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Foodgrains Saved, Foodgrains Produced

In spite of the widely acclaimed "Green Revolution", the food problem continues to baffle the Indian sub-continent and many developing Asian countries. The problem is two-fold. In the first place, it demands ever-rising levels of production to meet the challenge of population explosion and, in the second, it calls for a dead end to the loss and waste of food grains due to insects, rodents, fungi, fire, depredation and what not.

The magnitude of these losses is alarming. For instance, it is estimated that about 10% of the total production of foodgrains in India, which comes to more than 10 million tonnes, is lost every year due to one reason or other. The same is the case, in varying degrees, in other developing Asian countries. In many countries including India, the amount of loss and waste of foodgrains almost equals the shortages faced by them.

Needless to say, therefore, that prevention of loss and waste of foodgrains assumes critical importance in a country like India. There has to be a continuing search for more and more effective methods and techniques of prevention of loss and waste of foodgrains. At the same time, there is an urgent need for pooling together the national and international experiences in this field in order to wage an all-out war on loss and waste of foodgrains.

A recent international seminar on prevention of waste and loss of foodgrains, jointly convened by the Asian Productivity Organisation and the National Productivity Council of India at New Delhi from 9th October to 5th November 1973, was a modest step in the above direction. It was a four-week thought-session in which eminent experts took part in sharing their views on how to fight this menace. The Special Section of this issue of PRODUCTIVITY, in fact, is an outcome of the seminar. Most of the articles included in it are based on the presentations made by these experts. Some of the aspects covered in these articles relate to storage, preservation, transportation, rodent control in godowns and the fields, quality control, processing and milling of foodgrains and by-product utilisation. Also included in this Section is a contribution from Mr.H.A.B. Parpia of the Food and Agricultural Organisation dealing with the problems of technology transfer in food and agricultural industries in developing countries.

The other Section of this issue consists of two articles, one by Mr. R.P. Billimoria and the other by Mr. V.G. Gopal dealing with the problem of industrial relations in India. Presented to the A.P.O. Symposium on Productivity and Industrial Relations held at Tokyo in October, 1973, these articles, to some extent, reflect the current thinking of employers and trade unions in the country on what should be the *modus vivendi* between the employers and the trade unions, and provides the framework within which a sound system of industrial relations should be evolved in Indian conditions.

Prevention of Waste of Foodgrains—A Challenge

C. Subramaniam*

Availability of foodgrains depends not only on the total quantum of foodgrains that a country produces but also on how effectively it is being utilised. For the Indian population of about 550 million, a production of about 100 million tons of foodgrains does not appear to be inadequate. Yet some people go hungry, or precious foreign exchange is used to import foodgrains. It is not because the production is less but because adequate care has not been taken of the output, resulting in a loss of 10 per cent or even more due to loss in storage, by depredation of insects, rodents, fungi, fire etc. There is thus a vital need to prevent these losses. Continuing research, both at national and international level for new methods and techniques of prevention and control of foodgrains losses will go a long way in achieving this objective.

ACHIEVING success in the green revolution is only winning half the battle on hunger. Unless every bit of grain produced in the farm reaches the consumers without being wasted in between, our being able to increase the crop yield is of no avail. In fact, the green revolution has only served to underline and highlight the gross inadequacy of existing storage and preservation practices. Efficient storage should in this sense form the second stage of the green revolution. In many parts of the world, the emphasis is shifting from attempts to increase production, to finding effective methods of conservation to safeguard the benefits of increased yield already achieved. As such, there is an urgent need in India and in the other Asian countries to improve rural storage facilities and develop simple, safe and at the same time effective techniques of infestation control that can be easily adopted by our masses.

Magnitude of Waste

Total production of foodgrains in our country during the past 5 years has been varying from 94 to 108.4 million tonnes, with the estimated figures for 1972-73 being 100 m. tonnes. For a population of 550 millions, (which works to a crude average of 0.5 kg. per capita per day), this cannot, on the face of it, be regarded as inadequate. However, availability of the foodgrains is a factor not only of total production, but also of the extent to which we are able to reduce wastage. About 60-70% of the foodgrains produced by the farmers is retained

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The paper is based on the presidental address delivered by the author at the seminar.

for their own consumption and use as seed, feed, payment to labour in kind and also to serve as a cushion in case of failure of the next crop. According to conservative estimates, we are losing not less than 10% and possibly a much higher proportion of the foodgrains we are producing, during storage, by depredation of insects, rodents, fungi, fire hazards etc. This works out to a minimum of about 10 million tonnes, a little more than the quantum by which we fall short of our needs. In other words, some people go hungry, or precious foreign exchange is used to import foodgrains not because we have not produced enough, but because we have not taken adequate care of the output. Labour and investment have been used in the production of foodgrains. To lose the grain in storage or transport is a double loss.

Major Causes

Climatic conditions such as high temperature, high humidity in our country are on the one hand advantageous for the growing of crops ; but on the other hand, they are also conducive to fast proliferation of insect pests and micro-organisms which are responsible for rapid deterioration of food commodities in the field as well as during handling, storage and processing. Although national level action aimed at prevention of waste and loss of foodgrains from the activities of insects, moulds and rodents could significantly reduce the gap between production and consumption in a country, an international approach to accomplish this objective has to be promoted, so as to abridge the gap that arises from time to time. The FAO and other International Organisations and also the countries concerned have set up committees to assess the magnitude of loss of foodgrains at various stages from production to distribution. To-date there is wide discrepancy in the estimates in respect of such losses. Moreover these estimates are mostly confined to weight loss. But what could be stressed is that the weight loss does not unfold the total loss the commodities undergo after harvest. Other than loss in weight, the foodgrains also undergo a qualitative loss pertaining to carbohydrates, proteins, vitamins, minerals, etc. due to (1) the most nutritious material having been eaten away by the insects, (2) mycotoxins being produced by the mould infection, (3) unhygienic condition of the commodity resulting from insect fragments, excreta, etc. There is often a lack of full appreciation of the real parameters of the total loss.

Today we are also aware of the problems of fungal infection in foodgrains and oilseeds. This aspect of damage to the foodgrains was perhaps not very well appreciated till lately. Toxins produced by micro-organisms cause alarm regarding the safety of the foods contaminated with organisms producing these toxins. There is no denying the fact that some of these toxins pose great hazards to the health of our population.

Harvesting in the wet season and moisture condensation and seepage in storage structures are some of the factors responsible for the growth of micro-organisms resulting in the production of toxins, as normal metabolites to these infectious organisms. Drying of foodgrains is an important and simple step to overcome this problem, but it does not provide total protection against the infestation and infection. A good deal of further research and development work is needed on the problems of harvesting,

handling, drying conditions, storage structures, finding out non-toxic protectants for safe storage of food commodities and also newer technologies in respect of suitable insecticides, etc. Control of insect infestation by fumigation techniques has been found to be quite sound, successful and economical. The Indian Chemical Industry has been making efforts to manufacture fumigants required for such control measures in the country itself. As of late, large number of pest control firms equipped with modern scientific methods have also come forward to handle the problem of infestation control, who take up contract jobs for the food corporations, grains merchants and other traders. However, their services are mainly available in the urban areas but the problem today is not that much serious with the urban storages. The problem is acute in the rural areas where 50-57% of the foodgrains are retained by the growers for their own use. It is this quantity which is being stored in the most vulnerable conditions and requires scientific and technological inputs to minimise the losses due to infestation and microbial infection and contamination due to insects fragments, excreta, etc. The position is not far different in the neighbouring Asian countries.

Role of Research

Techniques to be recommended for application in the rural areas should essentially be simple, effective, safe and economical. The use of highly complicated techniques, sophisticated instruments and machines, requiring specially skilled technicians is not likely to be very popular or effective in our rural sector. It is, therefore, a challenge for the scientists and technologists to develop techniques which will be suitable in the conditions prevailing in the rural areas of the developing countries. It is gratifying to note that efforts are being made in various national and international research centres regarding the development of techniques and the know-how of simple, safe, effective and economical methods for handling and storage of foodgrains. This international training Forum will, no doubt, provide an effective opportunity for exchanging ideas and information on latest advances in the field of Prevention of Waste and Loss of Foodgrains available with various developing countries of the region.

As regards India, it must be said that the National Committee on Science and Technology which is preparing the Science and Technology Plan with the cooperation of a number of scientists, engineers, agriculturists, etc., has, in view of the importance of the subject of post-harvest technology, identified the need for concentrated studies in this sphere. To mention a few: (a) research and development on improved storage structures, (b) development of bulk handling equipment like driers, cleaning machines etc., (c) development of non-pesticidal methods to control insects and pests to avoid residues of harmful insecticides, and (d) programmes for the control of rodents.

Work on the above problems is already going on in a small way at the Indian Grain Storage Institute, Hapur, the Central Food Technological Research Institute, Mysore and a few other institutions. The Hapur institution which was set up in 1968 with assistance from UNDP is being converted into an apex-level training centre for imparting training in the scientific techniques of grain storage.

As merely obtaining results in the laboratory will not do, training and demonstration at the village level has to be provided on all the above projects to take the results of the laboratory to the field. The increasing involvement of public agencies in wholesale trade in wheat and rice would, it is hoped, provide the necessary infrastructure for the large-scale national effort for conserving food by the application of science and technology to the reduction of losses in transit and storage.

The Ministry of Agriculture for its part, has launched a programme of 'Save the Grain Campaign' throughout the country aimed at educating the farmers in scientific storage of foodgrains. The scheme was initially started in 1969-70 at the beginning of the 4th Plan. Under this scheme, the State Governments are given financial assistance for popularisation of improved types of storage structures. The State Governments in turn provide interest-free credit facilities to cultivators for the purchase of storage structures of 1 to 10 tonnes capacity designed by the Indian Grain Storage Institute. Training in scientific storage at various levels also forms an important part of the programmes, and the apex level training, as mentioned earlier, is to be provided at the I. G. S. I., Hapur, and its sub-units at Ludhiana, Punjab and Bapatla, Andhra Pradesh.

India being a country of vast distances, varying climates, and with a wide range of food crops, the problems of storage, transportation and processing of foodgrains are also bound to vary from region to region. Work on these problems has necessarily to be carried out on a zonal or regional basis. Modernisation of storage at the farm and community level can be carried out intensively in phases, in selected areas with marketable surplus and progressive cultivators and extending it on to other areas subsequently. What is true for India will be equally applicable to the whole of Asia ; a set of practices suitable to one region or country may not be exactly applicable to another region or country.

We are making great strides in the field of atomic research and irradiation techniques of foodgrains preservation is of direct relevance to us. Apart from guarding losses during storage, there is also an urgent need for developing methods to preserve seasonal and perishable commodities for longer periods to extend their availability at low cost, and to meet the nutritional needs of the masses. On this point, unlike fumigants, radiation disinfectation seems effective in killing or sterilising the insect in all forms of its life-cycle and freedom from toxic residues confers an important additional advantage. Low dose irradiation effectively inhibits sprouting in onions and potatoes and significantly reduces losses and opens up an alternative to costly cold storage facilities. Radiation-induced delay in ripening affords the crucial extension in shelf life and enables export promotion. Same is also the case with the preservation of seafoods.

In conclusion it may be pointed out that in spite of the work that has been done and is being carried out, the results achieved at the farm level so far have not been quite satisfactory. There is therefore an obvious need to find out where exactly the countries have fallen short in the implementation of their programmes and how best they can achieve better results. □

Problems of Technology Transfer in Food and Agricultural Industries in Developing Countries

H. A. B. Parpia*

Optimisation of the use of agricultural resources and their use in development of economically sound industries can add substantial amount of value to the primary produce, provide additional employment, conserve food, raise nutritional standards, earn more foreign exchange and raise the level of overall self-reliance. This would, however, require careful selection of appropriate technologies and their effective use. In the present paper the author identifies some areas where technology transfer could be a great help to the developing countries and provides policy guidelines and a framework within which selection of an appropriate technology and its effective use can be made in the developing countries.

A LOOK at the world picture of poverty and affluence clearly shows that economic progress is directly proportional to the use of science and technology. Increasing recognition of this fact is creating a new consciousness among the planners and decision-makers that the role of science and technology is of vital importance to overcome poverty, malnutrition, unemployment and several other factors responsible for human suffering; but it has yet to take a concrete shape in many developing countries to achieve the objective of speeding up progress and raising the degree of self-reliance.

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This paper was originally prepared for the International Seminar on Technology Transfer held in New Delhi, India, from 11-13 December 1972.

