Prospects for grain storage technology in the 21st century

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The Director-General of FAO has identified basic concerns for mankind into the 21st century as enhanced food security and nutrition and improved sustainability of agricultural and rural development

I shall examine aspects of one of these concerns, namely grain storage technology and, in the context of this conference, make special reference to maintenance of the quality of the commodity from production through to consumption

Although current technology foreshadows the technology for the 21st century, the new technology will have to be developed and exploited in a vastly different general environment Of prime importance will be the infrastructure in which the technologies are generated because this will also provide for the continuum of further appropriate technologies that will be necessary for the future In this presentation, I shall concentrate on features of the general environment he participants in this conference are better qualified than am I to speak on specific technologies

I shall identify some of the significant developments that are moulding future technologies and the constraints that govern their application This will include the arrangements for research and development and technology transfer Further, I shall consider some newer approaches that can be integrated into handling and storing systems, and the need for regional and global collaboration

Finally, I shall outline my perceptions of the short-term directions which technology should take to address current problems while laying the foundations for subsequent generations of stored product protection systems

Current developments of significance to grain storage technology

The social and commercial environments

As we move into the 21st century, the commercial nature of grain storage will change, as it too is driven by the same forces that are altering society today In the latter part of this century, the ideology of economic rationalism based on competition, self-interest, and profit, has in large measure subsumed social and environmental responsibility as the motivating force for change Moreover, in agriculture, competition can now be a matter of convenience, with subsidies and even quarantine and phytosanitary regulations being manipulated as non-tariff barriers to supplement or replace import duties to give market advantage These have to be accepted as valid parameters and whether or not they are desirable for ultimate common good, they provide boundaries within which technology must conform Additionally, production is moving away from the small producer, with the exception of subsistence farming in lesser developed areas of the world In that context, the technology of subsistence farming and associated grain storage has evolved over a long period and usually has the capacity to manage most problems except flood and drought Otherwise, the aggregation of smaller production units is inevitable, with increasing use of high-capacity handling equipment such as combine harvesters and complementary storage facilities Bulk handling must be a major consideration, although bag handling will retain a place, particularly in the distribution channels to consumers

Governments are moving away from direct involvement in regulating and marketing grain Public authorities were responsible for strategic planning and management of grain stocks and usually had three main objectives to stabilise prices and maximise returns to growers, to manage strategic stocks of grain that ensure regular and reliable supply to markets and industry, and to guarantee food security The change from monopolistic control towards freeing-up of the market leads to proliferation of private operators and activities dictated by market forces This leaves domestic markets more sensitive to market fluctuation, reduces returns to growers and reduces opportunities to exploit economies of scale The private sector has purely commercial interests, often with considerable involvement of multinational companies who manage their grain stocks and operations on a global rather than a national basis to suit corporate objectives and maximise returns to shareholders rather than producers or consumers

Another important issue is that the range of skills required by staff in the grain industry has increased dramatically with mechanisation, automation, and dependence on computers It is becoming mandatory for ongoing in-service training and regular formal courses to maintain competence in the changing technology This, coupled with increasing dependence on outsourcing and consultants to provide specific skills and services, requires that some form of regular, formal assessment be made of the competence of individuals This training is supplemental to the basic

Formerly Australian Centre for International Agricultural Research

qualifications needed for a particular position, and schemes for accreditation are now being implemented by some professional scientific and technological societies as an added qualification recognised throughout professions and industry

Research and development

The changes in the commercial environment of the grain storage industry are having a profound influence on research and development (R & D)

R & D support covers two broad fields Firstly, applied technology provides the direct support necessary for the industry in its day-to-day operations Secondly, basic studies underpin the applied technology, facilitating its development and ensuring its reliability

The same ideological agenda of economic rationalism and reduction of staff numbers that has driven commercial and public sector activities, has impacted on research and development and been mirrored in regulatory authorities particularly those vested with protecting the integrity of rural industries such as quarantine services These are matters of concern and must be rectified if the industry is to be adequately serviced for R & D

Currently, considerable R & D is carried out in the public sector in universities and in national and provincial departments of agriculture, or their equivalent, and is supported by public funding Nevertheless, responsibility is being shifted to industry to carry out its own R & D, or at least to fund activities in public organisations through industry levies, direct contribution, or contractual arrangements It does seem that despite these public bodies being funded on a cost-recovery basis, that R & D in the future will be moved increasingly to either industry-funded cooperative R & D schools based in universities or carried out by industry itself National research bodies without a teaching function are not using resources efficiently and not servicing the industry or community adequately A concern arising out of this is how mechanisms can be built into the system to ensure a continuum of basic research to underpin the future applied studies

