenne des Fabricants d'Adjuvants pour la Nutrition Animale. 1992. Animal nutrition and the environment: possibilities for the reduction of nitrogen and phosphorus pollution caused by animal production. FEFANA, Brussels, Belgium.

Fream, W. 1900. The Complete Grazier (14th Edition). Crosby, Lockwood and Sons. London.

Geraert, P.A., McLeod, M.G., Larbier, M. and Leclercq, B. 1990. Nitrogen metabolism in genetically fat and lean chickens. Poult. Sci. 69:1911-1921.

Gleadthorpe Contract Report. 1989. The effect of drinking system, type and design on broiler performance. Contract reports. C89/0150. p 26.

Goss, M.J., Barry, D.A. and Goorahoo, D. 1993. Impact of animal production on soil and water quality. Pages 108-120 *in* Proc. 29th Nutrition Conference for Feed Manufacturers. University of Guelph and Canadian Feed Industry Association, Guelph, Canada.

Graham, H. 1992. Enzymes for wheat-based diets. Poult. Internat., May. pp 72-77.

Green, S., Bertrand, S.L., Duron, M.J.C. and Maillard, R. 1987a. Digestibilities of amino acids in maize, wheat and barley meals, determined with intact and caecectomised cockerels. Br. Poult Sci. 28::631-641.

Green, S., Bertrand, S.L., Duron, M.J.C. and Maillard, R. 1987b. Digestibilities of amino acids in soyabean, sunflower and groundnut meals, determined with intact and caecectomised cockerels. Br. Poult. Sci. 28: 643-652.

Green, S. and Kiener T. 1989. Digestibilities of nitrogen and amino acids in soyabean, sunflower, meat and rapeseed meals measured with pigs and poultry. Anim. Prod. 48:157-179.

Hacker, R.R. and Du, Z. 1993. Livestock pollution and politics. Pages 3-21 *in* M.W.A. Verstegen, L.A. den Hartog, G.J.M. van Kempen and J. H. M. Metz, eds. Nitrogen Flow in Pig Production and Environmental Consequences: Proc. First International Symposium on Nitrogen Flow in Pig Production and Environmental Consequences. Pudoc Scientific Publishers, Wageningen, The Netherlands.

Health and Safety Executive Guidelines, 1986. *in* Occupational Exposure Limits, 1986. Guidance Note Environmental Hygiene 40/60. Health and Safety Executive Guidelines (London, HMSO).

Hotten, P. 1991. Why consider enzymes as a feed additive. Misset-World Poultry. 7:13-15.

Huisman, J., Verstegen, M.W.A., van Leeuwen, P. and Tamminga, S. 1993. Reduction of N pollution by decrease of the excretion of endogenous N in pigs. Pages 55-61 *in* M.W.A. Verstegen, L.A. den Hartog, G.J.M. van Kempen and J. H. M. Metz, eds.

Nitrogen flow in pig production and environmental consequences: proceedings of the First International Symposium on Nitrogen Flow in Pig Production and Environmental Consequences. Pudoc Scientific Publishers, Wageningen, The Netherlands.

Inborr, J. 1989 Use of supplementary enzymes in pig nutrition. Pages 32-44 *in* Proc. 25th Nutrition Conference for Feed Manufacturers. University of Guelph and Canadian Feed Industry Association.

Inborr, J. and Ogle, R. B. 1988. Effect of enzyme treatment of piglet feeds on performance and post-weaning diarrhoea. Swed. J. Agric. Res. 18:129-133.

Johns, D.C., Low, C.K., Sedcole, J.C. and James, K.A.C. 1986. Determination of amino acid digestibility using caecectomised and intact adult cockerels. Br. Poult. Sci. 27 : 451-462.

Johnson, D.E., Ward, G.M. and Torrent, J. 1992. The environmental impact of bovine somatotropin use in dairy cattle. J. Environ. Qual. 21:157-162.

Johnson, K.A. 1991. Dietary manipulation of the rumen metabolism to minimise methane production. Pages 11-20 *in* Proc. 26th Pacific Northwest Animal Nutrition Conference. Beaverton, OR.

Johnson, R., Williams, P.E.V. and Campbell, R.G. 1993. Use of enzymes in pig production. In Enzymes in Animal Nutrition. Pages 49-60 *in* C. Wenk and M. Boessinger, eds. Proc. First Symposium Kartause Ittingen, Switzerland.

Jouany, J.P. 1994. Methane emission from ruminants: Its contribution to the greenhouse affect and how to control it. *in* Proc. 3rd International Feed Production Conference. Piacenza, Facolta di Agraria (in press).

Keteran, P.P., Batterham, E.S., Dettmann, E.B. and Farrell, D.J. 1993. Phosphorus studies in pigs: Effect of phytase supplementation on the digestibility and availability of phosphorus in soya bean meal for grower pigs. Br. J. Nutr. 70:289-311.

Kies, A., Augier, V., Venuat, M. and Grimaldi, J.L. 1992. Diminution des taux proteiques: Influence sur la qualité d'azote excrété et les performances zootechniques du porc charcutier. Pages 219-226 *in* Proc. 24th Journées de la Recherche Porcine en France.

Koch, F. 1990. Amino acid formulation to improve carcass quality and limit nitrogen load in waste. Pages 76-95 *in* Proc. 6th Annual Carolina Swine Nutrition Conference. Raleigh, NC.

Kotarbinska, M. 1969. Badania nad Przeminana Energii u Rosnacych Swin. Inst. Zootech., Krakow, Wydawn. Wlasne N°238. Cited in The Nutrient Requirements of pigs.

Technical Review by an Agricultural Research Council working party. Commonwealth Agricultural Bureaux. p8.

Leclercq, B. 1989. Possibilités d'obtention et intérét des génotypes maigres en aviculture. INRA Prod. Anim. 2:275-286.

Leclercq, B. and Tesseraud, S. 1993. Possibilités de réduction des rejets azotés en aviculture. INRA Prod. Anim. 6:225-236.

Lei, X.G., Ku, P.K., Miller, E.R., Yokoyama, M.T. and Ullrey, D.E. 1994. Calcium level affects the efficacy of supplemental microbial phytase in corn-soyabean meal diets of weanling pigs. J. Anim. Sci. 72:139-143.

Low, A.G. and Longland, A.C. 1990. Carbohydrate and dietary fibre digestion in the pig and the possible influence of feed enzymes. Feed Compounder. 10:37-42.

Moal, J.F. 1994. Mise en évidence des émissions ammoniacales issues des apandages de lisier en Bretagne. *in* 26èmes Journées de la Recherche Porcine en France. Institut Technique du Porc. Institut National de la Recherche Agronomique. France.

Mroz, Z., Jongbloed, A.W. and Kemme, P.A. 1994. Apparent digestibility and retention of nutrients bound to phytate complexes as influenced by microbial phytase and feeding regimen in pigs. J. Anim. Sci. 72:126-132.

Muirhead, M.R. 1986. Effects of the major infectious diseases on food conversion efficiency and growth rates on a herd basis. Page 19 *in* P.R. English, V.R. Fowler, S. Baxter and B. Smith. eds. The growing and finishing pig. Farming Press Ltd. Ipswich, UK. 1988.

Nasi, M. 1990. Microbial phytase supplementation for improving availability of plant phosphorus in the diet of the growing pig. Fin. J. Agric. Sci. 62:435-443.

Neilsen, C. 1990. Assessing the problems and market opportunities. From Prevention of Noxious Gasses. Seminar at Terrington Experimental Husbandry Farm, May 2, 1990. Kings Lynn, Norfolk, United Kingdom.

O'Connor, J.D., Sniffen, C.J., Fox, D.G. and Chalupa, W. 1993. A net carbohydrate and protein system for evaluating cattle diets; IV. Predicting amino acid adequacy. J. Anim. Sci. 71:1298-1311

Oyetunde, O.O.F., Thomson, R.G. and Carlson, H.C. 1976. Aerosol exposure of ammonia, dust and *Escherichia Coli* in broiler chickens. Can. Vet. J. 19:187-193.

Pain, B. F. 1990. Reported in Stock Magazine, United Kingdom. Vol. 3, N° 4. p. 4.

Pain, B.F., Phillips, V.R., Clarkson, C.R. and Klarenbeek, J.V. 1989. Loss of nitrogen through ammonia volatilization during and following the application of pig or cattle slurry to grassland. J. Sci. Food Agr. 47:1-12.

Pain, B.F., Thompson, R.B., Rees, Y.J. and Skinner, J.H. 1990. Reducing gaseous losses of nitrogen from cattle slurry applied to grassland by the use of additives. J. Sci. Food Agr. 50:141-153.

Pen, J., Verwoerd, T.C., Paeidon, P.A., Beudeker, R.F., van den Elzen, P.J.M., Geerse, K., van der Klis, J.D., Versterh, H.A.J., van Ooyen, J.J. and Hoekema, A. 1993. Phytase-containing transgenic seeds as a novel feed additive for improved phosphorus utilization. Bio/Technology 11:811-814.

Petterson, D., Graham, H. and Aman, P. 1991. The nutritive value for broiler chickens of pelleting and enzyme supplementation of a diet containing barley, wheat and rye. Anim. Feed Sci. Technol. 33:1-14.

Pointillart, A., Colin, C., Lacroiz, C. and Radisson, J. 1993. Réduction chez le porc en croissance de la supplémentation en phosphore minéral par l'utilisation de céréales à activité phytasique élevée. Proc. 25thJournées Recherche Porcine en France. 25:233-238.

Quiniuo, N., Dourmand, J.Y., Henry, Y., Bourdon, D. and Guillou, D. 1994. Influence du potentiel de croissance et du taux protéique de régime sur les perfomances et les rejects azotés des porcs en croissance-finition, alimentés á volonté. Proc. 26th Journées Recherche Porcine en France. 26:91-96.