The objective of this paper is to discuss what science and technology can do to convert the economy of developing nations from being predominantly exporters of agricultural raw materials such as spices, cocoa, coffee, oilseeds, natural fibres, etc., to processors and manufacturers of food and agricultural products and exporters of finished goods.

The magnitude of the problem becomes clear from the fact that 71% of mankind which lives in the less advanced countries earns only 21% of the world income and produces about 42% of the food. Nearly 50 to 80% of the gross national product of a number of these countries comes from agriculture which is the main indigenous resource for further development and progress.

Optimization of the use of agricultural resources and their use in development of

economically sound industries can add substantial amount of value to the primary produce, provide additional employment, conserve food, raise nutritional standards, earn more foreign exchange and raise the level of overall self-reliance. This would require careful selection of appropriate technologies and their effective use. Development of food and agriculture industries can result in stimulation of agricultural economy to produce better quality raw materials at more economical prices and in the encouragement and support for the development of other industries such as chemicals, plastic films, paper and laminates, metal containers, transport, machinery, etc.

The food and agriculture industries cover a number of important areas The importance of these in the economic development of less advanced countries is briefly indicated below:

A. Foodgrain Industry

Foodgrains constitute nearly 80% of the diets of a large majority of the people and are also the largest single source of calories and proteins in the world. They include wheat, rice, corn, sorghum, millets and a number of grain legumes such as the chick pea (Bengal gram), mung beans, etc. Post-harvest losses of foodgrains in several developing countries vary between 25 and 50%. The qualitative losses are also very high as the protein efficiency ratio and the vitamin content drop considerably. Also microbial, insect and rodent infestations lead to development of harmful toxic substances and addition of undesirable extraneous materials. If the quantitative losses can be prevented and quality maintained through use of proper technology for storage, handling and processing, it will help many countries to achieve self-sufficiency in their nutritional requirements. Major areas of foodgrain industry which require immediate attention are:

1. Storage and handling of foodgrains. This should include improvement and design of suitable storage structures and development of post-harvest drying, handling and infestation control techniques for use in rural and urban areas.
2. Modernization of milling and processing technology of foodgrains.
3. Manufacture of cereal products—modern and traditional, including paste goods and bakery products.
4. Manufacture of foodgrain by—products and waste utilization.

The conditions under which these staple foods are processed, stored and consumed vary considerably from those in the advanced countries. Therefore, appropriate technologies have to be developed through adaptive and applied research to suit the socio-economic conditions.

B. Nuts, Oilseeds and Vegetable Protein Industry

Oil crops are not only the main sources of edible fats and oils in many developing countries but also the second largest potential supply of proteins after foodgrains. The traditional concept of oil millers must change and they should realize that the industry must also become a modern oil and protein industry. With the modernization of the entire traditional

operations especially in rural areas the quality and quantity of oil extracted can be increased substantially. With proper control on quality and processing conditions, the extracted oilseed meal can retain high biological value and can be used for human consumption in a number of food preparations. Better use of oilseed meal can also increase the total available supplies of food. Present daily consumption of fat in developing countries is 10-20 grams per capita as against the requirement of nearly 60 grams. If solvent extraction can be introduced, the fat supplies would go up by 10-15% in many countries. If fully utilized, oilseeds can supply up to 28 grams of protein per capita daily, which is over 50% of the requirement for human consumption. Exotic nuts such as cashews, almonds, pistacios, brazil nuts and chestnuts are important foreign exchange earners for many developing countries. Main areas of these industries which deserve priority attention for modernization through the use of appropriate technologies are:

1. Increasing the yield of oil extraction from oilseeds.
2. Processing of oils and fats for various end-uses.
3. Manufacture of high protein oilseed meals, concentrates, isolates.
4. Manufacture of protein foods using oilseed proteins.
5. Better use of non-traditional sources of oils for industrial purposes, such as soaps, lubricants, etc.
6. Improved processing of exotic nuts to manufacture better quality products for export in consumer size containers.
7. Manufacture of by—products.

There is urgent need to develop modern and efficient small and medium scale technology for the processing of oilseeds and nuts that would ensure quality products for consumption at home and export. At present several developing countries also export oilseeds and unrefined oil for processing and consumption to advanced countries.

C. Fruit and Vegetable Processing Industry

In many developing countries the losses of fresh fruits, vegetables, roots and tubers are very high, amounting to 25% or more. If the produce can be properly handled, prepackaged, stored, transported, processed and marketed, the food supplies can be increased substantially and economic returns of the growers improved, besides serving the consumer better and earning foreign exchange. The areas of this industry which need attention are:

1. Picking, transport, waxing, grading, packaging, cold storage and transport of fruits and vegetables for market.
2. Drying, freezing, canning and concentration, pickling, salting, curing of fruits and vegetable products.
3. Utilization of fruit and vegetable wastes for byproducts manufacture.

Improvement of traditional packaging and adaptation of modified modern packaging technology would require a systematic programme of research and development, specially to utilize the traditional raw materials.

D. Starch and Sugar Industry

The prices of sugar and starches are very high in most developing countries. Besides the high price of raw materials, the other factors which add to the price are uneconomic operation due to poor technology and equipment and improper utilization of waste for the manufacture of byproducts. The areas of this industry which require attention are:

1. Manufacture of sugar from beets and sugarcane on a small and medium scale.
2. Manufacture of high quality starch and glucose from certain cereals and tubers.
3. Byproduct utilization in composite animal feed formulations and other uses.

E. Fermentation Industry

Fermentation as a means of food preservation is one of the oldest known technologies. There are many traditional fermented foods consumed in different parts of the world. With economic development and urbanization, the demand for commercial production of these foods offers good potential. This calls for modernization of the industry and also for establishing manufacture of a number of modern fermented food products. The areas of this industry which require attention are the manufacture of :

1. Wine
2. Brewery products
3. Distillary products
4. Yeast manufacture
5. Amino-acids and glutamates production
6. Traditional foods, such as tofu, shoyu, tempeh and sauces.

The modernization of existing art technology for processing of traditional products, as demonstrated in Japan, can help to build small and medium scale industries for manufacture of high quality products for the urban population and for export.

F. Non-alcoholic Stimulant Products

Items like tea, coffee, cocoa and certain traditional drinks in different parts of the world, are consumed in large quantities. These products are also major earners of foreign exchange for them, but the industry faces a number of difficulties as the changing pattern of consumption requires new products to fill the nutritional and social needs. The area of this industry requiring attention are:

1. Tea, packaging, processing, storage and transport.
2. Coffee, packaging, processing and transport.
3. Cocoa, storage, handling and processing.
4. Chocolate and confectionory products manufacture.
5. Manufacture of byproducts such as caffene.

Development of new products and establishment of a techno-economically sound industry for their processing, especially in the case of cocoa, would help to export

finished goods rather than raw materials.

G. Spices and Essential Oils Industry

Although these products are large foreign exchange earners, they are exported by many countries as raw materials. If quality standards can be improved and processed products can be exported such as spice oils and extractives, the foreign exchange earnings can be increased substantially, besides providing additional employment. The areas of this industry which deserve priority attention are:

1. Pre-processing and packing of spices for home market and export.
2. Manufacture of spice oils and extractives.
3. Manufacture of byproducts.

Research and development work already carried out has shown potential for the manufacture of various products listed above. Their export will have to be carefully worked out as there would be stiff competition from the well-established manufacturers in the advanced countries. Perhaps cooperation with them in marketing may be a mutually satisfactory arrangement.

H. Meat and Poultry Industry

This is one of the industries which deserves urgent attention as the existing conditions of abattoir, handling, packaging, processing, distribution and marketing leave much to be desired in most of the developing countries and can also prove a serious health hazard. Its modernization can be of great value for providing stimulus to development of animal husbandary. Priority areas of the industry are:

1. Abattoir, packing, storage and marketing of fresh meat and poultry.
2. Curing, canning and freezing of meat and poultry products.
3. Collection, cleaning, grading, costing, packing, storage and distribution of eggs. Manufacture of egg powder.
4. Processing of hides, skins and animal byproducts.
5. Manufacture of leather goods on cottage and small scale.

Application of the technology already available can prevent breakage of eggs and bring better economic returns. Similarly, introduction of improved processing methods for animal byproducts suitable for different countries can increase foreign exchange earnings from byproducts several times.

I. Milk and Dairy Products

Milk and its products continue to occupy a high position in the nutrition of most countries including the developing ones, in spite of their high price. Considerable amount of attention has been given to its development in a number of countries and the industry deserves continued encouragement and support. The areas which need emphasis for further development are:

1. Market milk—its collection, standardization, processing and distribution.
2. Manufacture of milk products, such as weaning and infant foods, cheese, butter and other dehydrated and concentrated products, both traditional and modern.

3. Better utilization of byproducts such as casein and whey.
4. Stretching of milk supplies by the use of vegetable proteins and reduction in cost to meet the nutritional requirement of low-income populations.

The work already done on milk toned with vegetable proteins has shown the possibilities to meet the requirement of developing countries, in some of which the per capita milk consumption has been dropping.

J. Fish and Fish Products

The potential for the development of this industry in most of the less advanced countries is quite large. The fish resources of many of them, have been exploited only to a limited extent. Fish can not only improve the diet and raise nutritional standards with regard to high quality protein, but can earn larger amounts of foreign exchange in many cases. The areas of fish industry which deserve attention for further improvement and modernization are :

1. Collection, handling and packaging of fresh fish, cold storage, freezing, smoking and refrigerated transport.
2. Canning, curing, pickling and drying,
3. Fish byproducts.

Adaptation and development of packaging technology using local and modern materials has begun to show good promise in some of the developing countries.

K. Animal Feed Industry

The need for animal feed production is being increasingly felt in many developing countries of the world to raise production of milk and other animal foods. The areas which deserve urgent attention are:

1. Manufacture of balanced composite poultry and animal feeds from the available raw materials such as animal byproducts, fish meal and vegetable proteins.
2. Manufacture of pet food in some of the countries for export.

This industry will have to be based in many developing countries on *byproduct vegetation* as the per capita availability of land is low and the main produce has to be used for human consumption. This calls for modifications in the existing cattle feed manufacturing pattern as compared to the advanced countries.

L. Natural Fibre Industry

One of the largest areas of agro-industries is the manufacture of products from natural fibres. The products from the fibre industries represent culture, tradition, art and means of livelihood for a substantial portion of the world population besides meeting their clothing, packaging and other needs. For the survival and progress of this industry, it is most essential to place it on a modern scientific foundation. This will provide impetus to the raw material production. Natural fibres can be used to produce high quality fabrics by mixing them with artificial fibres. This will supply exotic goods to meet the requirements of the modern consumer and for export. The

areas of this industry which deserve greater attention are:

1. Cotton, ginning and grading, its spinning and weaving on a small scale.
2. Wool, shearing, scouring and grading, combing for further processing.
3. Introduction of high-yielding races of silk worm and improvement in silk reeling and weaving.
4. Jute ratting and decortication.
5. Flax ratting and scutching on cottage and small scale.
6. Mechanization and improved extraction of hard fibres such as coir, etc.
7. Development of mixed fibres having new properties.

Emphasis on production of specialized exotic fabrics, carpets and other handicrafts, their partial mechanization and development of better designs, colour-fastness etc., deserve special attention in many developing countries.

M. Rubber Industry

Demand for natural rubber continues to rise and its production is also increasing in many developing countries. If the processing industry can be developed along modern lines, it can bring better economic returns from export of finished products rather than raw materials. Increasing attention is required for improving the technology of :

1. Processing natural rubber after tapping, pre-processing rubber in various forms, e.g. block rubber, packaging and transport.
2. Manufacture of rubber goods on a cottage, medium and small scale.

N. Tobacco Industry

Production of tobacco in developing countries has been rising. The areas of this industry which deserve attention are:

1. Collection, curing and packaging of tobacco.
2. Manufacture of tobacco products on a cottage and small scale.
3. Byproducts.

This is another commodity exported as raw material. It would be advisable to develop specialized products as some countries have already done, and export tobacco at least partially as finished goods.

O. Food Machinery Industry

Technological success, quality and standards of the products of agro-industries and efficiency of their operation to maintain uniformity depends upon the use of appropriate equipment and machinery to a considerable extent. It is, therefore, essential that a sound programme of equipment and machinery design and development for indigenous manufacture to meet the requirement of cottage, small and medium scale agro-industries be undertaken on priority. This will help to set up the required machinery industry and ensure export of good quality products to stand competition on the world market. No technology can succeed without proper tools.