All R & D may involve consideration of intellectual property rights (IPR) but this can be of particular significance with industry funding The IPR may involve plant variety rights, patenting of processes, or even the rather dubious practice of claiming the genome of whole organisms and thus all rights to their biotechnological development. While IPR can protect the investment of individual groups, ensure some return, and provide incentive for further investment, the negative aspects can be very real, denying the technology to those who cannot afford it but who may, particularly in the stored product protection/food security context, be those who need it the most

Furthermore, and as in the industry itself, lifetime careers in the one organisation, or seemingly in the same discipline, are becoming features of the past as short-term contract/term employment becomes the norm Notwithstanding, it is absolutely essential that compatible arrangements be developed for staff working on long-term and basic research where often there are no obvious benefits in the short term

Computer and microprocessor technology

Computer and microprocessor technologies have enabled many radical innovations to be introduced into grain management. Today, they are the prime tools driving change in storage technology, both in research and development and in operational procedures Some of the more important applications are

- design of storages and handling systems,
- data collection, assembly, and processing,
- removing contaminants and ensuring uniform quality by electronic sizing and colour sorting equipment,
- monitoring and manipulation of storage conditions,
- process control in value-adding operations, automated handling and stock control;
- modelling of heat ass transfer and movement of moisture and fumigants in grain bulks;
- decision-support systems,
- communication and many forms of networking,
- operational instruction, and
- computer-aided learning

Computer literacy has become a prerequisite to working in the grain industry

Communication

Another major driving force of change in grain storage is the revolution in electronic communication It impinges in many ways, ranging from market intelligence and stock control networking to research on grain behaviour It is now obligatory for everyone to participate in the Internet and World Wide Web to speedily exchange documents and access information held in various data banks Networking and video conferencing are particularly valuable, providing global interaction within the industry at minimal cost

The data banks provide extensive literature coverage and unique search capability Increasingly, complete journals and scientific literature are becoming available electronically, and digital libraries are being developed by consortia to offset high costs of purchasing digital information. Access to the databases can be through the Internet or by CD-ROM CD-ROM technology has wide application because the format is more suitable for the developing world where sophisticated telecommunications

and access to Internet may be restricted In this context, Cornell University has developed The Essential Electronic Agricultural Library (TEEAL) which comprises initially the contents of 123 journals and 19 monographic series for the years 1993-1996 on 100 compact disks priced at $10,000 which is 10% of the subscription price of the publications These disks are available only to developing countries but illustrate the capacity of electronic data management and its indispensable role in technology development

Of particular interest in grain storage is the FAO-led initiative, the Information Network on Post-harvest Operations (INPhO) being developed in conjunction with GTZ and CIRAD and for which CD-ROMs, containing pilot versions of the databank, are now available Mention should also be made of the unique databases developed in the U K Ministry of Agriculture, Fisheries and Food and at Kansas State University It should be recognised that many databases are incomplete, as they do not include earlier literature and are only as good as the coverage and standard of the information supplied to their compilers But, overall, the Internet provides a relatively cheap and reliable method of communication Whether current growth, capacity and costs can be sustained can only be conjecture but as well as the need for everyone to be connected to Internet, every institution should have a descriptive home page on the World Wide Web

Automated handling and stock control

The 21st century will see automation gradually replace much of the labour force currently required to manage grain stocks The condition of grain in-store can be monitored remotely and continuously maintained or modified with automatic control of aeration, cooling, or heating All handling and storage operations can be automated, with personal intervention by staff required only for supervision and maintenance Stock control has been revolutionised by automated palletising, containerising, and bar-coding Even now, entire national or international operations can be monitored and controlled centrally through linked networks This is undoubtedly the future for stored grain technology

Significant technologies and arrangements for the 21st century

Decision-support services

A critical issue in management of grain stocks is ensuring that all strategic and operational decisions are timely and appropriate Many support services have been developed to cover both the hierarchical nature of decision-making and the wide range of economic, biological, and logistical factors that govern operation of these stores The services range from sophisticated market intelligence that provides the detailed and up-to-date information needed for decisions on procurement, processing or other value-adding, and disposal of commodities, to management systems that optimise the methodologies and strategies of storage The particular tools involved depend on the storage operation concerned The operation may have only a simple storage function or may comprise part of an integrated production arketing system Irrespective, both the overall and the component systems can be quantified and modelled providing that sufficient data and resources are available This enables all factors operating to be included in predictive simulations that provide assistance to decision-makers