Robert, J.C., Sloan, B.K. and Denis, C. 1994. The effect of protected amino acid supplementation on the performance of dairy cows receiving grass silage plus soybean meal. Anim. Prod. (abs; in press).

Robertson, J.F. 1992. Environmental and energy aspects of livestock housing. Pages 46-53 *in* Seminar of the 2nd Technical Section of the International Commission of Agriculture Engineering. Polanica, Poland.

Robertson, J.F., Wilson, D. and Smith, W.J. 1990. Atrophic rhinitis: the influence of the aerial environment. Anim. Prod. 50:173-182.

Rotter, B.A. 1990. The future of crude enzyme supplements in pig nutrition. Pig News and Information. 11:15-17.

Rotter, B.A., Marquarde, R.R. and Guenter, W. 1989. Optimising responses from enzymes in poultry and pig diets: New methods for ensuring response. Pages 149-159 *in* T. P. Lyons, ed. Biotechnology in the Feed Industry. Proc. Alltech Fifth Annual Symposium. Alltech Technical Publications, Nicholasville, KN.

Rulquin, H., Hurtaud, C. and Delaby, L. 1993. Effects of dietary protein level on lactational responses of dairy cows to rumen protected methionine and lysine. 8th Journées des Recherches sur l'alimentation et la Nutrition des Herbivores. Annual Booklet.

Rulquin, H., Pisulewski, P.M., Vérité and Guinard J. 1994. Milk production and composition as a function of postruminal lysine and methionine supply: A nutrient response approach. Livest. Prod. Sci. (in press).

Rylander, R., Donham, K.J., Hjort, C., Brouwer, R. and Heederik, D. 1989. Effects of exposure to dust in swine confinement buildings - a working group report. Scand. J. Work Environ. Health. 15:309-312.

Schaefer J. 1977. Sampling, characterization and analysis of malodours. Agric. Environ. 3:121-127.

Schutte, J.B. 1987. Utilization of synthetic amino acids in poultry. Pages 11-12 *in* Proc. 6th European Symposium on Poultry Nutrition. Kouriglutter.

Shepherd, M. 1990. Over winter leaching of nitrates following application of manure - Site report for winter 1989/90. ADAS Internal Report on Experimental Code SC01/008.

Simmons, P.C.M., Versteegh, H.A.J., Jongbloed, A.W., Kemme, P.A., Slump, P., Bos, K.D., Wolters, M.G.E., Buedeker, R.F. and Verschoor, G.J. 1990. Improvement of phosphorus availability by microbial phytase in broilers and pigs. Br. J. Nutr. 66:525-540.

Spoelstra, S.F. 1978. Microbial aspects of the formation of malodorous compounds in anaerobically stored piggery wastes. Ph.D. Thesis. Laboratory of Microbiology, Agricultural University, Wageningen, The Netherlands.

Stombaugh, D.P., Teague, H.S. and Roller, W.L. 1969. Effects of atmospheric ammonia on the pig. J. Anim. Sci. 28:844-847.

Strauch, D. 1987. Hygiene of animal waste management. Pages 155-202 *in* D. Strauch, ed. Animal Production and Environmental Health.

Tanksley, T.D. and Knabe, D.A. 1984. Formulation of swine grower diets on a digestible lysine basis. J. Anim. Sci. 61(Suppl 1):323. (Abstr).

Van Nevel, C.J. and Demeyer, D.I. 1988. Manipulation of rumen fermentation. Pages 387-443 *in* P. N. Hobson, ed. The Rumen Microbial Ecosystem. Elsevier Scientific Publishers Ltd. London, England.

Venables, K.M., Topping, M.D., Howe, W., Luczynska, C.M., Hawkins, R. and Newman Taylor, A.J. 1985. Interactions of smoking and atopy in producing specific IgE antibody against a hapten protein conjugate. Br. Med. J. 290:201-204.

Verité, R. and Peyraud, J.L. 1989. Protein: the PDI system. In Ruminant Nutrition: Recommended Allowances and Feed Tables. (ed. R. Jarrige). John Libbey Eurotext, Paris, France. pp. 33-47.

Voorburg, J.H. 1986. Odour research in ammonia volatilization. Pages 27-42 *in* V.C. Nielsen, J.H. Voorburg and P. L'Hermite, eds. Odour prevention and control of organic sludge and livestock farming. Elsevier Scientific Publishers Ltd. London, England.

Voris, J.C. 1992. Development of poultry guidelines to regulate interface with neighbours. J. Appl. Poult. Res. 1:110 -116.

Waldroup, P.W., Mitchell, R.J., Payne, J.R. and Hazen, K.R. 1976. Performance of chickens fed diets to minimize levels of essential amino acids. Poult. Sci. 55:43-253.

White, W.B., Bird, H.R., Sunde, M.L., Marlett, J.A., Prentice, N.A. and Burger, W.C. 1983. Viscosity of b-D-glucan as a factor in the enzymatic improvement of barley for chicks. Poult. Sci. 62:853-862.

Whyte, R.T. 1993. Aerial pollutants and the health of poultry farmers. World's Poult. Sci. J. 49:139-156.

Williams, P.E.V. 1993. Animal production and European pollution problems. Pages 68-83 *in* Proc. 29th Nutrition Conference for Feed Manufacturers. University of Guelph and Canadian Feed Industry Association, Guelph, Canada.

Williams, P.E.V., Pagliani, L., Innes, G.M., Pennie, K., Harris, C.I. and Garthwaite, P. 1987. Effects of the beta-agonist (Clenbuterol) on growth, carcass composition, protein and energy metabolism of veal calves. Br. J. Nutr. 57:417-428.

Wolin, M.J. and Miller, T.L. 1988. Microbe-microbe interactions. Pages 343-359 *in* P. N. Hobson, ed. The Rumen Microbial Ecosystem. Elsevier Scientific Publishers Ltd. London, England.

Zhu, X.S., Seib, P.A., Allee, G.L. and Liang, Y.T. 1990. Preparation of a low-phytate feed mixture and bioavailability of its phosphorus to chicks. Anim. Feed Sci. Technol. 27:341-351.

L'IMPACT ENVIRONNEMENTAL DE L'UTILISATION NON ALIMENTAIRE DES HUILES VEGETALES ET DE LEURS DERIVES

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Depuis plus d'une dizaine d'années, SOFIPROTEOL, l'établissement financier de la filière oléagineuse-protéagineuse, s'est engagé dans le secteur des utilisations non alimentaires des huiles végétales.

Je voudrais ici, compte tenu de cette expérience, vous présenter, à l'aide de quelques exemples significatifs, l'impact favorable que peut avoir sur l'environnement une filière maîtrisée au plan agricole et conduisant à des produits non toxiques et biodégradables. J'évoquerai les contraintes rencontrées et les mesures politiques nécessaires à l'émergence d'une telle filière.

Mon premier exemple sera bien entendu le Diester (biocarburant constitué d'Esters Méthyliques de Colza) puisque c'est le produit le plus connu, celui qui mobilise le plus d'hectares et celui dont le parcours est le plus représentatif.

Au début des années 1980, la filière oléagineuse française a cherché des débouchés pour le million de tonnes d'huile de colza non utilisé en Europe. Il ne s'agissait pas de réduire cette production car, d'une part, le colza est une excellente tête d'assolement en Europe et, d'autre part, notre déficit communautaire en matières riches en protéines s'élevait à 66 %.

Les voies prospectées pour accroître la consommation d'huile de colza furent :

- la reconquête du marché intérieur, surtout auprès des collectivités et des industries agro-alimentaires ;
- la reprise de nos marchés traditionnels dans les pays du Maghreb ;
- et enfin, les usages non alimentaires avec, en premier lieu, le secteur carburant car c'est celui qui représente le plus vaste débouché.

Nous pensions, dans un premier temps, attaquer ce marché avec de l'huile, mais les motoristes, les pétroliers et l'Institut Français du Pétrole (IFP) nous ont fait comprendre que pour avoir un carburant végétal banalisé, il fallait passer par la voie de la transestérification.

Ceci s'est donc traduit, en partenariat avec l'IFP, vers les années 1985, après les travaux de laboratoire, par la mise en place au sein de la société ROBBE à Compiègne, d'un réacteur pilote de 1 m^3 avec une contribution financière de l'ADEME.
Ce pilote a permis d'optimiser le procédé.

En 1988, deuxième phase avec la modification, toujours chez ROBBE, d'un réacteur de 15 m^3 dédié aux résines pour produire des quantités importantes d'esters destinées aux premiers essais de roulage sur flotte.

Lorsque la réforme de la PAC est survenue en 1992 avec son obligation de gel des terres, la filière oléagineuse était techniquement prête dans cette voie Diester.
Ainsi, dès le printemps 1993, l'unité de démonstration de ROBBE, d'une capacité de 20.000 tonnes, était en démarrage et elle fut pleinement opérationnelle à l'automne 1993.

Afin de banaliser le Diester à 5 % dans le gazole, un vaste programme expérimental, coordonné par l'IFP, auquel participaient les motoristes (Renault, Peugeot et Renault Véhicules Industriels), les pétroliers (Elf et Total), les Ministères de l'Agriculture et de l'Industrie, ainsi que l'ADEME et la filière oléagineuse française, fut lancé.
A l'intérieur de ce programme, mais également en dehors dans un cadre européen et communautaire (GEIE EUROBIODIESEL), de nombreuses mesures de polluants réglementés et non réglementés ont été réalisées. Il en ressort un consensus européen que l'on peut résumer ainsi :

Réduction des émissions atmosphériques:

- oxydes de soufre (SOx)
- dioxyde de carbone (CO_2)
- hydrocarbures
- particules

Par ailleurs -et c'était une première-, la filière oléagineuse a fait réaliser par la société ECOBILAN une analyse du cycle de vie du Diester du berceau à la tombe. Les principales conclusions sont les suivantes :

Effet de serre:

L'impact d'un véhicule léger roulant au Diester est de quatre à six fois inférieur à celui de la filière gazole ; l'impact d'un bus roulant au mélange de 30 % de Diester dans le gazole est inférieur de près de 25 % à celui d'un bus roulant au gazole.