Selection and Transfer of Technology

The need for selection and/or development of appropriate technologies and their utilization raises the complex question of technology transfer for the development of economically sound food and agriculture industries. In order to look for appropriate technologies, the following factors require careful study to identify the problems which the technologies are expected to solve in a developing country:

1. The level of economic and technological development of a country or an area where the problem exists.
2. The competence of the social structure to absorb and utilize technology.
3. The nature and magnitude of the problem for which solution is required.
4. The indigenous physical and human resources available.
5. The social change that can be introduced to build the competence to use a technology. The dynamic forces of culture change and motivating factors must be understood.
6. The existing practices, if any, to handle the problems. Study of any existing traditional art technology in use and the degree of its effectiveness. Its possible development into a science-based technology or substitution by another *workable* technology that would solve the problem and take the society forward.
7. Level of existing industrialization, the nature and level of its technology and its appropriateness or obsolescence.
8. The foreign exchange picture and what can be done to improve it.
9. Management competence available and the need to build it further at various levels.
10. The existing technological competence within the countries and the extent of supplementation required for progress.
11. The priorities given to agro-industries in the economic development plans. Are these priorities appropriate? Can changes be made in it?
12. The entrepreneurship available in the country? If not, how can it be built and the extent of supplementation needed from abroad.
13. The existence of an infra-structure for research and development, if any, in the specialised fields of food and agricultural sciences and technologies.
14. Degree of awareness of the value of science and technology among the planners, policy makers and executives in the government and industry. What can be done to strengthen this awareness where necessary.

A study of the above factors and an understanding of their network should help to arrive at a clearer idea of the manner in which the problems need to be solved and

the nature of the technologies selected to meet the requirements.

Effect of an Existing Structure

Perhaps one aspect which needs to be examined in some details is the existence of an industrial structure based on imported technology and its impact on the system for future progress. Some of its advantages and disadvantages are discussed below for an example:

Advantages

1. If the technology is imported, in many cases as a complete turn-key plant, the time factor to set up an industry is cut down.
2. Foreign exchange component for equipment is supplied by the expatriate collaborating firms as share of their equity. This provides additional capital.
3. Management and marketing experience is also provided in many cases, but is essentially based on foreign experience.
4. In a few cases a certain percentage of export is made possible.
5. This type of development helps to create the awareness of the role of industry in a developing economy if the awareness was not adequate already.

Limitations and Disadvantages

1. The technology supplied is kept secret and is not allowed to be used as the starting point of research and development in many cases.
2. If competition has to be created to meet increasing demands for the products, another foreign entrepreneur has to be licensed as the technology cannot be shared.
3. The plant and equipment supplied in several cases are obsolete or become obsolete after installation. Therefore, new technology has to be imported at a much higher cost after a few years.
4. In a number of cases the export of foreign exchange in the form of profit on shares and royalty payments far exceed the original investment within a few years.
5. Several collaboration agreements provide for export restrictions on finished products to eliminate competition with the parent company or support export of semi-finished goods to be finished abroad by the parent company.
6. This type of development does not encourage indigenous research and development to achieve self-reliance in science and technology.
7. In a number of cases the imported technology, plant and equipment are not the best suited to indigenous raw materials and operating conditions. The appropriateness of technology can be questioned. In several cases this has resulted in failures or high costs of production.
8. In most cases the pragmatic profit motive and export of earnings are the primary considerations of such enterprises; social needs or

commitments, if any, have a secondary place.

9. In case of centrally planned countries, the question of technical cooperation for industrial development is dependent upon different considerations as compared to the Western industrial nations, where collaboration is established with private firms, with due consideration to government policies.

Policy and Framework

The success of a technology depends not only upon its proper selection, but on its modification to suit the requirements and further development to meet the changing needs. This is a dynamic process which requires a proper infrastructure based on the following considerations :

1. A policy for scientific and technological progress geared to the economic development plans for improvement of the existing industries by raising their productivity and setting up of new units to ensure a systematic growth.
2. A clear decision on the technologies that have to be imported and those that need to be developed as short, medium and long range measures.
3. Allocation of resources for research and development in relation to the magnitude of the problems to be solved and the economic benefits to be derived.
4. Establishment of research and development institutes to fulfil the following needs :

(a) Assist the government and the industry in selection of appropriate technologies to be imported as per policy decisions.

(b) Modify the available or imported technologies and use them as the starting point for further research and development.

(c) Provide technological advice on the basis of available information to make better use of the existing and imported technologies for manufacture of high quality products.

(d) Collect and disseminate information from published literature to keep the industry, research organizations and government departments abreast of the changes taking place in the field of food and agriculture technology.

(e) Undertake technological research, priority-wise, based on available scientific information to develop new technologies.

(f) Undertake basic research to raise the level of existing technologies and to develop completely new technologies for keeping abreast of the world. This type of research in developing countries will, however, depend upon the resources available for the purpose Its importance must be recognized for building a self-perpetuating technological structure for a continuous process of socio-economic progress.

(g) Provide comprehensive consultancy and extension service for assisting the industry in preparing project reports, to set up new industries, carry out feasibility studies to prove the workability of selected or newly developed technologies and carry out extension work to provide assistance to the small scale industries for rural development.

(h) Carry out pilot plant production of new products and assist the industry in marketing them for establishing their commercial potential. This type of work becomes essential in developing countries to minimize the risk of small and medium scale industrial entrepreneurs whose resources are limited.

5. A sound programme of education and training to train personnel of industry, research and development institutions and government departments. The training should be based on providing practical and theoretical background to solve the problems and should not be given in isolation from them if it has to be of real value.

THE ROLE OF INTERNATIONAL AGENCIES

During the Second United Nations Development Decade, several U.N. Agencies have decided to give high priority to providing assistance, scientific, technological, managerial and financial, in setting up industries.

The Food and Agriculture Organization is particularly committed under its policy of agricultural adjustment to bring about a major change in the agricultural economy of developing countries. It has, therefore, laid emphasis on the development of food and agricultural products processing industries in these countries so that they may become manufacturers of products based on the raw materials they produce for their own consumption and export. They have prepared the following documents :

"High Priority Needed for Agro-Industries in the Economic Development Plans of Technologically Less Advanced Countries". AGS : MISC/71/58 July 1971 :

"Industry Twinning", AGS : MISC/71/57 July 1971.

The first one lays emphasis on the need to give high priority to agro-industries in the economy of developing countries while the second one aims at transfer of technology to achieve the objective of agro-indusries development.

The most important points emphasized in these FAO documents are as follows :

1. Transfer of technology from a small or medium scale industry to an advanced or a developing country, from where it is available as a gesture of goodwill and international understanding, to a developing country where a suitable entrepreneur is available and is interested in its utilization.

2. Obtaining technical knowhow from an advanced or a developing country

as a part of the purchase of machinery and equipments.

3. Outright purchase of a technical knowhow on payment.
4. Purchasing technical knowhow on payment of a royalty for a fixed period.
5. Providing technology as part of equity capital participation in an enterprise if the government rules and regulations permit.
6. Purchase of new technological knowhow from Research and Development Organization on outright payment or on royalty basis.

The technology can be transferred from an advanced country to a developing country or between two developing countries on the basis of the above. In certain cases there may be an advantage in obtaining technology from a developing country as it might be more suitable to the socio-economic needs of another developing country and may fulfil the needs more appropriately.

The main objective of the FAO Industry Twinning Programme is to locate a package of assistance which would include technolgy, management, marketing and training as these four factors are essential for the success of any enterprise.

The United Nations Industrial Development Organization (UNIDO) has also shown interest in certain areas of agro-industrial development under their Industry Partnership Programme. The International Bank for Reconstruction and Development (IBRD) has carried out several surveys to determine the needs of developing countries in different sectors of industry. They are seriously considering inclusion of research and development as essential components of every project sponsored by them in order to strengthen the indigenous foundation for making technological development self-sustaining in the developing countries. The International Trade Development Centre has carried out valuable surveys for marketing of food and agricultural products.

The international agencies could even assist in stimulating bilateral collaboration by using their good offices and strengthening the UNDP Country Programmes to achieve their objectives as a part of the country's economic development plan.

Several U. N. Agencies are working in the same direction and have shown keen interest in supporting the development of food and agricultural industries in the developing countries. With the growing cooperation among them it should be possible to ensure optimization of their resources to assist the developing countries in a more effective manner to build food and agriculture industries through transfer of appropriate technologies.

Before concluding this paper, it may be worth mentioning that the new awareness of technology transfer which has arisen over the last 15-20 years, can prove of immense value in speeding up overall economic progress in which agro-industries have a vital role to play. □

Management of Storage, Preservation, Transportation and Processing of Foodgrains in India

P. M. Thomas*

The magnitude of waste and loss of foodgrains during storage, transport, processing etc. calls for an integrated approach for minimising these losses. The basic elements of such an integrated approach are : construction of suitable storage structures with modern amenities for handling, weighing, cleaning drying etc., uniform grading of foodgrains; proper credit facilities; adequate provision for dunnage; proper stacking; quality control; better transportation; modern methods of processing; and training and extension service. Each of these elements are elaborated in this paper with a view to show their effectiveness in reducing the waste and loss of foodgrains.

AGRICULTURE provides the source of livelihood for more than two-thirds of India's 560 million people. But even then food production is not enough to meet the demands. As a consequence, India is compelled to import foodgrains. The population is growing at an annual rate of 2.5 percent while the urban population at 4 percent. The rate of increase in food production has to catch up with the requirements. By the end of Fourth Five-Year Plan in 1974, a target production of 129 million tons of foodgrains is aimed at to be self-sufficient.

Post-Harvest Loss

In tropical India, the high humidity and temperature are ideal for rapid multiplication of rats, insects and micro-organisms and considerable quantitative and qualitative losses are occurring to foodgrains. It is estimated by various agencies that loss in India on account of defective storage, handling, transport, packaging, etc. varies from five percent to 20 percent by weight. It is officially estimated that the loss is at 9.33 percent as shown in Table 1.

Much of this loss can be minimized by a scientific approach to the problem. Besides this quantitative loss, the qualitative loss due to sprouting, loss in viability, development of acidity, and, loss of nutritive quality of edible products, is manifold. By proper scientific storage and handling, this loss could be considerably minimized and the need for importing foodgrains can be substantially reduced. Of the total food-

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grains production in India, 60 percent to 70 percent is retained by farmers and the marketable surplus is handled by traders, cooperatives and Government agencies. The storage and handling loss in Government and Government agencies is estimated to be less than one percent since scientific storage and preservation are carried out by qualified and trained staff. Considerable improvement in storage is needed at village and trade levels. The cooperatives and warehousing corporation are extending scientific storage at these levels.

TABLE 1

Loss as Percentage of Food Production in Storage, India, 1962-65

	Threshing yard	*Transport*	*Processing*	*Rodents*	*Birds*	*Insects*	*Moisture*	*Total*
Wheat	1.0	0.5	—	2.5	0.5	3.0	0.5	8.0
Rice	2.5	0.5	2.0	2.5	1.0	2.0	0.5	11.0
Jowar	2.0	0.5	—	2.5	1.0	2.0	2.0	10.0
Bajra	0.5	0.5	—	2.5	1.0	1.0	0.5	6.0
Maize	0.5	0.5	—	2.5	0.5	3.0	0.5	7.5
Gram	0.5	0.5	—	2.5	0.5	5.0	0.5	9.5
Millet	1.0	0.5	—	2.5	2.0	0.5	0.5	7.0
Pulses	0.5	0.5	—	2.5	0.5	5.0	0.5	9.5
Total	1.68	0.15	0.92	2.50	0.85	2.55	0.68	9.33

Integrated Management

The storage, transport and processing problems are being tackled by an integrated approach from various angles as follows :

1. Construction of suitable storage structures with modern amenities for handling, weighing, cleaning, drying, etc. ;
2. Uniform grading of foodgrains ;
3. Extending credit facilities ;
4. Providing proper dunnage ;
5. Proper stacking ;
6. Preservation of quality ;
7. Better transportation ;
8. Modern methods of processing; and
9. Training and extension service.

Scientific Storage Structure

Suitably designed and constructed storage structure is the most important single factor for safe storage and economic handling of foodgrains. In India storage construction had been planned by Government for quick distribution, generally for bagged storage, since cheap human labour and steady supply

of jute bags are available. The conditions are rapidly changing and the planning for future storage needs has to fall in line with the national and international developments. The rice storage is planned for bagged storage, while for paddy, wheat and other foodgrains storage is planned either in bulk or for bagged storage. The storage structures differ from region to region depending upon climatic conditions. kind of commodity stored, quantity handled, storage period, expected life of structure, financial resources, etc. Broadly, storage is divided into bulk storage and bagged storage.