Pest management in stores has received particular attention and is usually considered in a general integrated pest management framework, taking into account the pest complex potentially present and conditioning factors such as temperature and water activity and less quantifiable parameters such as regulatory or quarantine restrictions, health considerations, and non-tariff barriers The decision tools available for pest management in grain have been considered in terms of knowledge acquisition and surveys, decision analyses, modelling of pest management and detection, and expert systems that communicate the logical decision-making to the end users

There is an increasing range of computer-assisted tools that can be incorporated into the decision-making processes These cover critical elements such as correct identification of pests by simple interactive keys and definitive descriptions, to models simulating the interacting components of any control activity such as detection and sampling for pests, insect population dynamics, residual behaviour of pesticides, pesticide resistance, fumigation and hygiene practices, and finally the physical processes of temperature and moisture manipulation by aeration or refrigerated cooling

An important issue in this predictive methodology is detection and quantification of infestations In this context, assumption of infestation as a basis for routine treatment with grain protectants or fumigants is now less commonly practised because of residue and resistance considerations Thus, the infestations must be located and assessed by sampling or trapping These are disciplines that have been extensively researched and modelled in their own right The interpretation of sampling and trapping data is complex and covers such areas as the probability of detection of infestations and the relationship between the relative numbers from trapping with absolute estimates of the size of pest populations As a further tool for risk reduction in pest management interventions, these approaches have been fine-tuned to locate infestations by precision targeting using spatial analysis of the data

Quality control

As for the commodity itself, the requirements of a market-driven industry are clear Quality control is paramount but will be a matter of economics Caretaking of grain or value-adding will extend only to perceptions of whatever is needed to sell the grain at a profit For example, in matters of contamination by insects or moulds, management procedures will be guided by buyer specifications, usually price based, and will not necessarily take into account biological or environmental considerations In some instances, no control measures may be taken This reduces costs and possibility of pesticide residues but passes on the infestation problem findeed there was a problem Governments continue to provide some regulatory constraints in conformity with international trade agreements or phytosanitary arrangements, but generally moves are towards completely freeing up trade with the marketplace regulating activities

Nevertheless, quality assurance is a major force that will have a profound influence on the future of the grain industry It provides tangible reassurance to buyers that certain quality standards have been met in the production, handling, and marketing of the commodity Quality assurance begins with production ensuring the grain is true to type, reliably meets the various grain quality specifications such as moisture content, protein content, etc , and is free of contamination This may require specific arrangements between the producer and the buyer and certainly will require that testing be done by qualified laboratories using qualified staff and agreed methodology So, the testing will have to be done by independently-accredited laboratories, and current staff and much of the self-training and in-house procedures practised today may not meet the vigorous scrutiny that will be required for acceptance in the future The equipment already available makes quality control a precision operation In fact, the limits of detection in many analytical procedures are now far below those levels that should sensibly be enforced Moreover, developments in enzyme-linked immunosorbent assay (ELISA) techniques and polymerase chain reaction (PCR) technology have dramatically widened the scope of both background studies and analytical and identification procedures Quality assurance in practice will extend to all handling and storing operations including monitoring of condition during storage and any remedial measures carried out It can be assumed that it will become mandatory in storage management systems in the 21st century

Accreditation of laboratories

The International Organisation for Standardization (ISO) defines laboratory accreditation as a formal recognition that a laboratory is competent to carry out specific tests or specific types of tests In the context of grain storage there are two basic types of laboratory involved hose for research and development, and those for compliance with regulations, monitoring, and quality control Accreditation, although not compulsory, is usually a contractual requirement when services are provided, particularly when documentation is generated to certify specific standards have been met Whether it be sampling and analysis of grain for various quality parameters, pesticide residues, mycotoxins, insect infestation or simply moisture content, it is becoming mandatory for laboratories to seek accreditation as a certified demonstration of their competence and as a component of a quality assurance program This has international standing that conveys confidence in users of their services and buyers of the commodities involved