Acidification de l'atmosphère:

L'impact de la filière Diester sur l'acidification de l'atmosphère est inférieur de 30 % à celui de la filière gazole.

Epuisement des ressources naturelles:

Compte tenu du cycle très long de renouvellement du carbone fossile, les réserves de pétrole font partie des ressources dites non renouvelables. Elles sont estimées à environ 40 ans au rythme actuel de la consommation. De ce point de vue, l'utilisation du Diester pur contribue près de quatre fois moins que la filière gazole à l'épuisement des ressources renouvelables.

La réforme de la PAC (aide à l'hectare et non au quintal de produit), les données de l'écobilan sur les dépenses énergétiques liées au engrais azotés, le souci de préserver l'environnement, ont conduit la Fédération Française des Producteurs d'Oléagineux et de Protéagineux (FOP) et le Centre Technique Interprofessionnel des Oléagineux Métropolitains (CETIOM) à élaborer une Charte de l'Environnement pour la conduite culturale des colzas énergétiques. Le dispositif de cette charte comporte trois volets :

1. Diffusion de règles générales de la conduite du colza d'hiver sur jachère agro-industrielle :

- Semer tôt pour favoriser la croissance d'automne et piéger les nitrates présents dans le sol avant l'hiver.
- Raisonner la protection de la culture pour éviter toute application inutile, sans prendre de risque majeur du point de vue économique comme du point de vue écologique.
- Contrôler les principales adventices en tolérant la présence de mauvaises herbes qui ne menacent pas sérieusement le potentiel, et le salissement ultérieur de la parcelle.
- Raisonner la fertilisation azotée : adaptation des doses en fonction des besoins et des fournitures du sol, fractionnement en 2 ou 3 apports, le premier étant postérieur au 15 janvier.
- Favoriser les repousses de colza pendant l'été dans les parcelles où l'azote risque d'être excédentaire (rendement du colza très faible ou engrais azoté excessif).

2. Diffusion des préconisations régionales et de conseils de saison par le CETIOM et ses partenaires (Services régionaux de la Protection des Végétaux, Coopératives, Négoces, Chambres d'agriculture...).

3. Enregistrement par l'agriculteur des conduites pratiquées sur chaque parcelle, facilitant l'élaboration de plans de fumure et l'établissement de bilans d'azote.

Ces techniques qui, indiscutablement, préservent l'environnement, ne concernent plus de manière exclusive les colzas énergétiques, mais ont été étendues aux colzas alimentaires.

Je ne reviendrai pas ici sur la fameuse polémique soulevée il y a 3 ou 4 ans par les écologistes allemands au sujet du protoxyde d'azote, les derniers résultats de l'INRA montrent qu'à l'évidence, leurs hypothèses étaient fausses.

Depuis 1993, les cultures de colza destinées au Diester ont connu un développement important lié à la mise en place d'outils de transestérification :

EVOLUTION DE LA JACHERE INDUSTRIELLE
COLZA EMC

	SURFACE (ha)
. Récolte 1993	**36 500**
. Récolte 1994	**128 400**
. Récolte 1995	**265 500**

Ceci a été rendu possible, outre par l'engagement des producteurs agricoles, par des mesures réglementaires et fiscales prises par les Pouvoirs publics français.

Au niveau réglementaire, compte tenu des résultats positifs obtenus dans la vaste expérimentation déjà évoquée, les Pouvoirs publics ont décidé de banaliser les Esters Méthyliques de Colza à 5 % dans le gazole et le FOD. Des taux d'incorporation supérieurs peuvent être obtenus après accord des ministères concernés.

Au plan fiscal, les Esters Méthyliques de Colza sont exonérés de la TIPP gazole plafonnée à 2,30 F/litre. Cette disposition fiscale n'est pas un don du monde politique au monde agricole. Une filière Diester génère en effet des externalités positives qui créent des recettes pour l'Etat.

On peut citer, sans être exhaustif :

- l'amélioration de la balance commerciale
- une moindre dépendance en produits pétroliers et en tourteaux
- la création ou le maintien d'emplois (10 emplois pour 1000 tonnes)
- un moindre effet de serre
- un impact positif sur la santé humaine.

Actuellement, une double stratégie commerciale est mise en oeuvre sur le Diester :

- vente banalisée à 5 % : les bienfaits environnementaux portent alors sur les bilans globaux CO_2 et Soufre.
- flottes captives à 30 % : s'ajoutent aux points précédents la baisse des émissions de particules et de HAP (Hydrocarbures Aromatiques Polycycliques).

Aussi, le Diester, par la mise en place de techniques culturales propres à la campagne, protège-t-il l'air des villes.

Si le Diester, comme je l'ai dit, est l'exemple le plus représentatif, il n'est pas le seul que peut présenter la filière oléagineuse.

Les agriculteurs, afin de réduire les doses de produits phytosanitaires, utilisent des huiles adjuvantes. Ces huiles ont longtemps été issues du domaine pétrolier et contenaient des produits aromatiques (xylène) toxiques pour celui qui les manipule et désastreux pour l'environnement. La société ROBBE a donc mis au point une formulation (ACTIROB B) à base d'Esters Méthyliques de Colza. Ces esters sont non toxiques et même reconnus comme alimentaires par la Food and Drug Administration. Ils sont évidemment écocompatibles et totalement biodégradables en 21 jours. Ainsi, au niveau de l'agrofourniture, les dérivés d'huile peuvent élégamment se substituer aux produits pétroliers.

Autre exemple : le secteur des lubrifiants : sur 4,5 millions de tonnes consommées annuellement en Europe, 1.140.000 tonnes sont perdues dans la nature et polluent le sol et les nappes phréatiques.

Pour certaines applications lubrifiantes (huiles de démoulage, de coupe, de chaînes de tronçonneuses, de fluides hydrauliques, de moteurs deux temps), des succédanés végétaux (huiles polymérisées, dimères, esters de polyols) existent déjà ou sont en cours de développement.

Bien évidemment, leurs prix sont supérieurs à des produits de base issus de la pétrochimie. La protection de l'environnement a également un coût.
Certains pays nordiques (Suède, Finlande), ainsi que l'Allemagne, ont déjà pris des dispositions réglementaires dans ce sens. Une réglementation européenne dans ce sens s'impose et les politiques devraient nous permettre de l'obtenir.

Nous pourrions multiplier les exemples dans d'autres secteurs (détergents, anti-poussières) : tous montreraient les bienfaits environnementaux des produits dérivés des oléagineux.

Ainsi, si des procédés chimiques propres sont mis en oeuvre sur des huiles issues d'itinéraires culturaux optimisés au point de vue environnemental, la filière oléagineuse peut proposer des produits non toxiques, écocompatibles et biodégradables.

ENVIRONMENT & PLANT BIOTECHNOLOGY

André d'Olne
Consultant

Over centuries, the amelioration of species has enabled humanity to feed itself in the face of an ever expanding population. Breeding has been practiced since the neolithic times and in an increasingly scientific way over the last two centuries. Techniques have evolved fast and deep, resulting in the much modified varieties which now feed 95% of the world's needs. The latest steps in this chain of innovations have been the various techniques known as biotechnology.

Much debated lately and unduly charged with many unproven maledictions, plant varieties improved by biotechnology are no more modified than in the ratio of an ameliorated gene implanted in the original 50,000 expressing genes of the plants, i.e. that for all practical purposes the plant is unchanged but for the very specific advantages it has now acquired.

Against this beneficent background genuine fears have arisen lately due to the lack of information or through deliberate manipulation of facts by politically driven opponents. The legitimate wish of some to be informed has thus been swamped by massive misinformation on a worldwide scale, much amplified by sensation seeking media.

The fact of the matter remains that the need of continuously improved techniques for improved breeding, i.e., at lower economic costs and friendlier ecological impact, is an absolute prerequisite to feed the world in the emerging 21st century. To regulate fairly and explain clearly is one thing, but to hold up through excessive and inadequate actions a vital necessity for humanity is quite another.

Plant genetic improvements are based on new, but nonetheless evolutionary, scientific concepts developed and applied essentially over the last decades. Their aims are very specific, clearly focused and are generally to either substitute themselves or complete current agronomic systems and practices. These improvements, based on plant breeding improvements, initially took place in Western Europe and North America, but their applications are developing now and will soon spread to all agricultural countries.

Albeit improvements in terms of plant modification are minute, and not visible (adding one expressing gene to an expressing plant genome of about 50.000 genes), specific regulatory pathways have been devised to ensure the three essential and traditional criteria of QUALITY, SAFETY, and EFFICACY.

Unfortunately, over the last couple of years the trend in Western Europe has been to impose to improved plants an enormously bureaucratic and costly system which is threatening the viability of future plant development in the European Union. In the USA, while having initially set regulatory targets at a very high level, authorities have gradually been relaxing their requirements, as experience with plants/genes specific combinations were being tested without observable negative side effects.

The detailed system (90/220 et al) required in the EU is characterized by the following handicaps:

1 - They have initially been devised for single molecules of micro organisms, i.e. industrial products. Such systems have only been "adapted" to plants as an after thought. The system does <u>not</u> fit the unavoidable requirements of plant breeding.
2 - They are overly complex, have long time delays which plants cannot afford (there is only one sowing period in any given year).
3 - They flout the basic principles of the SINGLE EUROPEAN ACT and the MAASTRICHT TREATY which should allow one access to the EU market, and not a doubling up of centralized regulatory bodies multiplied by the 15 national

competent authorities. The much heralded concept of “one door, one key” is, in fact, pure window dressing.

4 - Finally, inter-directional configurations result in significant overlapping of regulatory processes between DG XI/Environment for 90/220, DG III/Industry for Food Safety and DG VI/Agriculture for Varietal Registration and Feed Safety.