1. *Bulk storage*—The underground bulk storage had been traditional in India but it has not made much scientific advances as in Argentina or some other countries. The overground bulk storage structures in vogue in India are : (a) "Kothis" ; (b) small metal bins; (c) hexagonal bins ; (d) circular small bins ; (e) R.C.C. flat bins (2,000 to 4,000 tons capacity) ; (f) R.C.C. circular bins (700-1,250 tons capacity) ; (g) steel circular silos (500-ton capacity) with modern facilities for automatic lifting, cleaning, drying weighing, filling, aerating, disinfesting, discharging, bagging, stitching, etc.

2. *Bulk capacity*—Bulk storage structures are gaining more importance in current construction programmes. The existing bulk storage capacity with Food Corporation of India alone is about 440,000 tons and another 200,000 tons will be ready by the end of the current plan period. During the Fifth Five-Year Plan, 1.5 million tons bulk storage is likely to be added in F.C.I.'s programme.

3. *Bagged storage*—In India the bagged storage godowns are planned on scientific lines with high plinth, moisture-proof flooring, rodent and bird-proof with ancillary structures and modern amenities like road and rail movement facilities, quality control, laboratory, dead stock store, poisonous chemicals store, administrative block, isolation shed, canteen block, laboratory block and sanitary installations, water and electric supply, fire-fighting arrangements, lorry weighbridges with weighment rooms, resting shed for labour, drying platforms, compound wall, gates, watchman's cell, quarters for watchman and other facilities for staff use. Godowns are also equipped with power dusters, power sprayers, moisture meters, grain cleaners, wooden crates and other equipment for storage and preservation.

The existing bagged storage structures are for multipurpose use, including fertilizers and other commodities. Some of the existing designs are :

(a) Godown with wooden trusses,

(b) Reiser type godown,

(c) Conventional type with single iron or steel trusses and purlins,

(d) Conventional type with tubular trusses,

(e) Conventional type with modified specifications,

(f) R.C.C. shell roof, and

(g) R.C.C. flat roof.

Generally, for godowns of 10,000 tons and above storage capacity, railway sidings are provided. Out of the various types of designs, R.C.C. flat roof godown is considered ideal from storage angle.

4. *Reinforced cement concrete flat roof godowns*—For sizeable storage capacity, R. C.C. flat roof godown of 136 M x 24 M (154′—9″ x 80′—3″) with two partition walls dividing the godown into three compartments is considered ideal. The gable walls and longitudinal walls are of bricks or stone masonry with R.C.C. columns at intervals to support the roof structure. The roofing consists of a R.C.C. slab laid with a slope of 20 cm (8″) from the centre to the edge. On each longitudinal wall rolling shutters of 2.40 M x 2.40 M (8′ x 8′) are provided at the rate of 10 doors ventilators at the top as well as at the bottom which are provided within the walls as in the case of conventional godowns. Covered platforms are provided both on the road side and rail side of the godown. It is also provided with exhaust fans. The maintenance expenditure is comparatively less and the life of the building is estimated to be much longer than other designs. The quality maintenance of foodgrains is convenient since the structure could be made easily air-tight.

5. *Farm storage*—Price support and marketing operations bring sudden spurt in market arrivals, creating serious problems of transport, storage, labour needs, etc. The storage techniques had to be changed. To meet the challenge of storage, plastic bins, rubberised fabric bins, butyle rubber containers, Pusa bins, concrete bins, corrugated steel bins, etc. have been experimented on and tried with success.

6. *Cover and plinth storage*—To meet the acute storage problem, open storage was resorted to during the heavy procurement season in 1970. In this system, standard rectangular stacks of 30′ x 20′ or about 9 meters x 6 meters are built over wooden crates on constructed plinth in the open. Rectangular polythene covers of 30 feet long (about 9 meters), 20 feet wide (about 6 meters) and 18 feet high (about 5.5 meters) made out of 1,000 gauge black polythene are spread over 20 bags high. The covers are made of heat polythene films of 10 feet (about 3 meters) to 18 feet (about 5.5 meters) wide. On top of the stacks four layers of bags are arranged to form a dome to avoid accumulation of water. Three air duct tubes, approximately 12 inches long (30.48 cms) and 10 inches (25.40 cms) in diameter one on the centre of the top and two on the cover. The cover is fastened with a strong half-inch thick cotton rope twice horizontally and vertically knotting at the joints and fastening tightly to the wooden crates below to avoid balooning and blowing away by winds. This emergency storage proved very effective in preserving foodgrains in the open. At present over 1,663,570 tons of grains are stored in the open under cover and plinth programme.

7. *Cost*—In a modern silo, grain can be preserved for many years without fear of quantitative or qualitative loss compared to eight months to 10 months life in bagged storage. The cost of construction of bagged storage on scientific line with all ancillary buildings, roads, etc. would be about Rs. 200-250 per ton while a modern bulk silo would cost about Rs. 300-350 per ton with all mechanical equipments. For long storage mechanical bulk is essential.

Buffer Storage

By the end of the Fourth Five-Year Plan, the food production is planned to be about 130 million tons. By a scientific approach to agriculture, a green revolution

to increase the production of foodgrain is taking place. In spite of rapid increase in human population, it is expected that the food production by 1973-74 would be enough for domestic needs and the import of food could be avoided. With the increase in production, the Government of India has to undertake price support, which is being implemented through the Food Corporation of India. The F.C.I. has to provide suitable bagged and bulk storage accommodation for five million tons of buffer stocks proposed to be created during the Fourth Five-Year Plan. It is estimated that for public distribution, another 2.5 million tons will remain with the Government as the pipe-line stock. Thus, the Corporation is in need of about 7.5 million tons net storage capacity for 8.4 million tons gross capacity.

Grading, Scientific Storage and Credit

With the twin objectives of providing scientific storage and credit facilities for agriculture and industrial commodities by an Act of Parliament the Central Warehousing Corporation was created in Public Sector in 1956.

Three-Tier Warehousing

A village or a group of villages is served by a Cooperative Warehouse up to 250 tons storage capacity under the auspices of National Cooperative Development Corporation. On the other hand, in markets of State importance, State Warehouses up to 5,000 tons storage capacities are provided. The C.W.C. warehouses of bigger capacities are located at markets of all-India importance for inter-state trade and at port towns for import and export. The C.W.C. also provides specialized facilities like cold storage and air-conditioned storage,

1. *Commodities warehoused*—Besides foodgrains, a large number of agricultural and industrial commodities require quality control and scientific storage. These are food products, vegetables, fruits, oil seeds, spices, oil cakes, fertilizers, sugar, jaggery, oil and ghee, tea, coffee, cashewnuts, pesticides, rubber, cement, leather, textiles, wool, steel, agricultural implements, etc. The Central and 15 State Warehousing Corporations are extending quality control, scientific storage and credit facilities for over 200 different agricultural and industrial commodities in 800 centres having a total storage capacity of 3.6 million tons. Similarly, under the auspices of the National Cooperative Development Corporation in Cooperative Sector three million tons storage capacity is available in small godowns capacities.

Storage Capacity for India's Fourth Five-Year Plan

The constructed storage capacity with the Food Corporation of India, State Governments, Central and State Warehousing Corporations and Cooperatives during the Fourth Five-Year Plan is distributed in Tables 2 and 3.

The storage need for the Fourth Five-Year Plan is planned as an integrated programme. The requirements of storage for buffer stock and operational stock of foodgrains are met by F.C.I. Warehousing facilities for producers, Cooperatives and Government agencies are made available by the Central and State Warehousing Corporations. Those of Cooperatives, both for distribution of agricultural inputs and

marketing of agricultural produce, are met by cooperative storage.

Dunnage

Proper dunnage is of prime importance to protect the commodities from moisture seepage and damage. The bottom layer bags of stacks are damaged due to seepage or condensation of moisture by diurnal variations in temperature even though the floor of the godown is made moisture-proof. Among the different dunnage materials in use, wooden crate dunnage is considered ideal as it keeps the stack 10-12 cms. above the floor facilitating the circulation of air underneath. In the absence of wooden crates, a layer of polythene laminated basin or a layer of polythene sheet sandwitched between two layers of matting or 2-3 layers of matting is provided for dunnage purposes. No commodity should be stored without dunnage.

The wooden crates are 1.52 m x 0.6 m size made out of four 1.52 meter lengthwise and four 0.6 meter breadthwise battons of 6.35 cms. x 6.35 cms. in section which are uniformly spaced and nailed to make the frame rigid and painted with two coats of solignum.

Stacking

Generally, different commodities requiring different disinfestation measures are stored separately in different compartments. For safe storage, accounting and preservation, proper stacking is necessary. Stacking is an art and great care is required to lay-out for stack plan before the stock is received. A neat stack plan is made by dividing the floor area into uniformly sized and serially numbered rectangular or square basis. The stack line of 5 cms. broad is drawn in white or black paint to serve as boundary line of the proposed stack. It is

TABLE 2

Constructed Capacity, India's Fourth Five-Year Plan

Agency	*Beginning of Fourth Five-Year Plan (1969)*	*Expected at end of Fourth Five-Year Plan (1974)*
	million tons	
Food Corporation of India	2.62	5.60
State Government	1.40	1.80
Central Warehousing Corporation	0.65	1.30
State Warehousing Corporation	0.23	0.60
Cooperatives	2.60	4.00
Total	7.50	13.30

also important to leave 75 cms. wide alleyways in between stacks, between stacks and walls or pillers for ventilation and operational purpose. The main haulage alleyways should be at least one meter wide. The size of the stack is a matter of convenience depending upon the available area of godown and fumigation cover sizes. Ordinarily the maximum size of a stack should not exceed 9 m x 6 m. Three types of stacking in vogue are simple, cross and block.

In simple stacking the bags are laid one over the other in the same direction and this type cannot form high stable stack. In cross stacking a layer of bags is laid in complete bags alternating to form blocks and in any two adjacent layers this system of lengthwise and breadthwise tiers is reversed. This type of stacking is easy for handling and even after breaking, the stack remains neat and in countable position.

All bags in a stack should be of uniform size and weight. An ideal stack is one which after completion remains stable, perfectly solid in form, having all bags in one plane with no face bulging outward and inward at any point. When stacking, the stitched mouth of bags should not face the peripheral side in any case.

TABLE 3

Owned and Hired Storage Facilities by F.C.I., India*

Agency	*Hired by F.C.I.*	*Owned by F.C.I.*
	(thousand tons)	
Food Corporation of India	—	4,898.79
State Governments	494.77	—
Central Warehousing Corporation	776.72	—
State Warehousing Corporation	280.48	—
Private Parties	1,575.46	—
Total (hired and owned)	8.026.22	
Cover and Plinth (CAP) open storage	1,663.57	
Total	9,689.79	

* As of 1st June, 1973.

lengthwise or breadthwise alternative layers systematically. This type is advantageous in long-term storage because of marked stability of stacks. In block stacking each layer has tiers of lengthwise and breadthwise

The proper height of stack is important. Different commodities are stacked to different heights, depending upon the condition and nature of the commodity. The height of a stack is limited to leave sufficient space over

the stack for operational purpose. Generally, maximum stack height for foodgrain may not exceed five meters.

Preservation

Micro-organisms, mites, insects, rats and birds are mainly responsible for loss in storage.

1. *Micro-organisms* : The damage caused by microflora in the grain stored are heating, discolouration and characteristic odours. Fungi and bacteria are usually seed-borne. Among the fungi group, only moulds are of importance in the deterioration of stored products. Moulds appear as the moisture content increases above the minimum and as optimum temperature and oxygen concentration are reached.

Bacteria require higher moisture levels for growth in grain than moulds requiring 17 percent in the case of wheat. It causes heating, sick wheat, putrid odour, ropy bread, etc.

2. *Insects* : Insect is a major threat to quality in storage. It is estimated that one pair of rice weevils under favourable conditions could multilply to one million in three months. Many of the major insects complete their life-history in the grain unobserved. It is estimated that for every tunneled grain there could be five times more grain with hidden infestation. During the growth stages of insects, they excrete toxic and harmful products inside the cavity of the grain which when ground with immature stages of insects adversely affects the health of consumers.