The standards on which laboratory accreditation are based are wide ranging and global, being sourced from national groups such as standards institutes, public health authorities, environmental protection agencies, and quarantine services, as well as recognised international authorities such as the Association of Official Analytical Chemists (AOAC), the British and United States Pharmacopoeia, the International Seed Testing Association (ISTA), the International Mycological Institute, and the International Standards Organisation (ISO) In Australia, for example, accreditation is administered by an autonomous body, the National Association of Testing Authorities (NATA), which is governed by a council on which government, industry, and professionals are represented The criteria on which NATA accreditation is based are comprehensive, covering organisation and management, the quality control system being operated, the competence of staff, adequacy of the laboratory accommodation and the testing environment, availability of equipment and reference materials, standardised and traceable measurement and calibration procedures, appropriate and documented standard and non-standard test methods, and sampling, recording, reporting, and certification procedures

The competence of accredited laboratories is assessed by two complementary techniques involving firstly on-site evaluation and secondly proficiency testing of performance by interchange of methodology and samples between laboratories Internationally, the systems are monitored by peer review under guidelines laid down by ISO/IEC within mutual agreement partners in the Asia Pacific Laboratory Accreditation Cooperation (APLAC) and the European Cooperation for Accreditation of Laboratories (EAL)

Biotechnology

Biotechnology approaches can ensure that quality of the commodity does not deteriorate in storage This is achieved by managing metabolic activity and the depredations of pests and diseases The mechanisms for this are manipulation of

temperature, moisture content, or composition of the atmospheric gases in the storage and, if necessary, by changing the nature of the commodity so that it is less affected by the factors causing deterioration Metabolic activity influences storability in terms of germinability and milling, cooking, or other processing characteristics These are features of the commodity established by the plant breeder and highly specific in their interaction with storage conditions Pests in storage must be considered in terms of infestibility of the commodity, suitability of the storage environment for pest survival and multiplication, preharvest infestation, and reinfestation in storage Spoilage microorganisms are active within similar parameters but usually at higher water activities

Gene technology enables beneficial agronomic characters or end-use attributes including protection against pests and diseases to be conferred on plants, seeds, and other organisms These genetically modified organisms can be synthesised by conventional cross-breeding and/or selection within interbreeding populations or much more expeditiously by transfer of desirable genes among unrelated species by genetic engineering While most studies have been focused on increasing production and managing field problems, the postproduction subsector is now receiving attention commensurate with its potential Opportunities in grain storage are more limited than in the production sector and in value-adding processes such as industrial fermentation but nevertheless they are significant Plant breeders have been slow to recognise the need to integrate the production performance of cereals with their storability It is only recently they have come to realise that increases in yield can be negated by storage losses and that a total production/postproduction approach may provide greater net gains more efficiently

Conventional plant breeding will continue to provide a valuable technique for incorporating desirable characters that improve the storability of grain The classical studies on increasing husk length in maize to reduce attack by birds and field infestation by *Sitophilus zeamais* are typical of the opportunities to prevent infestations in the field being carried into storage With cereals there has been limited success in developing resistance to insects as many of the features sought by plant breeders are conducive to insect attack Maize is a notable exception The hard vitreous and flint varieties restrict insect development but are less in demand by consumers Active principles can also be present in maize, often providing spectacular varietal differences

By contrast, the legumes offer considerable potential for development of resistance to insects, as the differences between varieties in susceptibility to bruchid attack are quite marked, with some exhibiting very high heritable resistance There is a vast literature on screening species and varieties of legumes for resistance to Bruchidae, particularly in countries such as India where legumes are a major component of the diet Field infestation by the bruchids is a common precursor of infestations in storage and while exacerbating the problem also provides greater opportunity to develop resistance in the host plant Moreover, field infestation has ensured that plant breeders working with legumes have been more cogniscent of pest problems in storage than their cereal counterparts It is significant that transgenic peas have been developed containing an alpha amylase inhibitor gene from beans that has conferred resistance to *Bruchus pisorum*

There are also exciting prospects for developing resistance to microorganisms in grain, both as spoilage agents and as precursors of toxins As with insects, field infection can be a vital component This allows either full development including production of toxins before harvest, or inoculum to be carried into storage with development when conditions are suitable Undoubtedly, where problems exist and as more becomes known of toxins and their epidemiology, current studies will be extended to include resistance to microorganisms, particularly where infections start in the field It would be expected, for example, that problems with *Alternaria* and *Fusarium* spp and their suites of associated toxins would be addressed in this manner