Prospects for the years ahead are not optimistic. They indicate a growing chasm between the regulatory systems for improved plants of Western Europe and the USA. Since virtually all seeds companies and plant breeders in the world are now developing genetic techniques for plant improvements, we are facing an impending crisis in what is essentially one single world market.

There is an urgent need for the European Union and the USA to recognize and accept one anothers products approval. In the longer term, the European Union needs to go back to basics and redesign plant regulatory systems which are scientifically, politically and economically compatible with their objectives. Current projected so-called “simplifications” are getting nowhere and result in yet more layers of regulation differentiation. Radical change is needed and collaboration with the seed world, rather than confrontation is a needed objective.

Should regulatory authorities fail to see the impasse in which modern plant breeding and agriculture are heading, such worldwide issues might eventually become a major topic of attention for the World Trade Organization.

HOW IS AGRIBUSINESS RESPONDING TO THE ENVIRONMENTAL CHALLENGE?

Robbin S. Johnson
Cargill, Incorporated

This seminar is organized around a tantalizing question: How can agriculture feed the world without harming the environment? The answer is relatively straightforward:

- sound science
- good management
- correct policies

Sound Science

Science holds the key to a number of agricultural challenges for the 21st century.

- It must increase the output per unit of input, so we can feed more people better while using less land and other scarce resources per person;
- It must unlock new uses for marginal lands that cannot produce annual row crops in an environmentally sound manner;
- It must open up new uses for renewable raw materials from agriculture, both to stretch our natural resources and to limit the environmental harm from finding and exploiting them.

What we can see emerging from laboratories is very promising. For example, there is a new movement in the United States that can change farming by the field to farming by the foot. It uses extensive soil testing, global positioning satellite technology and computer mapping and control techniques to vary inputs according to the needs of

small pieces of a field. Farmers can get more output at lower input costs, and the environment will suffer less runoff or seepage of damaging chemicals.

New uses for marginal lands is a frontier of knowledge that can build on already large gains in scientific land management. Between 1982 and 1992, for example, conservation tillage practices in the U.S. farm belt cut sheet and rill erosion 25 percent, or one ton per acre. Fast growing tree crops for pulp or energy can grow well in flood plains, need less pesticide and fertilizer, hold soil better and provide wildlife habitat.

New uses of crops also are being unlocked by sophisticated fermentation technologies. Between 1925 and 1989, plant material's share of the industrial use market was reduced from 30 to 16 percent, largely displaced by petroleum as a feedstock. Biobased materials are now beginning to make a comeback. Uses such as feedstocks for chemicals, corn-based plastics and biofuels are growing. Plant-based products still are generally more costly than petroleum-based materials, but technology will continue to eat into those cost differences. And plant-based materials often have other advantages, such as biodegradability.

In other words, part of agriculture's ability to feed people better yet respect the earth's resource base turns on the secrets science can unlock. Increased productivity, better land use and new products are all parts of this cornucopia.

Good Management

Alongside sound science are improving management practices. More sophisticated management practices in the United States, for example, have increased

nitrogen efficiency by one-fifth and reduced crop protection chemical use one-third in the last 15 years, even as crop output has risen by one-fourth.

But the role of good management is much larger. In fact, the role that agribusiness increasingly will play in the world food system is to improve management of production, storage, transport, processing and preparation of foodstuffs. That will mean:

- reduced pre- and post-harvest losses
- more efficient use of energy
- reduced presence of unwanted toxins, saturated fats and bacteria
- increased safety, convenience, healthfulness and nutrition in our diets

Some examples may help to make the point:

- Food processing plants have reduced wastes and emissions well below the energy consumption and waste associated with preparation of food in the home.
- Steam pasteurization techniques Cargill has helped develop can remove 99.9 percent of the bacteria on fresh meat carcasses.
- New oilseed hybrids permit manufacture of vegetable oils with less transfatty acids.

Good management practices also are having global effects. More efficient transportation systems and better functioning global markets have reduced the risk of famine and enabled the world to handle crop fluctuations with lower stocks. Since it

costs about one-fifth of grain's value to carry it from one year to the next, this is a huge gain not just in food security but also in feeding efficiency.

Similarly, multinational companies (MNCs) are investing to develop agricultural marketing and processing infrastructure in developing countries. This raises income prospects for the rural poor while lightening the food budget burdens of a rapidly urbanizing world. Also, MNCs take their worker safety, environmental protection and food safety knowledge and practices to these developing countries along with their capital. This is raising safety and environmental standards of the developing world far more rapidly than occurred in the already industrialized regions.

So, good management is reducing waste and improving food quality, as well as spreading these practices globally.

Correct Policies

For science and management to work best, they need to respond to the right incentives. For much of the world, the incentives that drive food production are still heavily managed -- and distorted -- by governments.

Governmental policies can and do:

- promote excessive production of protected crops;
- discourage rotation and diversification in favor of monoculture;
- distort trade and investment flows, often disadvantaging agricultural development in poorer countries;

- erect barriers to scientific progress and market liberalization on the basis of poorly evaluated or misguided risk assessments.

Again, some examples illustrate the problem:

- High production subsidies for grains have resulted in excessive stocks and subsidized disposal of surpluses in some years, supply controls and excessively tight supplies in other years; these practices destabilize the food system, distort trade and reduce overall global welfare by a quarter of a trillion dollars;
- Some segments of the food sector get protected at the expense of other sectors, retarding economic development and aggravating income inequities unnecessarily;
- Society worries about pesticide residues at levels well below naturally occurring toxins;
- Food borne pathogens in raw meat that will be killed by cooking attract more concern than risks associated with food products that will be consumed without further processing;
- We systematically undervalue the risks of malnutrition associated with raising food costs through regulation.

Progress in society's approach to regulation is occurring. More allegiance is given to fact-based decision-making. More attention is being devoted to cost/benefit analyses. More reliance is being placed on market forces and consumer choices than command-and-control. But, this regulatory progress is far from where it needs to be.

Similarly, the recent Uruguay Round finally capped rising levels of agricultural protection and began a process of liberalization. But such reforms need to be continued beyond this tentative start. And frankly, they need to be accelerated, if we are to meet the challenge posed in the title to this seminar.

Conclusion

So, my answer is that agriculture can feed people better and protect the environment. Agribusiness will play a key role in advancing food science and globalizing sound management practices. How quickly this progress is achieved probably turns mainly on how soon sound food and agriculture policies are put in place.

HOW IS AGRICULTURE RESPONDING TO THE ENVIRONMENTAL CHALLENGE?

Claudio Rocchietta
Novaol

I would like to take this opportunity to look at the development of new agricultural products and the importance of government policy. I would like to focus on biofuels as a way of illustrating some of the points.

- Within the Eridania Béghin-Say group we have a long experience in the development of new agricultural products. My own company, Novaol, has in particular been involved in the use of agricultural products as a source of renewable fuels. In Europe we are currently producing about 150,000 T/Y of "biodiesel" which is made from the esterification of rape and sunflower oils.
- The EEC has been a strong promoter of the development of biodiesel and biofuels in general.
- The major reasons are: environmental (e.g. reduced CO2 output), political (alternative sources to fossil fuels), social (industrial uses of set aside areas to maintain jobs in agriculture).
- EEC directives were introduced that promoted investment in biodiesel plants and gave member states the opportunity to develop biofuels by exempting them from mineral oil taxes.
- The use of set aside production for biofuels has provided the industry with competitive priced raw material and enabled the farmer to maintain production and have added income.
- As a result of these factors, our own group (and others) invested heavily in R&D and biodiesel production plants. Today it is fair to say that biodiesel has been demonstrated to be a viable technical alternative to fossil fuel. There are many environmental advantages (e.g. CO2 balances, biodegradable). This has led to major car manufactures promoting the use of biodiesel.

Despite this promising start, today these same companies find themselves facing a very unclear future.

- The EEC directive regarding biofuels has been interpreted and implemented in different ways at the national level leading to problems in the free flow of goods both for raw materials and finished products. Existing tax exemptions could be reduced/modified at any time leading the write off of significant investments.
- Some governments are still unconvinced about the cost benefits of biodiesel and are therefore reluctant to exempt it from mineral taxes.
- Biodiesel has been the major outlet for set aside oilseed oil. These areas are being reduced leading to a potential problem with raw material sourcing.
- These negative factors are added to a growing consumer demand for biodiesel.

What can be done?

- Government policy should be clear and coherent. For example, to evaluate the feasibility of biodiesel the minimum plant size that is economically feasible is 50,000T and requires an investment of around $30 million. The pay back period is many years. It is clear that to be interesting for a private investor the political risk associated with the investment should be minimal, e.g. the period for which biofuels will be exempt from mineral oil taxes should be clear from the outset.
- Agricultural materials are traded internationally. Any EEC policy must as a minimum ensure a free flow of goods within the community. Otherwise the diseconomies of scale are enormous and the additional transport costs etc. defeat the objective of biofuels.
- Policies that lead to a development of consumer demand that cannot then be met are unacceptable and damaging to the development of alternative environmental strategies.

- The objectives of government policy should be clear and supporting legislation coherent with these objectives. Two examples come to mind:

The use of biofuels would lead to reduction in CO2 output. To meet existing and planned CO2 reductions targets there is a debate as to whether or not biodiesel is a viable option. If, however, the CO2 targets are reduced further (as planned) reducing pollution from gasoil becomes very expensive compared to using biodiesel i.e. the balance swings strongly in favour of biodiesel.

Biofuels and biolubricants are biodegradable and offer strong benefits on inland water ways. Gasoil on inland waterways is generally taxed at a very low level, therefore biofuels are not competitive in the very area where they offer the most advantage! Given the high level of pollution in inland water ways it would seem sensible to promote biofuels either by legislation or higher taxes on the polluting alternative (e.g. in Austria fuels used in national parks must be biodegradable).