3, *Rats and birds* : Like insects, the rat is a major problem in storage by their prolific breeding and ability to live in close competition with man for food. On the average, a pair of rats could produce about 300 descendants in a year. A common rat consumes on an average of 24 grams of foodgrains per day or about 10 kg. a year. It is estimated that 300 rats eat about one ton of foodgrains a year.

Important micro-organisms and pests responsible for damages in foodgrains during storage are cataloged in Table 4 by scientific and common names.

TABLE 4
Catalogue of Micro-Organisms and Pests

Scientific name	*Common name*
Aspergillus Sp.	Fungi
Penicillium Sp.	Fungi
Alterneria Sp.	Fungi
Fusarium Sp.	Fungi
Cladosporium Sp.	Fungi
Rhizopus Sp.	Fungi
Pseudomonas trifoli Sp.	Bacteria
Bascillus mesentericus Sp.	Bacteria
Bacterium coli	Bacteria
Bacillus Sp.	Bacteria
Pseudomonas florescens	Bacteria
Sitophilus oryze L.	Rice weevil
Rhizopertha dominica F.	Grain borer
Trogoderma granaria F.	Khapra
Bruchus species	Pulse beetle
Sitotroga cerealella O.	Grain moth
Tribolium Sp.	Red flour beetle
Ephestia cautella W.	Fig moth
Corcyra cephalenica S.	Rice moth
Oryzephilus surinamensis L.	Saw-toothed beetle
Lactheticus oryze W.	Long-headed flour beetle
Loamophleous minute O.	Flat grain beetle
Alphitobius Sp.	Black fungus beetle
Tenebroides mauritanicus L.	Cadelle
Periplaneta americana L.	Cockroach
Blatta orientalis L.	Cockroach
Liposcelis Sp.	Psocid
Tyroglyphus Sp.	Grain mite
Mus Sp.	Mouse
Rattus Sp.	Black rat
Bandicoota Sp.	Bandicoot
Columba Sp.	Pigeon
Passer Sp.	Sparrow
Corvus Sp.	Crows
Funambunus Sp.	Squirrel
Macaca Sp.	Monkey

Pesticides

In addition to regular prophylactic measures with insecticides dust are used to control insect pests, rodents, etc. The more common insecticides are Gamma BHC (Lindane), Lindane smoke, malathion spray, pyrethrum dust, pyrethrum piperonyl butoxide spray, fumigants like EDCT mixture, methyl bromide, ethylene dibromide, aluminium phosphide and raticides like zinc phosphide and cyanogas.

Periodic dusting of stocks is undertaken with different insecticides at intervals of 3-4 weeks to arrest cross infestation to stocks in storage. Generally, cereals, millets, pulses, etc. are dusted with Gamma BHC (Lindane) 0.65% w/w in 200 mesh white talc and milled products, spices, oil seeds, oil cakes, etc. are treated with pyrethrum dust of 0.2% pyrethrem w/w in 200 mesh soap stone at the rate of 2.5 kg. per 100 sq. meters of surface area. The surface area of a stack is calculated for its five sides and by adding 20% as an allowance for inter-bag space and alleyways. The dusting is repeated after thorough brushing of stack.

1. *Malathion* spray is also used to control cross infestation at intervals of three to four weeks at the rate of three litres per 100 sq. meters or one litre per 300 cu. meters of air space. The malathion spray premium grade is diluted with water in 1 : 100 ratio.

2. *Smoke generators* are also advantageously used to control moth infestation in warehouses.

3. *Pyrethrum piperonyl butoxide* spraying is undertaken when flying insects are not controlled by routine dusting or spraying. It contains pyrethins 2% w/w, piperonyl butoxide 20% w/w, pine oil 2% w/w in high grade mineral oil. Before spraying it is diluted with high grade mineral oil in a 1 : 30 ratio and sprayed at the rate of 570 grams per 100 cu. meter of air space and one kg. per 100 cubic meters of surface area.

4. *Ethyl dichloride-carbon tetrachloride mixture* among fumigants is easy to handle; it would give fairly good kill of insects. It can safely be applied to various commodities without causing serious hazards to the operator. It is applied at the rate of 30 to 45 kgs. per 100 cu. meters of volume with an exposure period of 48 hours to 72 hours depending upon the nature of infestation, moisture percentage of the commodity, temperature, humidity, etc. The EDCT mixture is not used for fumigating milled products, spices, oil seeds, etc.

5. *Methyl bromide* is a very effective fumigant that would give quick knock-down effects on all stored insect pests but requires specially trained personnel. It can safely be applied to cereals, millets, pulses, coffee, cotton textiles, etc. at the rate of 1.5 to 2.5 kgs. per 100 cubic meters of volume with an exposure period of 12 hours to 18 hours.

6. *Aluminium phosphide* commonly known in trade as Phostoxin, Delicia or Celphos is a new fumigant which is replacing other fumigants. It is available in solid compressed tablet form and can be safely applied for effective control of pests both in bulk and in bagged storage structures. It is used on all agricultural commodities. A dosage of two tablets per ton is applied in storage which can be made perfectly air-tight. In the case of structures that cannot be made

perfectly air-tight the dosage is increased to three to four tablets per ton. For storage under perfectly air-tight conditions, a dosage of 140 tablets per 100 cu. meters of space is used. The dosage is, however, reduced or increased by one tablet per ton depending upon the temperature and moisture content of the commodity and the nature of infestation present. The minimum exposure period for this fumigant is 12 hours whereas if the temperature and degree of moisture of grain is below 15°C and 10 percent respectively, the exposure period is extended even up to 5 days.

7. *Rat control*—Aluminium phosphide tablets are also used with advantge for fumigation of rat burrows. Systematic rat control measures by caging, poison-bating, poison-gassing, etc. are carried out besides making the storage rat-proof.

Transportation of Foodgrains

The geographical distribution of foodgrain production and consumption needs necessitates heavy transportation from producing to consuming centres and states. Sizeable quantities of foodgrains are being imported from foreign countries to meet food deficit which is also transported from port towns to interior states mainly by rail.

1. *Marketable surplus*—The Indian farming is generally a subsistence farming. A great portion of the products is retained by producers for domestic consumption, seeds, barter deeds, payment in kind, etc. In the case of rice hardly 33 percent of the production is marketable surplus while for wheat it is about 40 percent, gram 50 percent, pulses 50 percent and Bajra, 25 percent.

2. *Transport from farm to market*—The oldest and simplest method of foodgrain transport is carrying of the bags by man on head or back or on animals. A major portion of the foodgrain movement from farms to markets is by bullock-carts. The marketable surplus of farmers being small and connecting roads being *kacha* and seasonal, the bullock-carts will continue to play this important role for a long time to come. About 80 percent of the villages in India are not connected to any market by pucca all-weather roads. The absence of roads and improved facilities for transport make it difficult for farmers to bring their produce to the market for sale where they can obtain fair prices.

3. *Transport from wholesale market*—This process is generally done by mechanized road transport, water transport or by railways. Water transport movement takes place in Kerala, Madras, Orissa, Bihar, U.P., West Bengal and Assam.

4. *General pattern of foodgrains movement*—Inter-state transport which means long distance movement of large quantities is taking place by rail. The originating tonnage of foodgrains on the railways has been about 12 million to 14 million tons per year with an average fluctuating lead of around 800 Kms. Generally, inter-district movement within the state of 100,000 tons and above is by rail. The inter-district transport within the state less than 100,000 tons is generally shared both by rail and road. The road transport is increasingly taking up a bigger share of transport, particularly for short leads.

The coastal movement of foodgrains by ships includes transport from Bombay to

minor ports in Maharashtra and from Madras to Tuticorin and from Haldia to Calcutta.

5. In 1970-71, five commodities (rice, wheat, pulses, jowar, gram) weighing about 32.1 million tons were estimated to have been moved by road and rail as shown in Table 5.

TABLE 5

Road and Rail Foodgrains Transport, India, 1970-71

Commodity	*Rail*	*Road*	*Total*
	Million tons		
Rice	6.5	5.2	11.7
Wheat	6.2	6.6	12.8
Jowar	0.9	3.0	3.9
Gram & Pulses	2.0	1.7	3.7
Total	15.6	16.5	32.1

6. In 1972 F.C.I. alone transported 17.65 million tons of foodgrains comprising 7.16 million tons as inter-state movement, 8.58 million tons as intra-state transport and 1.9 million tons from and via ports. Since economy and speed in post-harvest operations are needed the whole transport handling, storage and distribution is gradually switched on to bulk from the present bagged handling.

7. *Food export to Bangladesh*—Immediately after the liberation of Bangladesh, food had to be rushed to avoid misery and famine. Over 948,398 tons of food was transported to Bangladesh from various parts of India on an emergency basis by rail, road and sea. In this massive movement, 607,318 tons were transported in 33,770 railway wagons, 289,022 tons shipped in 52 ships and 30,570 tons were moved in 572 barges, 38,470 tons by road moved in 7,669 trucks. This was the first large-scale food export from India in recent years.

Processing of Foodgrains

Rice milling and wheat grinding are the two important food processing industries in India. The rice production of 42.7 million tons in 1972 is roughly 46 percent of the total production of cereals and 41 percent of food production in India.

1. Paddy is converted into rice partly by hand pounding and partly by hullers or mechanized mills. At present there are 57,445 single hullers, 1,925 batteries of hullers, 5,164 shellers cum-hullers and 2,566 shellers having a total capacity of 7,900,424 tons of paddy as indicated in Table 6.

A large portion of the fine paddy is milled. Similarly, a major portion of the coarse paddy is hand-pounded. Medium varieties are both used for hand-pounding and milling. Hand-pounded rice of medium and fine varieties are costlier than machine milled rice but hand-pounded coarse varieties are sold at a cheaper price, The hand-pounded rice is generally considered more nutritive than milled rice.

2. *Hand-pounding and machine-milling*—Hand-pounding is done by (a) mortar and pestle, (b) 'dhenki' and (c) in 'chakkies'. Wooden or stone mortar is generally used. Paddy in the mortar is pounded with the pestle which is made of wood and fitted with iron hub at one end and iron ring at the other.

TABLE 6
Distribution of Various Types of Rice Mills, India

State/ Territory	*Single hullers*	*Batteries of hullers*	*Sheller cum-huller*	*Sheller*	*Capacity tons of paddy per year)*
					Thousand tons)
Andhra Pradesh	5,332	29	3,032	316	12,502
Assam	409	*	412	10	1,263
A & N Islands	95	—	3	—	104
Bihar	1,839	181	3	2	2,213
Chandigarh	19	—	—	1	22
Dadra & Nagar Haveli	14	—	4	—	22
Delhi	40	1	—	—	42
Gujarat	2,641	27	169	242	3,759
Goa, Daman & Diu	396	14	8	—	440
Haryana	1,447	110	36	121	2,102
Himachal Pradesh	763	—	—	—	763
Jammu & Kashmir	1,810	-	—	27	1,891
Kerala	3,861	11	4	35	3,996
Madhya Pradesh	3,502	250	527	195	5,137
Maharashtra	3,075	—	444	321	4,926
Mysore	5,289	—	212	671	7,726
Manipur	59	3	27	—	119
Nagaland	—	—	—	124	372
Orissa	2,388	206	169	1	3.141
Punjab	2,435	108	22	192	3,271
Pondicherry, Karikal, Mahe Yenam	184	—	—	—	184
Rajasthan	344	—	40	15	469
Tamil Nadu	11,207	96	92	21	11,646
Tripura	146	—	4	—	154
Uttar Pradesh	4,017	228	171	256	5,583
West Bengal	6,133	661	37	16	7,577
Total	57,445	1,925	5,164	2,566	79,424

* Information not available.

The dhenki is an improvement of the mortar and pestle. The pestle is attached to a wooden pole of 6 to 8 feet (about 2 meters to 2.5 meters) long placed on a fulcrum for working. By stepping alternatively on and off at the end of the pole the pestle is repeatedly dropped into the wooden mortar fixed on the ground and containing paddy. It is used both for dehusking and polishing.

Hand chakki consists of two grinding discs made of stone, wood or clay, which are placed one over the other and is so adjusted that the upper disc can be rotated with a handle while the lower one remains fixed. By this rotation the paddy is dehusked and rice is polished further with the help of the dhenki or pestle and mortar.

The huller, on the other hand, is power-driven machinery consisting of two grooved horizontal cylinders set side by side in an outer casing. The husking is done by a steel blade against which the cylinder revolves. The rice is further passed through the same or another huller for polishing. Single hullers are used mostly in rural areas. There are rice mills of huller types, each containing a number of shellers as well as sheller type mills wherein dehusking is done by grinding the paddy between two stone discs similar to the stone for the chakki.