The search for desirable traits to be incorporated into commercial crops is escalating rapidly This is based on detailed examination of the responses of extensive ranges of host varieties and more recently the genome of both donor and receptor organisms Whereas previously irradiation or treatment with mutagenic agents was a common method of inducing variation in particular organisms, this is used rarely now The range of chemical defence proteins being studied as candidates for inclusion in host commodities in pest management programs has been defined as unique, bioactive proteins that, when engineered into plants, offer one avenue of pest management that can be highly selective for the pest and more friendly to non target organisms and the environment than conventional pesticides These chemical defence proteins target the endocrine, nervous, skeletal, and digestive systems in insects and include *Bacillus thuringiensis* toxins, juvenile hormone esterase and inhibitors, insect-specific neurotoxins, vitamin-binding proteins, lectins, chitinases, proteinase inhibitors, and alpha amylase inhibitors The *Bacillus thuringiensis* toxins have so far been the only commercial applications – as recombinant plants and microorganisms that are toxic to insects

Collaboration

An important element of systems for safe storage of grain in the 21st century will be collaboration that facilitates acquisition and exchange of information and resources

The benefits that accrue from collaboration among

authorities are manifold and derive from five distinct sources

- With the *commonality of problems* in grain storage, many storage authorities face similar issues and accordingly similar principles are involved in their solution Sharing of experience can obviate costly investigative work
- The linkages possible in collaborative activities enable a *wider scope* of the studies and potential for new, more comprehensive dimensions to the investigations and the resultant greater challenges to researchers
- As modern technology often requires multidisciplinary skills and capital intensive resources, collaboration widens the *access to expensive* and *sophisticated equipment* of types that cannot be expected to be found in every laboratory, centre, or even country
- There are opportunities to conserve resources by *complementary programming*
- Finally, the perspectives afforded by regional or global collaboration provide an opportunity to *focus resources* on those problems that have been identified as having the highest priorities The resultant collaborative programs enable successful solution of these problems in the shortest possible time

The nett result of all these initiatives is better use of resources and time The prerequisites for successful collaboration are as follows

- Networking Collaboration requires networking in many forms, but ideally should cover all areas of interchange of information and ideas Significant economies follow when all participants work together towards common goals Indeed, this conference is a vital strand in the global network of stored-product protection The contacts made and relationships established during the various sessions and social events of this gathering can be as important as the information exchange in the formal proceedings of the conference
- Harmonisation of regulatory frameworks for commodity inspection, treatment, and documentation is a vital component of global collaboration and is complementary to effective networking Moreover, it is essential for orderly marketing of agricultural produce and enhances the adoption of new technology if there is a basis for common acceptance
- Standardisation Harmonisation is most effective if methodologies and procedures for evaluating technologies are standardised As well as facilitating direct transfer of technology, standardisation provides the basis for comparing results from different sources, thus expanding the comparable databases

  Databases The development of relevant, comprehensive, and usable databases is implicit in providing an information base for effective collaboration Databases must be readily accessible, and management and solution of problems may require inputs from many sources involving a range of disciplines chemistry, engineering, biometry, and economics Such multidisciplinary contributions to core activities of collaborative programs must be of critical mass individually and collectively If one is inadequate the effectiveness of the other is compromised
- Economies of scale must also be considered and exploited to increase chances of success in solving problems Research and development teams that are too small may be uneconomic or ineffective, whereas greater access to resources enables a stronger focus on a problem with collaboration providing access to resources not available to individual laboratories

Intranational collaboration is vital in individual countries, but compared with the international scene it is practised less and is less formalised Unfortunately, competition rather than collaboration is the order of the day with State/provincial authorities vying with the better endowed national bodies for funds and staff True collaboration is difficult in these circumstances and usually is achieved only by impartial third-party funding of the collaborative programs Conferences help fill the gap as it is the discipline-orientated independent associations and societies that provide significant opportunities for researchers and technologists to meet regularly and publish newsletters and technical journals

International collaboration involves bilateral, multilateral, or regional activities Bilateral collaboration is the normal technical interchange between individuals and institutions, externally funded projects, and assisted scientific programs that provide for partnerships between groups in different countries Multilateral and regional collaboration are the province of organisations such as FAO, WHO, Codex Alimentarius, GASGA, CGIAR, and the International Agricultural Research Centres in the public domain and the many discipline-based societies and associations that provide for global standardisation and exchange of information FAO particularly has provided an indispensable service to grain storage technology The biggest deficiency has been with the International Agricultural Research Centres which consistently failed to recognise the need for developing complementary and fully integrated postproduction systems as part of their responsibility in enhancing production