Once investments to develop new agricultural products have been stimulated, further modifications to agricultural policy should bear in mind these investments (e.g. biodiesel was promoted to use set aside production yet these areas are now being reduced with the risk on the private investor).

I should be explicit with the case of biofuels, if some of the uncertainties above were realized it does not mean a reduction in profits but the write off of projects that are already working on very tight margins with long pay back periods. The message is clear, industry is prepared to invest in the development of new products and to undertake the industrial risks - which are often large when entering new markets and facing major established competitors. It is reasonable to expect that political risk is reduced as much as possible (though it will never be eliminated) by clear thinking government policies that at least define the objectives and keep the goal posts fixed for a period of time.

AGRICULTURE AND THE ENVIRONMENT IN THE 21ST CENTURY
HOW IS THE WTO ADDRESSING ENVIRONMENTAL CONCERNS?

Richard Eglin
Trade and Environment Division, WTO Secretariat[1]

When Trade Ministers approved the results of the Uruguay Round negotiations in Marrakesh in April 1994, they also took a Decision to begin a comprehensive work programme on trade and environment in the World Trade Organisation (WTO). Their Decision ensured that the subject of trade and environment is being given a high profile on the WTO agenda.

Reaching consensus to begin this new work programme was a difficult process, and many aspects of the subject remain highly controversial within the trading community. It was the EFTA countries which first proposed in 1990 that trade and environment policy linkages should be examined in GATT. Their proposal, which was far more modest in scope than what was agreed on in Marrakesh, was met nevertheless with considerable hesitancy by many GATT Contracting Parties. Some felt OECD governments were over-reacting to pressure from vocal "green" lobbies to pursue environmental goals at every opportunity and at any cost. Some worried that the subject was a threatening new manifestation of protectionism. Doubts of that kind were widespread then, and in several respects they are still much in evidence now.

The fact that it proved possible to put the doubts to one side in Marrakesh reflects the extent to which confidence about this issue has built up among GATT Contracting Parties. That is due in part to a successful phase of preparatory work in GATT which confirmed that the subject represents a complex area of policy linkages which demands attention and involves the responsibilities of all members of the trading system.

[1]The views expressed should not be attributed to the WTO Members.

The change of attitude warrants a few more words of explanation than that, however, since governments are now entering a much broader debate, and potentially in due course a negotiation in this area, each with its own views on where its national interests lie, how these can be advanced through the WTO, and what might constitute a balanced result. Understanding the stakes that are involved can be helpful in drawing up realistic expectations of what the work programme can achieve and how the process can best be moved forward. During the next few years the WTO must establish its credentials as the successor to the GATT in managing the multilateral trading system responsibly and effectively. Its handling of the trade and environment work programme will be viewed critically from many points of view as a gauge of its success.

Background to the Marrakesh Decision

One of the most influential factors in forging the basis for a common approach to the subject of trade and environment, particularly between developed and developing countries, has been the elaboration of the concept of "sustainable development." This has replaced the "limits to growth" paradigm that was popular in the 1970s, through which economic growth was viewed as being part of the problem of environmental degradation, not part of the solution. Making development sustainable means inter alia ensuring that economic growth goes hand in hand with better environmental protection, and it has become a fundamental starting point in debate about the links between trade and environment. That came out clearly from the UN Conference on Environment and Development. Crudely put, the formula for tackling environmental problems cooperatively with the full participation of developing countries and for addressing the high adjustment costs associated with achieving sustainable development is through financial transfers, technology transfers and open markets -- in other words improving the quality of economic growth, but not reducing its quantity.

The goal of sustainable development is stated several times in the Marrakesh Decision on Trade and Environment, and it will act as an important political parameter as well as one of the most challenging technical aspects of the WTO work programme.

Whatever recommendations are arrived at in the WTO, they must satisfy the criterion that they will advance economic policy objectives in member countries. The way in which this helped forge the consensus in Marrakesh is that trade liberalisation is accepted as an essential, even if not a sufficient element of policies to achieve better environmental protection and sustainable development. Further liberalisation of international trade flows, both in goods and services, has a key role to play: as a generator of foreign exchange earnings and wealth that can be used to help pay for environmental clean-up; as a more efficient allocator of resources, including environmental resources, to allow the same level of output to be produced at less resource cost; and in removing restrictive trade policies that also impact adversely on the environment. The extent to which the WTO work programme succeeds in building on the momentum created by the Uruguay Round for more liberal and competitive international trade will be a carefully watched indicator of its success in balancing trade, environmental and development objectives.

The other side of the coin, of course, will be an examination in the WTO of whether and what the proper role for trade restriction might be in protecting the environment. In this context claims are often made that there is an inherent tension and even conflict between trade and environmental policy objectives, and that the GATT/WTO rules stand in the way of environmental policy-making. However, it will not do simply to join the populist debate, which has been engaged time and again in the past few years to very little avail, about whether the GATT needs "greening." The questions that must be addressed are when are trade restrictions efficient and effective policy instruments to address environmental problems, and what are the economic costs of using them for this purpose? Those questions must be answered convincingly if the WTO work programme is to make headway. In practical terms restricting trade is never costless, and recent economic history is replete with examples of abandoned experiments in restricting trade that failed to live up to expectations. It would be a tragic mistake, from the point of view of the environment and the trading system, to jump blindly to the conclusion that trade restriction can be a universal remedy for environmental problems, only to discover in ten years time that this has not prevented environmental degradation and we have wasted ten years finding that out.

Trade restriction is a far more complex matter these days than simply applying tariffs and quotas at national borders, and in its complexity is to be found another factor which influenced the Marrakesh Decision on Trade and Environment. The demand for a cleaner environment and for environmentally-friendly goods and services has been increasing worldwide, and has generated a range of new policy measures, both price-based and regulatory, that are designed to revalue environmental resources in the marketplace, a notion sometimes referred to as internalising environmental costs. This has been most evident so far in the OECD countries, but the implementation of new environmental legislation and product and process standard-setting is spreading to developing countries, and the trend is likely to accelerate. The direction and speed of events, from the demands of consumers to industry reaction in the marketplace and thereon to national government legislation, makes the need for multilateral policy coordination urgent. Recognition of the fact that new environmental policies can have significant trade effects, even when they do not involve trade policies directly, undoubtedly played a role in persuading GATT member countries to bring the issue into the WTO where their trade concerns can be properly addressed.

The Marrakesh Decision and the WTO Work Programme on Trade and Environment

The Marrakesh Decision sets up a WTO Committee on Trade and Environment with a broad-based remit covering all areas of the multilateral trading system -- goods, services and intellectual property. The Committee has been given both analytical and prescriptive functions: to identify the relationships between trade and environmental measures in order to promote sustainable development, and to make recommendations on whether any modifications to the provisions of the multilateral trading system are required. In the first instance, recommendations are to be forwarded to the WTO Ministerial Conference in Singapore in December 1996.

Two important parameters will guide the Committee's work. One is that WTO competence for policy coordination in this area is limited to trade. In other words, there

is no intention that the WTO should become an environmental agency, nor that it should get involved in reviewing national environmental priorities, setting environmental standards or developing global policies on the environment; that will continue to be the task of national governments and of other international organisations better suited to the task. The second parameter is that if problems of policy coordination to protect the environment and promote sustainable development are identified through the Committee's work, steps taken to resolve them must uphold and safeguard the principles of the multilateral trading system which governments spent seven years strengthening and improving through the Uruguay Round negotiations.

Within those parameters, any issue considered by a WTO member country to be relevant may be raised. The task of the Committee, initially at least, is set out in ten areas of work. These have been drawn up on the basis of collective insights gained during GATT's work over the past three years on trade and environment, as well as matters raised by individual governments as being of particular concern to them in this area. No prejudgments are implied by the work programme, and no issues are taboo, but it is clear that any recommendations stemming from the Committee's work will need to command the broad support of the WTO membership.

A start on the work programme was made soon after the Marrakesh meeting, under the authority of the WTO Preparatory Committee, and since 1 January 1995 the WTO Committee on Trade and Environment has taken over responsibility for all WTO work in this area. The Committee is aiming to complete a first review of all the items on the work programme by October 1995, at which point it will engage in a stocktaking to define more clearly how it should tackle its task of reporting to the Ministerial Conference in December 1996 on the progress it has made, possibly with recommendations in certain areas.

The following is an informal review of the substance of the discussions that have taken place so far on specific items of the work programme.

The Multilateral Environmental Agenda

Several items on the work programme relate to the interface between the rules and disciplines of the multilateral trading system and trade-related aspects of the multilateral environmental agenda.

The main one is the relationship between the provisions of the multilateral trading system and trade measures applied pursuant to multilateral environmental agreements (MEAs). This has received considerable attention already in GATT/WTO. The Montreal Protocol, the Basel Convention and the Convention on International Trade in Endangered Species all contain trade provisions, and consideration is being given to including trade measures in new environmental agreements, for instance climate change, the protection of the world's forests, and possibly bio-diversity. The legal consistency of these provisions with WTO rules has never been put to the test. In all probability there will never be any need to do so in the case of trade measures applied among parties to an MEA. While it is surely desirable that such trade measures should be applied in a manner consistent with the rules of the WTO, both for legal reasons and in the interests of good economics, the provisions of the environmental agreement, including its dispute settlement provisions, would be likely to be viewed as prevailing in the case of a conflict.

Doubts about WTO consistency could arise, however, when an MEA calls for applying discriminatory trade measures to force non-parties to join or to abide by its provisions. In this case, a WTO Member would have the right to complain that its WTO rights were being violated and a formal finding to that effect could indeed point to a basic legal conflict between the provisions of the multilateral trading system and trade measures applied pursuant to an MEA.