Hand-pounding is 10 times more labour-intensive than milling. The out-turn in hand-pounding is greater than in machine-milling process which is generally due to greater degree of polishing possible in mills.

The efficiency of these types of rice mills in terms of grain recovery is indicated in Table 7.

TABLE 7

Comparative Percentage Recovery of Three Types of Rice Mills, India

Type of Mill	*Percentage Recovery**
Sheller	69 to 70
Hullers or huller	68 to 69
Hand-pounding	70 to 73

* Includes broken grains.

3. *Modernization of rice milling industry*—Rice milling is the largest and oldest food industry in India and it requires modernization. The industry is using old and obsolete milling equipments. Paddy has to be milled before marketing. Considerable loss is incurred in the old milling process. The F.C.I. has embarked on a programme of setting up a chain of 24 modern rice mills as a pilot project. Twenty-one mills of four-ton per hour capacity each have been set up so far. A rice mill of two-ton per hour capacity is also being installed at Imphal. Of the 24 mills programmed for installation, 21 have parboiling facilities. Five complete rice mills and 19 other mills with more intricate components such as paddy separators, paddy huskers and rice whitening machines were ordered from Japan in 1967.

4. *Parboiling*—Rice produced from parboiled paddy is more nutritive than raw rice. By parboiling, the rice grain is gelatinized and it does not form glutinous matter by cooking. The parboiled rice retains its freshness after cooking for long hours compared to raw rice. It is less infested by insects and stands storage better compared to raw rice. From 50 percent to 66 percent

of the total rice used in India is obtained from parboiled paddy. Parboiling is done mainly for medium and coarse varieties of soft and chalky structure. The breakage of rice during milling is minimized by parboiling. In India 60 percent of the coarse rice and 30 percent of the medium rice and 10 percent of the fine varieties are parboiled. Generally parboiled rice is preferred by people of coastal states,

5. *Roller flour mills*—The roller wheat flour mill industry is well organized in India. The Government is distributing wheat through F.C.I. for wheat processing by roller flour mills. It is an all-India industry having mills almost in every state and union territories. The distribution of flour mills in different states with their capacities is listed in Table 8.

TABLE 8

Distribution of Flour Mills in India

State/Territory	*No. of Mills*	*Monthly quota (Metric ton)*
Andhra Pradesh	8	13,345
Assam	11	22,447
Bihar	18	29,927
Gujarat	12	13,302
Haryana	7	18,402
Himachal Pradesh	1	500
Jammu & Kashmir	1	—
Kerala	5	6,550
Madhya Pradesh	7	9,574
Maharashtra	9	41,302
Mysore	23	22,999
Orissa	6	11,350
Punjab	10	29,462
Rajasthan	5	8,830
Tamilnadu	22	50,710
Uttar Pradesh	32	83,226
West Bengal	25	50,713
Union Territories		
Chandigarh	2	3,141
Delhi	7	25,610
Pondicherry	1	2,500
Goa	1	2,250
Total	215	446,140

These roller flour mills process about 5,353,680 tons of wheat per year, in the form of whole meal atta, maida, suji, etc. In addition to the roller flour mills, there are thousands of chakkies grinding small quantities of wheat throughout the country.

6. *Paddy dryer*—The F.C.I. has set up 30 modern dryers for paddy in Tanjore district of Tamilnadu in order to process Kuruva paddy which is highly susceptible to germination after 48 hours of harvesting during monsoon if stored without proper drying. The machinery was indigenously manufactured. The capacity of these dryers is 160 tons per day based on three passes of paddy.

7. *Maize dryer*—One maize dryer of a drying capacity of five tons per hour with holding capacity of 12 tons can bring down the moisture content by five percent in one pass. It can handle roughly 9,000 tons a year on the basis of 90 days working season at the daily output of 100 tons. The approximate operation and maintenance cost is estimated at Rs. 2.12 per ton.

8. *Maize dry milling plant*—A new maize dry milling plant imported from Italy is installed at Faridabad in Haryana with a capacity of 25 tons per day. The plant is devised for dry milling process and will be

able to process 7,500 tons of maize per annum.

9. *Fortification of atta*—Wheat whole meal fortification is done with grinding along with vegetable protein concentrates, 1.4 percent ; vitamins and minerals, 0.2 percent consisting of vitamin A, Thiamine, Riboflavin, Niacin, calcium and iron. It is getting very popular and 53,240 tons was produced in Bombay and Calcutta during 1972.

10. *Balahar*—This low-cost high protein food for children is manufactured in the name of Balahar. It is made up of 70 percent bread flour, 25 percent groundnut flour and five percent skimmed milk powder.

Some 36,000 tons of Balahar were produced for distribution among children. In addition, 2,812 tons of Balahar was produced by F.C.I. for free distribution to school children for mid-day meal programme of Cooperative American Relief Everywhere (CARE). The final product is fortified with 22 percent to 25 percent of vitamins and minerals in order to make it palatable to children. Butter, coriander, saunf, and salt are added. It is sweetend by the addition of saccharin.

11. *Modern bread*—Another food processing industry that became popular recently is the modern bakeries manufacturing bread fortified with vitamins, minerals and protein concentrates. Six out of nine units of automatic equipment for manufacture of modern bread has been completed. These units are located at Ahmedabad, Cochin, Delhi, Madras, Bangalore and Kanpur. Modern bakeries had marketed about 94 million standard loaves. By the end of the year the modern bakeries is expected to achieve a target of 103 million standard loaves.

Training and Extension Service

There is no regular college or university imparting a comprehensive training and extension service in various scientific aspects of threshing, transporting, marketing, grading, construction of scientific storage, preservation, modern handling, etc. The Department of Food (Ministry of Agriculture), Central Warehousing Corporation, Central Food Technological Research Institute, Mysore, Grain Storage and Training Research Institute, Hapur, Plant Protection, Quarantine and Storage Directorate (Ministry of Agriculture), Indian Agriculture Research Institute and some other Government and commercial agencies are now taking up training and extension services. Long-term and short-term training courses are also held for qualified personnel. Refresher courses are also held for officers and staff to keep abreast with the latest development. Disinfestation extension service in private godowns is now included as one of the functions of the Central Warehousing Corporation. Advanced training facilities are needed to provide post-graduate level course. Qualified and experienced officers are also being trained in the latest technology in advanced countries. The technological development achieved in advanced countries in post-harvest handling of grain is being taken advantage of by training experts abroad. The awareness of scientific post-harvest handling of grain is taking place to reduce the avoidable loss. □

Improvement of Storage Conditions and Storage Methods in India

T. V. Sri Ram*

A Committee on Post Harvest Losses of Foodgrains in India appointed in 1966 by the government estimated that about 2.75 per cent of the total foodgrains production is being lost due to losses during pre-storing stage, i.e. in threshing yards, transport, processing etc. Added to it are the losses caused by rodents, birds, insects, moisture and so on during the storage stage which takes away another 6.58 per cent of the total production of foodgrains. In other words, about 10 million tonnes of foodgrains are lost every year due to such wastes. Much of this waste could be controlled through the proper storage system. The Government has already undertaken various measures to reduce these losses and, in fact, has launched a "Save Grain Campaign" throughout the country in order to coordinate efforts for reducing losses of foodgrains in storage. This paper deals with the theory and practice of storage system in India and describes in brief the various services given to farmers, traders, pest control firms, manufacturers of storage bins, research institutions etc. under the "Save Grain Campaign".

WITH the development of foodgrain technology, the principles of scientific storage are known, but what is needed is their large-scale application. The approach of this paper is to touch upon the important facets of Storage Technology, problems encountered in India and the important steps being taken by the Government to control wastage and losses to foodgrains during the post-harvest period at different levels of handling.

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Necessity of Storage

Storage of foodgrains in the proper way is a vital factor in the Nation's economy. Storage is a *must* of a part of each harvested crop for a period from a few months to one year, because harvesting of wheat, paddy and other foodgrains is only seasonal, whereas consumption is there continuously all the year round. Some longer term storage is also necessary to act as a buffer against fluctuations of production from year to year. Temporary or prolonged shortage of foodgrains not only has drastic effect on prices and progress in other

sectors, but also causes hunger and human suffering.

Foodgrain Production in India

Increased production of foodgrains is the only answer to avoid such shortages. The land from which man derives his sustenance is not unlimited. He has gone through periods of anxious awareness of this fact for the last several decades. Increased production was obtained earlier mainly by bringing more area under plough by continuous deforestation in densely populated regions of the world. New agricultural technology consisting of growing legumes in crop rotation combined with the use of chemical fertilizers, or the opening of fertile heavy blank soils by using agricultural machinery, which were tried successfully in some parts of the world during the 19th century, did not touch the Indian soil. Renewed concern about agricultural production in the first half of the 20th century led to the application of science to agriculture at an increased pace. The level of foodgrain production in India was, however, almost constant at about 67 million tonnes during the period from 1900 to 1948. By the beginning of the Fourth Five-Year Plan period, the production in India increased by about 50%, which was slightly higher than the rate of increase in population. Despite the drought conditions that prevailed in the country in 1965-66 and 1966-67, with the introduction of new high-yielding varieties from 1966-67, there was a sudden spurt in foodgrain production between 1965 and 1971 from 72 to 108 million tonnes. From the commencement of the 4th Plan period in 1969-70, an average combined growth rate of more than 4.5% per annum was reached as compared to the average rate of increase of 2.5% in population. Despite this achievement, which is popularly known as "Green Revolution", it is admitted that there is neither enough of right kind of food to nourish the entire population fully nor all the people are in a position to buy them even if available. All the same, there is an atmosphere of optimism pervading in the country that it is possible to achieve this goal sooner or later.

Need for Proper Storage

Proper storage practices are necessary both in the times of need and plenty. If the foodgrains are not stored properly, wastage and losses occur. The APO member-countries reported in the 1968 Survey that from 5 to 10 per cent of all foodgrains products were lost during storage and distribution. In some countries, the quantity thus lost is equivalent to food shortages, which will have serious effect in the year when production falls. Even in a year of plenty, loss-free storage is necessary to build a buffer stock and/or to export to other needy countries. Losing foodgrains in storage is like losing money that has already been put in a bank. Since labour and money have been used in the production of foodgrains, it will thus be a double loss to lose them in storage.

Objectives

The main objectives of proper storage are: (1) to minimize foodgrain losses and maintain original quality to help in the economic development of the country; (2) to improve the economic well-being of the farmers who produce the life-sustaining food for the country; and also (3) to reduce as much as possible the employment of human

labour in carrying heavy foodgrain bags, by introducing mechanisation.

Marketed Surplus

Agriculture is yet to be industrialised in India. Over seventy-seven million farmers practise agriculture as a vocation and are hardly able to make a living out of it. Large farms are not many and, on an average, the holding per farmer is five acres. On this account, the size of storage on the farms is restricted. Due to the variation in the size of holdings, the proportion of the produce retained by the farmers varies between 10 to 100% from grain to grain and from region to region. However, the average proportion of produce retained by the farmers for their own use has been placed at 60-70% in the country. The rest is marketed. The entire marketed surplus is not disposed off at one time or in one transaction but is released gradually depending upon the economic condition of the farmer and the prevailing market price. The marketed surplus undergoes transit by road and rail, changes hands 3 to 4 times, remains in storage 1 to 2 months between two transactions and then reaches the consumer.

Categories of Storage

Foodgrain storage in India can be said to be of three categories viz., (1) Farm Storage, (2) Commercial Storage and (3) State Storage. Conditions and methods of storage in these are different from one another. Before elaboration, it is necessary to touch upon the storage principles.

Principles of Storage

A grain is a seed and each seed is a living organism that breathes, requires nourishment, grows and dies. Seeds must have essentially the same care that is required by other living organisms if they are to remain alive and in good condition. The seed embryo is particularly sensitive to temperature and humidity. If temperature and humidity could be kept low (15°C and 15% m.c. of grain), the embryo remains viable but inactive and the grain can be stored for long periods However, when the temperature and humidity increase, the viable embryos become active, draw nourishment from the concentrated nutrients, particulary starches and proteins stored in the endosperms. Heat and moisture result in the process and soon the grain mass begins to warm up. This further stimulates the activity of embryos and a chain reaction is formed. Moulds and micro-organisms frequently present on the grain kernals, and also insects, if present, are also stimulated to become active, thereby producing still more heat and moisture. Eventually, a part or all of the grain mass may develop a temperature of 135°F (57.2°C) at which time visible deterioration and rotting begin. It is with this background that grain is recommended in simple language to be "kept always cool and dry". The following can be listed as the main factors causing changes in grain :

1. Physical : Temperature, humidity.
2. Chemical : Moisture, oxygen
3. Physiological : Respiration, heating
4. Biological : Insects, rodents, micro-organisms.