All such collaboration must be fostered in every way possible To that end, such activities must be underwritten by both government and the private sector

Directions for the future

As we move into the 21st century the reality is that there will be little major change in grain storage technology except for the adjustments made in response to organisational restructuring The corporatisation and privatisation of public

grain handling bodies, the upgrading of handling facilities for consistency with modern transport systems, and the general reduction in staffing numbers in both the industry and its support research and development will have their influence, albeit marginally Various forms of automation and containerisation will be introduced, ranging from bags and one tonne bulkers to conventional freight containers The increasing need for segregation will require specific facilities to prevent cross-contamination and, overall, a high standard of quality control will have to be maintained through quality assurance programs

Quality assurance programs lead to consideration of both the accreditation of organisations as participants in programs and the capability of their staff Such accreditation will become mandatory in the future in the grain trade

Consumers and storers will liaise with production personnel, including plant breeders, not only to dictate the end-use requirements of grain but also the characteristics necessary for its safe storage This will be achieved not only by conventional selection but also, if needs be, by genetic engineering if such is economically justifiable

Increasingly, there will be dependence on physical methods of pest control, including hygiene and exclusion, as these have the in-built reliability that is not a feature of chemical or natural control Manipulation of storage conditions and the physical attributes of the commodity will be in the forefront Drying for safe storage of grain will continue to be the major consideration for the industry in both the wet tropics and other moist areas, and indeed remains a major global priority Grain cooling and cold storage technology are also high priorities often obviating the need for any other treatment Controlled atmosphere technology will continue to service niche markets

Markets today are moving towards policies involving residue-free commodities and it is prudent to have such a target even in the long term Nevertheless, residual pesticides will remain a valuable tool for pest control in circumstances where infestations and storage conditions are severe, physical control is impractical, and damage probability is immediate and high

Fumigation will also continue to play a key role, with phosphine being the major material of choice for store operators Fumigation of leaky structures will become unacceptable because of increasing dosages in response to pest resistance, changing threshold limit values, the hazardous nature of any gas concentration in the workspace, and the public liability that would be incurred in today litigious society Good new fumigants and fumigation technologies are unlikely The reincarnation of ethyl formate shows limited promise in certain spot applications and bulk treatments The most promising methodology would seem to be high pressure fumigation with carbon dioxide This would be comparable to vacuum fumigation with methyl bromide if current methods could be simplified and costs reduced to reasonable levels In the interim, current provisions for phasing out of methyl bromide seem unlikely to be a real constraint, particularly in developing countries where it is most needed The most vocal and proactive supporters of the methyl bromide phase-out are countries which are least affected by its loss Nevertheless, the agreed exemptions will allow its use with little hindrance for the foreseeable future

Irradiation is a feasible alternative to fumigation and pesticides for disinfestation treatment Unfortunately, it has had limited acceptance despite the inherent dependability of dosing levels and pest responses and the freedom from pesticide residues The current campaign to replace methyl bromide as a fumigant has rekindled interest in irradiation as a potential alternative for short-term disinfestation and this is being actively promoted by both FAO and IAEA with necessary approvals in place in both Europe and the USA It already has a significant place in treatment of perishable commodities for quarantine and general pest control Applications in treatment of durable commodities including grain need to be pursued vigorously to overcome the lack of demonstrated economic incentives for its use and the availability of alternative technologies that are currently perceived as less capital intensive and more socially acceptable

In addition to the necessary support research and development in pest management, the improvement of arrangements for transfer of technology to end-users, and communication and collaboration generally, the areas that must be identified for specific attention are the basic support sciences of biology and ecology

Finally, in the lead in to the 21st century and consideration of choosing among the technology that is most likely to succeed, we must refer to the decision-support systems that are being developed to assist in making these choices This methodology will increase the probability that the most rational decisions are made

Before I conclude I would like to thank the Organising Committee of the 7th International Working Conference and their Chairman, Professor Jin Zuxun, for the excellent conference that has been prepared for us and the Australian Centre for International Agricultural Research and the Australian Agency for International Development for the support they have provided not only for my attendance at the conference but for the attendance of many of our colleagues associated with stored product protection projects throughout the developing countries in Asia