The principal question for the Committee, then, is should environmental officials be instructed not to use any trade measure in MEAs which is inconsistent with their governments' WTO obligations, or should the WTO rules be changed to permit discriminatory trade measures to be applied against one of its Members under an MEA,

and if so under what conditions? That question requires a response which is sensitive above all to political considerations, in particular the need not to abuse the WTO as a powerful tool for multilateral policy enforcement in areas outside its specific competence. The environment is not the only area of international affairs where this question arises -- proposals have been made recently, for example, to enforce international labour standards through the WTO -- and trade sanctions are not the only, nor necessarily the best, enforcement tool available. There is, nevertheless, a discernible movement in certain countries to view international trade and environmental issues as increasingly important elements of national security considerations, and that is having an influence on the direction the debate is taking in the WTO on this particular matter.

If a political decision were to be taken to equip the WTO with the means to enforse various elements of MEAs, then a range of technical solutions would need to be carefully considered, from waivers, to interpretations or amendments of GATT rules, or the drafting of entirely new WTO provisions in order to provide the necessary legal authority to override existing GATT or WTO rights and obligations. Neither the political decision nor the technical work is to be taken lightly, since the obligations in question are those of non-discrimination, the absolute cornerstone of the GATT legal system and the principal means of protecting the rights of weaker and poorer members of the multilateral trading system. Whatever solution is found must command the full support of WTO members.

A related item on the Committee's work programme is what is the appropriate forum for the settlement of disputes that arise over the use of trade measures pursuant to MEAs; is it the WTO, or is it whatever dispute settlement machinery exists in the MEAs themselves? This item can probably be tackled sensibly only after decisions have been taken on how to resolve any substantive conflicts that may exist between the rules of the trading system and the trade-related rules of MEAs. For the time being, however, many delegations feel that their WTO rights would be the only acceptable starting point for examining a trade measure applied against them by other WTO Members, no matter what the purpose or context of the trade measure might be.

Debate on the use of trade measures in MEAs could help to shed light on the vexed issue of whether there are grounds for permitting a WTO Member to use trade restrictions outside the context of a multilateral agreement to try to influence unilaterally the environmental policies and practices of another. The United States government has argued at times that such a need may exist in certain circumstances, notably to deal with an environmental threat to animal and plant species or aspects of the global commons. However, two GATT dispute settlement panels which examined U.S. legislation authorizing trade embargoes against imports of tuna fish caught in a way that caused incidental dolphin mortality concluded that unilateral action of this nature is not consistent with GATT obligations, and their reasoning has received widespread support from other WTO Members.

The issue of unilateralism is highly controversial. It raises fundamental questions about sovereignty, and fears that the same arguments in favour of unilateralism could be applied to other aspects of national policy-making that a country's trading partners did not happen to agree with, something which could undermine entirely the integrity of the WTO legal system. It will be particuTarly important, cherefore, that a/search for consesus in this areaeached earlye best known example. This is a very controversial area which brings out most directly fears of misuse of trade policy for "green" protectionist purposes. For that reason it must be approached with caution. Ill-considered proposals made in this context could seriously jeopardise confidence in the degree of multilateral commitment that exists towards an open, non-discriminatory trading system.

National Environmental Policies

The relationship between the provisions of the multilateral trading system and national environmental policy measures that can have trade effects, such as environmental taxes and charges, environmental subsidies, and environmental requirements, regulations and standards is a key element of the Committee's work programme and one which covers a vast amount of ground. GATT Contracting Parties

began a detailed examination of the trade effects of eco-labelling and eco-packaging regulations, and the WTO Committee has extended the scope of that work to other environmental measures dealing, for example, with recycling and waste handling as well as the use of environmental taxes and subsidies. These are already a reality in many OECD countries, and they constitute one of the fastest evolving areas of policy-making.

Complex and potentially significant effects on trade can result from these policy measures, many of which are quite unfamiliar in terms of traditional trade policy analysis. It is hard, for example, to find anything quite the same as a deposit refund system that has been used in other areas of policy-making in the past and that has been analysed comprehensively in terms of its trade effects. Important questions arise, therefore, about the adequacy of WTO rules and disciplines to ensure that unnecessary obstacles to trade are avoided, and from the other side of the coin about whether those rules and disciplines permit effective and efficient environmental policy-making to be undertaken without running an unacceptable risk that a third country may lodge a commercial challenge to valuable new environmental practices. The Committee will need to relate environmental measures addressing both consumption and production pollution to the framework of WTO rules.

Consumption pollution is best addressed through consumption and product taxes and regulations. The GATT already has extensive experience in providing safeguards against unnecessary trade restriction or distortion occurring from measures such as these, but a number of new issues arise in the case of environmental measures. One is how environmental product regulations and standards, which are fully warranted from an environmental point of view in one country but not necessarily in others, can be formulated to ensure that when applied to imported products their effects are no more trade restrictive than necessary to do the job required of them. An example is recycled content requirements, which will naturally be based on environmental conditions in the importing country and as a consequence may in fact, even if not in theory, treat imported goods less favourably than domestically produced like products. Another issue under examination is how environmental taxes fit in with GATT rules on border tax adjustment.

The controversy surrounding the introduction of a carbon tax in many OECD countries, for example, makes it likely that the trade implications and GATT treatment of such a tax will warrant careful scrutiny.

Stating the problem in this way is sometimes seen from an environmental perspective as implying that in the WTO environmental objectives and concerns will be over-ridden by trade considerations. However, it is not the legitimacy of environmental objectives that is at issue in the WTO -- the challenge is to find the proper mix of policies that can respect environmental goals and priorities and avoid trade restrictive and distorting effects to the greatest extent possible.

A separate set of issues arises in connection with production pollution, which is addressed most effectively through taxes and regulations applied to process and production methods. For environmental policy-making life-cycle analysis of a product, including the way it is produced and ultimately disposed of as waste, is important to ensure the full environmental impact of both production and consumption activities is taken fully into account. Is there, in that regard, any legitimate case to be made for using trade restrictions to try to reduce a source of pollution overseas?

For the time being, real doubts exist. How a product is processed or produced is not, in general, a characteristic that can be taken into account under GATT rules to determine how it should be treated in the course of international trade. Nothing in the GATT, of course, prevents governments from legislating on the processes and production methods used by their domestic industry. However, a product made in a polluting way may not be differentiated at the border from a similar product made in a less-polluting way unless the pollution can be detected in the product's characteristics. The rationale behind that approach lies in the efficient assignment of policy instruments, the point being that trade restrictions are ill-suited to being used to change production methods abroad.

What, for example, would be the reaction of a foreign supplier facing an additional border tax or tariff in his export market because it has been determined there that his production process is too polluting? To be sure, one reaction may be to change to a less polluting process if the producer has the financial and technological resources to do so. Equally, however, might he not decide to lower his environmental standards and costs still further in order to try to recoup the competitiveness lost through having to pay the extra tariff? The ambiguity of the response suggests strongly a mis-assignment of policies. Trade restrictions cannot be counted on to operate predictably to achieve the policy objective, yet the costs of using them are ever-present.

Closely related to the issue of trade measures based on process and production methods are arguments which are sometimes put forward in favour of using trade restrictions to protect domestic producers with high environmental production standards against competition from overseas suppliers with lower standards. Demands from some environmental groups for "eco-dumping" duties to be imposed on goods produced in a polluting way are probably the best known example. This is a very controversial area which brings out most directly fears of misuse of trade policy for "green" protectionist purposes. For that reason it must be approached with caution. Ill-considered proposals made in this context could seriously jeopardise confidence in the degree of multilateral commitment that exists towards an open, non-discriminatory trading system.

Empirical evidence does not support arguments that real problems of international competitiveness are created by differing environmental standards in different countries. Even if such arguments were found to be of real concern in business circles, a subsidiary question is whether trade restrictions are an effective way of trying to compensate for international differences in environmental standards. If, as has just been suggested, they will not act predictably to change an overseas producer's methods of production, the argument for using trade restrictions boils down essentially to one of a domestic industry's need for protection against foreign competition. That is not evidently a matter which would fall within the mandate of the WTO Committee on Trade and Environment. The reason for lack of international competitiveness, whether environmental or

something else, is a secondary consideration. The WTO already provides possibilities for protecting domestic industry against foreign competition, for instance through safeguard action, and it hardly seems necessary to invent and bless a new protective instrument with a specifically green label attached to it.

An important means of ensuring that national environmental policy measures, such as labelling and packaging requirements, do not create unnecessary trade restrictions is to make the measures fully transparent to all WTO Members. Transparency provides security and stability for members' rights in the multilateral trading system, and can act as an effective means of preventing misunderstandings, and ultimately trade disputes, from arising. This is an additional element of the Committee's work programme. The WTO contains extensive mechanisms for assuring the transparency of trade and trade-related measures that are subject to substantive disciplines of various WTO Agreements. The degree of transparency called for ranges from simply the publication of national legislation through requirements to notify WTO Members once legislation is in place, or even (in the case of technical regulations and standards) notification before legislation is enacted so that a country's trading partners can provide input at the stage of drafting legislation to ensure that it takes their specific trade interests into account. The Committee has begun examining the adequacy of existing transparency mechanisms to deal with trade-related environment measures and considering whether anything additional might usefully be created, for example through an extension of the system of "enquiry points" which exists already under the WTO Agreement on Technical Barriers to Trade.

Trade Liberalisation

The effect of environmental measures on market access, especially for developing and least-developed countries, and the environmental benefits of removing trade restrictions and distortions is one of the most important and promising areas of the work programme. The Committee's task is to explore areas where increasing market access and trade liberalisation go naturally hand in hand with better environmental protection

and the promotion of sustainable development, and to relate these in particular to the situation of developing country members of the WTO.

The results of the Uruguay Round negotiations can provide the Committee with a ready source of inspiration in this area: reducing tariffs and tariff escalation and removing non-tariff barriers to trade in environmentally-friendly goods and services; providing developing countries with improved market access for higher value-added production to relieve the pressure they face currently to specialise in natural resource exploitation or low value-added, environmentally sensitive activities; disciplining and reducing environmentally-damaging subsidies, for example those awarded to energy and agricultural production; encouraging the spread of environmentally sound technology by enforcing intellectual property rights. The advances made through the Uruguay Round in areas such as these add up to a significant contribution that governments have made already through the multilateral trading system to ensuring coordinated, mutually supportive policy-making that is of benefit to both the environment and sustainable development.