The factors that cause wastage and losses during post-harvest handling of foodgrains may be listed as below :

1. *During drying* : Crackages, rodents, birds, high

moisture content, spillage, contamination and over-drying.

2. *During storage* : High moisture content, high temperature, respiration, dampness, rodents, insects, micro-organisms, molds and fungi, birds, spillage and contamination.

3. *During Transportation* : Spillage, rodents, wetting, contamination.

Losses and Wastage

Frequently, losses and wastage are taken to mean the same thing, but it is not so. Losses relate to quality and cost whereas wastage relates to quality and quantity. In case of a lot of grain affected by insects, the loss may be difference between initial and final weight, but apart from this, the insects would have affected the quality and even made the grain unfit for human consumption. The loss other than the loss in weight would be the wastage, though literally speaking, entire loss could be both wastage as well as loss. In practice, it is mainly the quantitative loss and qualitative loss of conspicuous nature, such as caused by water coming in contact with grain, etc., that are taken into account. Losses caused to the nutritive value are often ignored as these are of a complicated nature and not easy to determine. Definition of loss also varies from investigator to investigator.

Some loss in the course of handling is inevitable which fact is mostly lost sight of. Driage is an example of inevitable loss.

There is considerable interest in knowing the extent of wastage. It is, however, not easy to estimate the same as foodgrains are handled by millions of cultivators, traders, middlemen and finally by the consumers. There is a wide variation of wastage and losses at each stage depending upon various factors.

A committee on "Post-Harvest Losses of Foodgrains in India" appointed in 1966 by the Government of India gave its interim report in 1967, in which it was estimated that losses to the tune of 9.33% occurred in the country. The break-up is as under :

S. No.	*Stages where the loss is caused*	*Total estimated loss*
1.	Threshing yard	1.68%
2.	Transport	0.15%
3.	Processing	0.92%
4.	Storage :	
	(a) Rodents	2.50%
	(b) Birds	0.85%
	(c) Insects	2.55%
	(d) Moisture	0.68%
	Total	9.33%

This is the official figure available till any further report is released.

Storage Requirements

The basic function of an ideal storage structure is that it should maintain the grain

stored in it at a quality as high as when it was placed in the structure. This is a tall order to comply with, particularly when high temperatures and high humidity climatic conditions prevail as in India. The requirements of a storage structure for prevention of deterioration in grain quality and other wastage and losses are as under :

1. Water-tightness to prevent entry of liquid water from outside.
2. Air-tightness to prevent absorption of water vapour from outside atmosphere and to facilitate fumigation to kill insects.
3. Rodent-proof quality.
4. Bird-proof quality.
5. Facilities for drying (while receiving freshly harvested grains), air circulation (for removal of any hot spots, and mechanical handling.
6. Economical with respect to materials, construction, equipment, maintenance and long life. Materials and equipment must be those which can be produced indigenously.
7. Suitability for adoption/modification to suit different needs of capacity, size, etc.

Harvesting, Handling and Storage Conditions at Farm Level

Harvesting is done by manual labour in most of the areas in the country. The plants are cut about 10-15 cms. above the ground and packed in small sheaves. The sheaves are stacked in groups of 6 to 8 in the field and exposed to sun for about a week till they are dry enough for threshing. Moisture content of grain at harvest varies between 14 to 22% and after drying in the sun from 12 to 14%. Threshing is done either by using a thresher or by beating down the ears against a stone depending upon the quantum of harvest. In majority of the cases, the threshing floors are open yards plastered with mud. Therefore, mud, pieces of stones, etc., get mixed with grains. Some loss occurs when birds, insects, monkeys and rodents are not checked. At places, insect infestation develops in paddy ears, particularly that of *sitotroga cerealella* in the field. Other two major pests that start their activity on grain before harvest are *stiphilus Oryzal* and *Bruchus Spp.* Combines and mechanical driers are yet to reach the farming millions.

Though large quantities of foodgrains are handled on the farm, these are spread over a large number of individuals, reducing the size in each case from half to ten tonnes. The grain is held for 4 to 12 months depending upon the availability and is processed in small quantities from time to time as required. In countries like India, where foodgrains constitute upto 80% of the diet and where there is wide gap between supply and demand, it is not easy to make the farmers part with their produce. In addition, the age-long habit of getting small quantity of foodgrains processed for family use as and when required, also makes it difficult to get the produce pooled and centralise storage. Neither there is any law to make the farmers release all the marketable surplus nor it is possible to enforce it if enacted.

The farmer stores grain usually in indoor structures or structures kept outside his

house. The usual mode of storage of foodgrains is in bulk or jute bags. For storing grain in bulk, the farmer invariably uses various types of low-cost and locally made storage structures which vary in size, shape and material of construction. In limited areas, the farmers store bulk grain underground in pits varying in capacity between 50 to 100 tonnes.

If scientific storage is described as one which can protect the stored grain from the ravages of insects, rodents, dampness and fire hazards, none of the present practices in vogue would, by and large, satisfy all the requirements. Losses in storage are maximum at this level.

Commercial Storage Conditions

This served as a buffer reserve before World War II, but later developed into transit storage due to increased gap between supply and demand. Storage in underground pits or above ground rectangular bins got replaced by storage in bags. Transport facilities in the country are capable of handling grains in bags only. Grains stored in commercial warehouses generally range in quantities from 20 to 500 tonnes and the storage period from a few days to four months. Many agricultural commodities are stored simultaneously in the same place. The warehouses were hardly vacant till the take over of wholesale wheat trade this year. In most cases, the structures are neither rodent or damp-proof. Damage due to insects, rodents, dampness and birds is a common feature in these stores. While the losses in storage with the private trade were to an estimated 3 to 5%, the cooperative, corporate and State agencies have started operating in this sector, limiting the losses to below 2%.

With the formation of the Food Corporation of India in 1965 and its take over of the function of the Central Storage Depots, this sector has now once again become a buffer reserve sector.

State Level Storage

This was a development after the Second World War due to rise in prices in some countries and the problem of securing better prices for the surpluses in other countries. However, it can now be seen as a boon, since there has been significant development in the storage conditions due to the interest and initiative the States could ensure by taking over the responsibility of viewing the problem from all angles and arranging for necessary research, legislation and development programmes.

Storage capacity at this level was practically all of bag storage godowns till large-scale bulk storage structures like silos and flat storage godowns were started to be constructed, the first metal silos having been erected at Hapur (U.P.) in 1958. Godowns were taken on rent to meet the requirements. All the godowns constructed by the Government were ensured to be damp and rodent-proof. Regular inspection and periodical disinfestation was made possible in these godowns and the losses in storage were brought down to an almost insignificant level. As brought out earlier, the Food Corporation of India has taken over the Central Storage Depots and it is now the largest single agency handling and storing foodgrains in the country.

Improvement of Storage Facilities

With the increased scope of modernisation of storage facilities at the level of the Government or its agencies and with the policy of the Government to take over wholesale trade, the area for maximum concentration of work is of the farm level storage, where nearly two-thirds of the produce is retained.

The factors impeding the improvement of storage conditions at the level of farmers can be briefly stated to be as under :

(i) Small land holdings and small volume of foodgrain production per farm.

(ii) Necessity for small farmers to immediately convert the produce into cash.

(iii) Low technical know-how and ability of farmers.

(iv) Non-availability of materials and equipment to the farmers.

(v) Low income and investment capability on improved storage.

(vi) Attachment to traditional methods.

(vii) Existence of an infrastructure of local marketing organisations that take advantage of small farmers.

(viii) Lack of stimulus to farmers to preserve foodgrains properly.

(ix) Insufficient training centres, staff and facilities directed towards the reduction of foodgrain losses.

Improvement of storage conditions at farm level comprises of three main steps, viz., the provision of suitable storage structures ; mass application of insecticides and raticides on a community basis ; and proper education about the need to prevent storage losses and wastage.

For provision of proper storage facilities, the first attempt should be to improve the existing storage structures to make them damp-rodent-and bird-proof. New designs of storage structures suitable under different climatic conditions need to be developed but these will be successfully introduced when provision of credit is also a part of the programme. The third step, viz., education, is of great importance. For considerable periods, the Indian farmer was thought to be illiterate and ignorant and, therefore, it would be difficult to make him adopt the new techniques. But to the surprise of everyone, he proved that he was, like any other good farmer elsewhere in the world, able to understand the business of farming, perhaps, much better than the educated men. He demonstrated that his capacities were underestimated. From the success achieved in increasing foodgrain production, it is evident that the farmer would be prepared to practice new agricultural techniques that would give him better returns in preference to what he and his forefathers were practising for many generations. He received the new technology with unprecedented enthusiasm. The same enthusiasm should be cashed in for improving his storage conditions also. Mere paper publicity will not, however, give the results and it is necessary that the improved storage techniques are practically demonstrated to the farmer and he is convinced about the usefulness of the same.

The experience of the field extension workers in different parts of the country shows that there still existed three categories,

viz., (i) those who can quickly understand the new technology and practice the same with full interest ; (ii) those who have only half understood the new technology—there being several examples of mixing hazardous chemicals meant for plant protection into foodgrains meant for consumption ; and (iii) those who are still ignorant of the new technology.

There also exists apathy towards the losses, may be from ignorance or religious sentiments or just indifference. A temple in the village Deshnoke in Rajasthan hit the news a few years back where people fed the rats in the temple with foodgrains regularly. Similarly, indifference was clearly evident in that nobody bothered to do something about the rats making burrows and moving about freely even during the day time in a corner of the park facing the Esplanade East in the heart of Calcutta. It is very difficult for one particular division of a Government Department to improve the storage conditions at different levels of handling in the country. To begin with, it is very essential that all the State machinery s moved into action. The ultimate aim should be to involve the people directly in this development programme.

Steps Taken by the Central Food Department (Storage and Inspection Division)

At the time of formation of the Department of Food its main area of concern was to build buffer stocks. For this, it was necessary to have qualified and trained personnel. It was also necessary to screen the various pesticides and storage methods for selection of the most suited ones for application in the Central Storage Depots. It was with this purpose that the Department established Grain Storage Research and Training Centre at Hapur in the year 1958. Codes of practices for scientific storage were laid down and ultimately it was possible to bring down the losses to less than 1% in the Central Storage Depots. It was then considered that the techniques adopted in the Central Storage Depots should be popularised at other levels also. As a result, the State Government personnel and interested representatives of the private trade were imparted training at Hapur. The Centre also gave demonstrations of scientific storage in the nearby villages. Considering the successful results achieved during the demonstration and also the need of extending the programme on wider scale which was emphasised during seminars and official meetings, a pilot project of Save Grain Campaign was undertaken in the years 1965-66 in selected markets and rural centres in different parts of the country. The pilot project also proved successful and the need was felt for making it a regular feature. A scheme was accordingly drawn up for full-time placement of technically qualified teams in different parts of the country for undertaking training, demonstration and publicity programmes in close collaboration with the State Governments and other private organisations. Though the scheme was formulated in the year 1966, it was finally cleared after modifications in November 1969. Due to paucity of funds, only a small Central Unit at the headquarters and a regional team each at Bombay and Patna could be established. Certain other short-term non-plan programmes for improvement of farmer's storage facilities were also taken on hand with fund assistance received from the Pesticides Association of India, U.K.—F.F.H.C.,

and the Netherlands Foundation for India. The Pesticides Association of India gave funds for manufacture and installation of demonstration bins of the improved designs developed by the Hapur Centre at villages in U.P. and Bihar. The funds made available by the U.K.—F.F.H C. were utilised in supply of metal bins at 60% subsidised rates in four villages near Bapatla in Andhra Pradesh. The funds received from the Netherlands are being utilised for construction of modern silo storage facilities in M.P. and Maharashtra in the cooperative sector which also includes a programme of setting up of metal bins at the rural collection centres.

With further assistance provided under the United Nations Development Programme, the Grain Storage Research and Training Centre at Hapur has been developed into an Indian Grain Storage Institute by the inclusion of a fulfledged Engineering Division and other facilities. The main purpose of this Institute is to design and develop improved types of storage structures, to work out improvements in the conventional storage structures and also development of suitable extension material for use of the various training centres in the country.