The challenge will be to examine how those advances can be taken further. In traditional areas of market access, schedules for the liberalisation of trade have been agreed to in the Uruguay Round and will be implemented progressively over the next few years. That does not, however, stand in the way of additional agreements being reached to open markets further, for example to processed tropical products and natural resource-based products, nor to creative thinking about whether new areas of market access can be identified and developed. One promising line of examination may be the incorporation into the international marketplace of environmental services which, although already traded, are not for the time being assigned any market value nor paid for. An example which has already been taken up in the context of negotiations on a climate change agreement is the export of greenhouse gas absorption services by countries with large forest resources; the countries concerned are receiving no payment for providing exports of those services. A similar situation exists in other areas also, such as the protection of

biodiversity and the disposal of certain wastes. The Committee will be well-placed to examine whether there is any potential role for the WTO to play in this regard.

The Case of Agriculture

Agricultural production is particularly sensitive from an environmental viewpoint because of its direct links to natural resources (land, water, soil, biodiversity, etc.). The agricultural sector contains many examples of the failure of markets to incorporate environmental externalities which are particularly difficult to estimate and to monitor (Runge 1994a), and the task of designing proper environmental policies to deal with that is not easy. What has made this sector a matter of such environmental concern, however, is that market failures have been compounded by trade restricting and distorting policies with negative environmental consequences of their own, making policy failure a problem demanding attention for both economic and environmental reasons.

Although it is difficult to isolate precisely the impact of trade restricting and distorting policies from other factors, economic, environmental and policy-induced, that affect farm management practices, the results of the studies undertaken to date paint a largely unambiguous picture of direct, negative, and often significant environmental effects stemming from market access restrictions, domestic support policies and export subsidies on the one hand, and from high taxation of agricultural production relative to other economic activities on the other (not only directly but also indirectly through exchange rate over-valuation and import protection of other sectors of activity). (e.g., Runge 1994a, Anderson 1992a and d).

Adverse environmental effects typically associated with policies applied by countries that protect agricultural production behind market access restrictions and domestic support policies are: production subsidies, support prices and deficiency payments increase the intensity of use of fixed factors of production (e.g. land, water), discourage crop rotation and diversification, thereby requiring the use of more fertilizer, and lead to deforestation and the drainage of wetlands for agricultural extension and to

overgrazing by livestock; input subsidies encourage more intensive use of agro-chemicals (pesticides, fertilizers and feedstock) and environmentally sensitive inputs such as water for irrigation; and land set-asides lead to less extensive use of marginal land but also to more intensive use of land that is cultivated. Multiple trade restrictive measures can cause compounded environmental damage in various ways: for example, water, air and soil pollution from agro-chemicals and animal effluent, soil erosion, which at the extreme can result in desertification, falling groundwater levels and the silting of lakes and watercourses, and shrinking wildlife habitat (Reichelderfer 1990, Faeth et al. 1991). "Driven by these incentives, farmers adopt chemical-intensive monocultures that lead to more soil erosion, chemical run-off, loss of biological diversity, and conversion of once natural eco-systems to cropland than would otherwise take place" (Repetto 1994).

In addition, agro-chemical residues in food is a matter of growing concern in many countries (Lang 1992).

Valuable empirical work of the environmental effects of specific policies in specific countries and regions is available. Runge (1994a), for example, reviews in detail evidence of environmental damage stemming from trade restrictive and distorting agricultural policies in the United States and the European Communities. Repetto (1993) describes the effects of policies to protect sugar production in the United States in the following terms: "Markets for low income foreign producers, such as the Dominican Republic and the Philippines, have been severely restricted, crippling the sugar industries in those countries and sending millions of poverty-stricken workers into upper watersheds to become slash-and-burn farmers. Meanwhile, water and chemical uses by Florida sugar-cane growers have devastated the unique Everglades ecosystem." Margot Anderson (1994) provides details of the implications for Mexican agriculture of trade liberalization under the NAFTA.

Using evidence of New Zealand's experience over the past ten years, Reynolds et al (1993) conclude that reduced support to the agricultural sector, and in particular decoupling support from output and from the use of specific inputs, has acted in

conjunction with other factors (of which the general downturn in commodity prices was important) to reduce fertilizer use, reduce land clearing, increase diversification, reduce pesticide use and reduce livestock concentration. Certain problems are also noted, such as reduced investment in soil conservation, lower levels of risk management for climatic changes, and lower investment in agro-forestry as a result of reducing artificially high returns to farming, for which the study suggests targeted resource management policies need to be introduced to complement further reductions in agricultural support.

In countries where agriculture is heavily taxed rather than subsidized and/or there is an anti-export bias in the policy mix, problems of rural poverty mean that low prices induce poor farmers to cultivate marginal lands subject to erosion and run-off and to clear forests for agricultural extension, and the incentive structure can work against crops that can be environmentally beneficial (e.g. tree crops for export such as coffee, tea and cocoa can be beneficial for soil stability) (Pearce and Warford 1993). Attempts to offset the policy bias by providing input subsidies for fertilizers and pesticides has been shown to produce much the same results of soil erosion and intensive chemical use as in highly protected agricultural markets (Repetto 1985), but also to involve greater threats to the health of local farmers and consumers from incorrect application of agro-chemicals (Runge 1994a).

Agricultural export subsidies depress prices of agricultural products on world markets generally, and specifically in targeted export markets. They reduce farm incomes and inhibit badly needed investments in agriculture in third countries, and can result in the spread of low-yielding farming and ranching into ecologically vulnerable tropical forests (Repetto 1994). They also aggravate rural poverty which is associated more generally with environmental degradation. Within a restricted world market environment, preferential access arrangements can also be environmentally damaging. Runge (1994b) notes, for example, that special arrangements for imports of manioc into the EC from Thailand, in addition to contributing to increased nitrate pollution in the Netherlands, had caused in the late 1980s extensive soil erosion and deforestation in Thailand.

Two points should be made here. One is that the kinds of trade restrictive and distorting agricultural trade policies described above are being wound down through the results of the Uruguay Round negotiations. However, there is little empirical evidence for the time being about what kind of environmental benefits that might bring. Research on the impacts of policy on agricultural sustainability in six cases studies has been carried out by the World Resources Institute (Faeth, et al., 1991; Faeth, 1993).

The second is that removing or reducing trade restrictions and distortions will not be enough on its own to correct all the environmental problems to which they contribute. This has been well summarized by Runge (1994a): " The adverse environmental impacts of agriculture in developing countries are tied to their agricultural income problems which arise from both domestic and international trade distortions. In order to resolve these interrelated dilemmas, three types of policy reforms would have to occur together. First, developing countries would have to be prepared to reform domestic policies which tax farmers and lower incentives to produce. Second, developed countries must be prepared to open market access to developing country exports, and to reduce the level of surpluses and export subsidies used to dump these surpluses on world markets. Together, these two reforms would lead to higher prices and expanded commodity trade for developing country agricultural producers, resulting in income growth. Given this increase in growth per capita (assuming that debt burdens do not draw off these gains), developing countries would then be positioned to undertake the third measure: the expensive regulatory task of environmental intervention now only beginning in the OECD countries, in which lands sensitive to environmental damages are protected from unsustainable practices."

Two areas in which concern has been expressed that liberalizing trade in agriculture may bring with it adverse environmental effects are that the rural countryside will be less visually attractive and less populated than it is in highly protected markets at present as farmers respond to lower domestic production incentives by "getting bigger or getting out", and that higher food prices on international markets will cause relocation of

agricultural production to developing countries and raise land prices there, which will stimulate agricultural extension into environmentally sensitive areas and heavier doses of chemical inputs to increase yields (GATT 1992). In neither case, however, does this add up to a strong argument against reforming trade restrictive or distorting agricultural policies; it points, rather, to the need to complement trade policy reform with appropriate resource management policies aimed directly at correcting environmental problems at their source.

Furthermore, empirical evidence suggests that fears of this sort may be exaggerated. Anderson (1992a and 1992d, Anderson and Strutt 1994) simulated the effects of the complete removal of all farm support policies in all industrial countries and the US land set-asides in 1990, with full adjustment in that year. Even with such huge liberalization and quick adjustment, the estimated impact on world food output in aggregate is negligible and the relocation of production is minor. Much of the decline in production would be concentrated in western Europe and Japan, which lends support to concerns that there could be a fairly radical transformation of the countryside there as adjustment took place. It is also in those regions, however, that major environmental benefits from reduced intensity of agricultural production would be concentrated. In developing countries, the increase in production would represent only a small share of current output, especially for grain. Consequently, although the use of agro-chemicals has been found to be highly correlated with prices received by producers, Anderson concludes that pressure to increase chemical use and expand land area cropped would be less than might be expected. As regards livestock, the relocation of production to lightly populated, poorer countries would be associated with a reduction in grain-fed and supplement-fed (e.g. growth hormones) livestock and an increase in pasture fed livestock. The use of less-intensive methods would reduce not only air, soil and water contamination from fertilizers and animal effluent but also chemical additives in the meat produced. As regards land, there would be more intensive cultivation in countries not currently subsidizing production; how much is an empirical question, but it would be starting from a relatively low base in many of them and evidence suggests a relatively low elasticity of land area to farm prices. In sum, Anderson concludes there would be a

much larger reduction in environmental degradation in industrial countries than there would be an increase in environmental degradation in developing countries, with an overall net beneficial effect.

Reforming agricultural trade policies alone will not resolve all the environmental problems associated with agricultural production; targeted environmental policies to better define and assign property rights, tax pollution and, where appropriate, subsidize conservation, are also needed in a combined policy package (Krutilla 1991, Gray and Vocke 1994). Furthermore, removing trade restrictive and distorting agricultural trade policies in isolation without any accompanying environmental policies to correct the failure of markets to take environmental costs properly into account may exacerbate specific environmental problems (e.g. lower animal feed prices resulting from liberalizing market access may encourage an expansion of livestock production with consequent problems for animal waste disposal (Haley 1994). Overall, however, "One of the most potentially constructive effects of the interdependence of trade and environmental issues is that in developed countries, accompanying environmental interventions can help to "sell" trade reform in agriculture to a broader public. In developing countries, on the other hand, the benefits of trade reform including market access, higher prices and expanded exports, can help these nations "buy" needed environmental improvements" (Runge 1994a).

Other Issues

The subjects described so far constitute only a part of the full WTO work programme on trade and environment. The Marrakesh Decision calls also on the Committee to examine the role of the WTO in relation to the links between environmental measures and the new trade agreements reached in the Uruguay Round negotiations, on services and intellectual property. This will need to break entirely new ground, since there is very little understanding at present of how the rules of the trading system might affect or be affected by environmental policies in these areas.

Concluding Remarks

The key to moving the WTO work programme on trade and environment along will be ensuring that it remains focused on four points.

First, it must remain strictly within the competence of the WTO, which is not now nor has any aspirations of becoming an environmental agency. Evidently, the process in the WTO will be helped immeasurably by progress made elsewhere on the multilateral environmental policy agenda.

Second, within the WTO this is first and foremost an exercise in multilateral trade policy cooperation, albeit one which needs to be properly informed about and aware of the importance of the environmental policy objectives involved. In the final analysis it will need to yield tangible trade benefits for WTO members if it is to succeed.

Third, it must remain vigilant to the threat of the use of environmental measures for trade protectionist purposes. Slippage there will poison not only the trading system but also national and international environmental agendas.

Finally, it must remain sensitive to the situation and needs of the developing countries. To a very large extent it is the OECD countries that have been responsible for bringing the subject of trade and environment into the WTO and starting the process there. It cannot be concluded, however, without the consent and support of the developing countries.

References and Select Bibliography

Anderson, K. 1992a. "Agricultural trade liberalization and the environment: A global perspective." *World Economy*. Vol. 15, No. 1.

Anderson, K. 1992d. "Agricultural policies, land use and the environment." The 14th Denman Lecture, University of Cambridge. Granta Editions, Cambridge.

Anderson, K. and A. Strutt. 1994. "On measuring the environmental impacts of agricultural trade liberalization." Seminar Paper 94-06, Centre for International Economic Studies, University of Adelaide, Adelaide.

Anderson, M. 1994. "NAFTA and environmental quality: Issues for Mexican agriculture." in J. Sullivan, (ed.). Environmental Policies: Implications for Agricultural Trade. U.S. Department of Agriculture, Washington, D.C.

Faeth, P., R. Repetto, K. Kroll, Q. Dai and G. Helmers. 1991. Paying the Farm Bill: U.S. Agricultural Policy and the Transition to Sustainable Agriculture. World Resources Institute, Washington, D.C.

Faeth, P. 1993. Agricultural Policy and Sustainability: Case Studies from India, Chile, the Philippines and the United States. World Resources Institute, Washington, D.C.

GATT. 1992. International Trade 1990-1991. Vol. 1. GATT Secretariat, Geneva.

Gray, D. and G. Vocke. 1994. "Policy choices in the use of land and water." in J. Sullivan, (ed.). Environmental Policies: Implications for Agricultural Trade. U.S. Department of Agriculture, Washington, D.C.

Haley, S. 1994. "Assessing environmental and agricultural policy linkages in the European Community." in J. Sullivan, (ed.). Environmental Policies: Implications for Agricultural Trade. U.S. Department of Agriculture, Washington, D.C.

Krutilla, K. 1991. "Environmental regulation in an open economy." *Journal of Environmental Economics and Management*. Vol. 20, No. 2.

Lang, T. 1992. Food fit for the world? Sustainable Agriculture, Food and Environment (S.A.F.E.) Alliance. London.

Pearce, D.W. and J.J. Warford. 1993. World Without End: Economics, Environment and Sustainable Development. Oxford University Press, Oxford.

Reichelderfer, K. 1990. "Environmental protection and agricultural support: Are trade-offs necessary?" in K. Allen, (ed.). Agricultural Policies in a New Decade. Resources for the Future, Washington, D.C.

Repetto, R. 1985. Paying the Price: Pesticide Subsidies in Developing Countries. Research Report 2. World Resources Institute, Washington, D.C.

Repetto, R. 1993. Trade and Environment Policies: Achieving Complementarities and Avoiding Conflicts. World Resources Institute, Washington, D.C.

Repetto, R. 1994. Trade and Sustainable Development. Environment and Trade Series No. 1.UNEP, Geneva.

Reynolds, R., W. Moore, M. Arthur-Worsop and M. Storey. 1993. Impacts on the Environment of Reduced Agricultural Subsidies: A case study of New Zealand. Ministry of Agriculture and Fisheries Technical Paper 93/12. Wellington.

Runge, C.F. 1994a. "The environmental effects of trade in the agricultural sector." in OECD, The Environmental Effects of Trade. Paris.

Runge, C.F. 1994b. Freer Trade, Protected Environment. Council on Foreign Relations, New York.

World Trade Organisation

Trade and Environment

Decision of 14 April 1994

Ministers, meeting on the occasion of signing the Final Act embodying the results of the Uruguay Round of Multilateral Trade Negotiations at Marrakesh on 15 April 1994,

Recalling the preamble of the Agreement establishing the World Trade Organization (WTO), which states that members' "relations in the field of trade and economic endeavour should be conducted with a view to raising standards of living, ensuring full employment and a large and steadily growing volume of real income and effective demand, and expanding the production of and trade in goods and services, while allowing for the optimal use of the world's resources in accordance with the objective of sustainable development, seeking both to protect and preserve the environment and to enhance the means for doing so in a manner consistent with their respective needs and concerns at different levels of economic development,"

Noting:

— the Rio Declaration on Environment and Development, Agenda 21, and its follow-up in GATT, as reflected in the statement of the Chairman of the Council of Representatives to the CONTRACTING PARTIES at their 48th Session in December 1992, as well as the work of the Group on Environmental Measures and International Trade, the Committee on Trade and Development, and the Council of Representatives;

— the work programme envisaged in the Decision on Trade in Services and the Environment; and

— the relevant provisions of the Agreement on Trade-Related Aspects of Intellectual Property Rights,

Considering that there should not be, nor need be, any policy contradiction between upholding and safeguarding an open, non-discriminatory and equitable multilateral trading system on the one hand, and acting for the protection of the environment, and the promotion of sustainable development on the other,

Desiring to coordinate the policies in the field of trade and environment, and this without exceeding the competence of the multilateral trading system, which is limited to trade policies and those trade-related aspects of environmental policies which may result in significant trade effects for its members,

Decide:

— to direct the first meeting of the General Council of the WTO to establish a Committee on Trade and Environment open to all members of the WTO to report to the first biennial meeting of the Ministerial Conference after the entry into force of the WTO when the work and terms of reference of the Committee will be reviewed, in the light of recommendations of the Committee,

— that the TNC Decision of 15 December 1993 which reads, in part, as follows:

"(a) to identify the relationship between trade measures and environmental measures, in order to promote sustainable development;

(b) to make appropriate recommendations on whether any modifications of the provisions of the multilateral trading system are required, compatible

with the open, equitable and non-discriminatory nature of the system, as regards, in particular:

— the need for rules to enhance positive interaction between trade and environmental measures, for the promotion of sustainable development, with special consideration to the needs of developing countries, in particular those of the least developed among them; and

— the avoidance of protectionist trade measures, and the adherence to effective multilateral disciplines to ensure responsiveness of the multilateral trading system to environmental objectives set forth in Agenda 21 and the Rio Declaration, in particular Principle 12; and

— surveillance of trade measures used for environmental purposes, of trade-related aspects of environmental measures which have significant trade effects, and of effective implementation of the multilateral disciplines governing those measures;"

constitutes, along with the preambular language above, the terms of reference of the Committee on Trade and Environment,

— that, within these terms of reference, and with the aim of making international trade and environmental policies mutually supportive, the Committee will initially address the following matters, in relation to which any relevant issue may be raised:

— the relationship between the provisions of the multilateral trading system and trade measures for environmental purposes, including those pursuant to multilateral environmental agreements;

— the relationship between environmental policies relevant to trade and environmental measures with significant trade effects and the provisions of the multilateral trading system;

— the relationship between the provisions of the multilateral trading system and:

(a) charges and taxes for environmental purposes

(b) requirements for environmental purposes relating to products, including standards and technical regulations, packaging, labelling and recycling;

— the provisions of the multilateral trading system with respect to the transparency of trade measures used for environmental purposes and environmental measures and requirements which have significant trade effects;

— the relationship between the dispute settlement mechanisms in the multilateral trading system and those found in multilateral environmental agreements;

— the effect of environmental measures on market access, especially in relation to developing countries, in particular to the least developed among them, and environmental benefits of removing trade restrictions and distortions;

— the issue of exports of domestically prohibited goods,

— that the Committee on Trade and Environment will consider the work programme envisaged in the Decision on Trade in Services and the Environment and the relevant provisions of the Agreement on Trade-Related Aspects of Intellectual Property Rights as an integral part of its work, within the above terms of reference,

— that, pending the first meeting of the General Council of the WTO, the work of the Committee on Trade and Environment should be carried out by a Sub-Committee of the Preparatory Committee of the World Trade Organization (PCWTO), open to all members of the PCWTO,

— to invite the Sub-Committee of the Preparatory Committee, and the Committee on Trade and Environment when it is established, to provide input to the relevant bodies in respect of appropriate arrangements for relations with inter-governmental and non-governmental organizations referred to in Article V of the WTO.

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