Considering that enforcement of safe storage provision is also essential, it has been made obligatory on the part of the foodgrains dealers, wheat roller flour mills and rice mills to protect the foodgrains and milled products handled by them from ground moisture, insects, rodents, contamination, etc. As a measure of protection against any hazards, it was also made obligatory that fumigation should be carried out by trained personnel only. Free training facilities have been offered for those private stockists interested in getting their personnel trained in fumigation and other techniques. Similar training facilities were also offered to the representatives of the private pest control firms so that they could extend pest control service on payment basis wherever necessary. With the encouragement given to the industry, most of the pesticides required for proper storage maintenance were started to be manufactured within the country. Encourgement was also given to the bigger industries to take up large-scale manufacture of improved types of storage structures.

At this stage, with the availability of an amount of nearly 1.4 crores under the PL-480 (Section 104-K), it became possible for the Department to grant loans to the State Govts. for the specific purpose of manufacturing improved types of storage structures designed and developed by the Indian Grain Storage Institute and supplying them to the farmers on defferred payment basis. To begin with, only Rs. 40 lakhs were made available out of the said rupee fund and these have been loaned equally to the State Governments of Punjab, Haryana, U.P., M.P. and Bihar.

While these programmes were under implementation, an Expert Committee on Storage constituted by the Planning Commission, examined *inter alia* the development of farm Storage in the country. In its report released in September, 1971, the Committee observed that the pattern of storage in the rural areas is changing in the country, especially in those regions where production of foodgrains has increased considerably within a short time. It expressed that more effective preservation in

storage is possible by provision of suitable storage structures and that the use of pesticides should be entrusted to trained personnel. The existing research programmes and extension net-work not being quite adequate, the Committee recommended that a coordinated programme for modernisation of storage at farm and community level should be chalked out and carried out in phases. It desired that the scheme which could be considered in all its essentials as an improvement of Save Grain Campaign project of the Central Food Department may be taken up for immediate implementation. The Finance also came to the help of the Department by making available the remaining amount of nearly Rs. 1 crore for these activities. A comprehensive scheme for "Improvement of Storage Facilities at Farmers' level and Popularisation of Scientific Techniques of Foodgrains Storage and Pest Control" was accordingly drawn up and has been sanctioned for implementation during 1973-74 with an outlay of Rs. 90 lakhs. The scheme includes allocation of Rs. 68 lakhs to 10 more States for the bin distribution programme, as also for applied research coordination and apex level training through the Indian Grain Storage Institute, and for State level training and extension programme by setting up four more Regional Teams at Ghaziabad, Bhopal, Hyderabad and Madras and strengthening the earlier Regional Teams at Bombay and Patna and the Unit at headquarters. A comprehensive scheme for reduction of storage losses to foodgrains and Wastage in the country has also been prepared for implementation during the 5th Plan period starting from 1974-75.

The Save Grain Campaign is now a general term used to refer to the various coordinated efforts enumerated above for reducing losses of foodgrains in storage. Following are the main benefits accruing from the Save Grain Campaign to the general public :

(a) Any interested private stockist can approach the Department's headquarters or the regional teams of Save Grain Campaign for technical advice on his specific foodgrain storage problem, free of cost.

(b) The private stockists can obtain free literature on the types of improved storage receptacles that can be adopted, control of insects, rodents, as well as advisory notes on the use of different recommended pesticides.

(c) Representatives of the farmers or traders or cooperative organisations can avail of free training facilities offered under the Save Grain Campaign Scheme. Every year, five training courses are held and about 30 candidates are admitted to each course. Applications are invited through newspaper advertisements. The minimum educational qualifications required is high school in science. On successful completion of the training, each candidate is awarded a certificate and also a stipend of Rs. 50/- per head as an incentive. The training is free and the courses are conducted in different parts of the country.

(d) Associations of foodgrains dealers, wheat roller flour mills and rice

mills can also avail of training facilities in proper implementation of the safe storage provisions contained in the relevant Licensing Rules/Orders for protecting the food-stuffs handled by them from various factors causing damage/ losses in storage.

(e) Private pest control firms can get their technical personnel trained in disinfestation techniques so that they can render effective disinfestation services in the godowns of the private stockists.

(f) Manufacturers of storage bins can also obtain the designs developed by the Indian Grain Storage Institute in case they are interested in manufacturing and supplying the same.

(g) Farmers can also obtain technical guidance in improvement of their existing storage facilities.

(h) Interested farmers can also purchase improved types of metal storage bins as designed by the I.G.S.I. on deferred payment basis through the respective State Governments to whom funds have been made available for this specific purpose.

(i) Farmers or traders can obtain the benefit of free demonstration of the disinfestation techniques which are arranged under the Save Grain Campaign free of cost, if combined request is received from them to give demonstrations at a particular station where they can all assemble and witness the same.

(j) Research institutions which are carrying out research on storage problems can approach the Department for grant to conduct research on specific problems that will be assigned to them under the applied research coordination programme being implemented by the Department.

(k) Individual research workers can also avail of the facilities available at the Indian Grain Storage Institute for award of M.Sc. or Ph.D. degrees.

(l) Engineering concerns or even village blacksmiths can obtain training and guidance through the Engineering Division of the Indian Grain Storage Institute in the fabrication of improved grain storage structures. □

Rodent Damages in the Field and their Control

I. Prakash*

The devastating power of otherwise innocent-looking small creatures in the rodent family is generally overlooked. But statistics reveal that among the various hazards to which our agriculture is exposed, rodents are perhaps, the worst. A study in Madras shows that on account of rodent attack, the yield of the paddy was reduced to 59.5 percent. Similar evidences could also be seen in other parts of the country. The elimination of rodents is quite a ticklish problem because of 'rodent mix' in a given field. This makes the task of selecting the most effective rodenticides difficult. In this paper some useful tips are given to control the loss due to field rodents.

FIELD rodents are a serious problem and a concerted effort has not been made so far to tackle the problem on a national basis and thus India is faced with a great task of controlling rodents over a vast region. As other speakers will tell you about the damages by rodents in residential areas, in bulk storages, warehouses and godowns and their control, I have restricted my topic to field rodents and their control.

I. Losses Due to Rodents in the Field

Grasses : It has been observed in the rangelands that wherever the seeds of *Cenchrus setigerus*, *C. ciliaris* and *sindicus* are sown for improving the fodder quality to enable better animal production, the rodents dig them up and feed on them leaving no chances for their establishment. The intake of grass seeds especially by *M. hurrianae* is maximum as compared to other desert rodents (Prakash *et al*, 1967). In addition, they cause considerable damage to standing grasses. In monsoon, the rodents prefer to feed upon the unripe inflorescence of grasses but as they are unable to reach them, the entire plant is cut and only the choicest parts are eaten, rest being left to dry and blown away by strong winds. Like this they devastated 40 acres of *Lasiurus sindicus* experimental pastures at Bikaner and 27 acres of pastures of *Cenchrus ciliaris*, *C. setigerus* and *L. sindicus*, at Jodhpur, deterring all the efforts for providing better grasses to experimental sheep. At Maulasar, one of the Range Management and Soil Conservation paddock of the Institute, during rainy season in 1965, the desert

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gerbil population was estimated to be 477 per hectare and an immense loss was incurred by gerbils to the natural grasslands. It was revealed that they did not feed upon plant species which are inedible to livestock but prefer to devastate the fodder species. The palatability index on the basis of unconsumed plants which were found lying near the gerbil burrow openings in four principal plant commuities was (Prakash, 1969) :

Cenchrus ciliaris - 4.0, *Aristida adscensionis* - 3.7, *Eragrostis ciliaris* - 3.0, *digitaria adscendens* - 2.7, *Brachiaria ramosa* - 2.6, *Tragus biflorus* - 2.6.

This clearly indicates the gerbil preference for grasses which are also relished by sheep and other livestock. It was estimated that the annual feed requirement of gerbils at the above density level would be 1044 kg/hectare (Costing Rs. 225.68/hectare). The annual forage production of this rangeland was 1210 kg/hectare. The comparison of these two figures indicates that gerbils would not leave any forage for the livestock to graze. Thus the desert gerbil is a serious competitor to the livestock for forage and if it is to be developed, this pest should be effectively controlled.

A study of the stomach contents of the desert rodents (Prakash, 1962) further highlights their damaging propensities. During the winter they feed chiefly on grass seeds but during the summer they turn to rhizomes of grasses, partly because the seeds have already been consumed by them and partly to get some water from the rhizomes, which have a higher water content. In the rainy season the rodents feed upon leaves and flowers. This "rotational" feeding by the rodents makes them all the more dangerous for the maintenance or regeneration of natural pastures.

Trees : The damage done by the rodents to the tree species particularly to saplings, is chiefly of two types: (i) debarking, and (ii) completely slicing the stem. The first type of damages have been observed on *Albizzia lebbek*, *Prosopis cineraria* and *Acacia tortilis*. The activity is restricted to about half a metre from the ground surface but may extend to the lateral branches also. Usually the cortical cells of the stem are debarked which means a detrimental effect on the growth of the trees but at times even the xylem vessels are injured which prevents the ascent of sap, causing the death of the tree. The debarking activity has been observed in trees upto 3 to 4 years of age. In the hilly terrains porcupines inflict severe damages to trees.

Stems of *Prosopis juliflora* and *Acacia tortilis* were also observed to have been completely cut, resulting in the death of trees which were even 4 metres tall. In sanddune fixation area at Udramsar, 20 trees were damaged in about one month. This activity goes on under the soil surface. It is detected only when the tree starts drying up and after investigation it is found that the whole stem has been transversely sliced by the desert marauder. Similar areas were observed at Gadra Road in an *Acacia tortilis* plantation. *P. juliflora* trees were also observed drying due to rodent damages in the Great Rann of Cutch.

Rodents damage standing crops, almost both kharif and rabi, at every stage of their

life-history. In the paddy fields in U.P., 7.1 to 21.5 percent tillers of plants were destroyed by rodents but in Madras in the rodent infested paddy fields 5.2 to 65.3 percent of tillers were damaged. On account of rodent attack the yield of the paddy grains was reduced by even up to 59.5 percent. The reduction in yield of straw was reduced up to 45.7 percent (Anon., 1965, Jotwani & Beri, 1968).

Damages to groundnut crop in Andhra Pradesh were observed from 0 to 9 percent at seedling stage, at growth stage from 18.2 to 25.8 percent and at maturity stage from 4.1 to 7.6 percent (Anon., 1965; Jotwani & Beri, 1968). Wagle (1971), however, found a very low intensity of rodent damage in rice fields in lower Sind.

The rodent damage to wheat and barley crops, at Kanpur during rabi season was found to be maximum at the seeding stage, 11 percent in both (Jotwani & Beri, 1968).

The sugarcane fields in U.P. suffer an average loss of Rs. 66.50 per hectare due to rodent activities and for the entire state it comes to Rs. 7.8 crores (Gupta *et al.*, 1968). In Punjab Bindra & Sagar (1968) found that loss in yield of gur due to rodent damage averages to about 200 kg/ha. and in the lodged crop at Rupar it amounted to 575 kg/ha.

Rodents attack coconut trees also. 11.2 percent palms were attacked in Andhra Pradesh (Krishnamurthy, 1968) while the loss to the nuts or the attacked trees was maximum (17.1 percent) during rainy and winter seasons. But Kidavu Koya (1955) reported that the coconut yield was reduced by 50 percent due to rodent damage in Laccadive islands.

In Rajasthan, during 1970, *Gerbillus gleadowi* proved to be a major pest of Bajra crop and the intensity of destruction to sown seeds was so high that the crop in four districts had to be sown 3 to 4 times. In Rabi crop wheat and *sarson (Brassica compestris)* is destroyed to a great extent.

After cutting the Bajra *(Pennisetum typhoides)* cobs from the field, they are heaped in clear spaces in the backyards of hutments in the villages in the desert region for harvesting. The gerbils also move around the stacks of Bajra cobs or straw, tunnel under them and feed upon the bajra grains leaving the cob near the burrow openings. In Luni Block, in a small area of about 40 x 15m where Bajra was harvested, an occular estimate revealed about 40 gerbils, which is a very high density. The desert gerbil thus damages standing crops as well as the harvested one.

Orchards : In orchards and vegetable gardens, the rodents devastate the fruits. The squirrels are the major foe of grapes, guava, blackberry, etc. *Tetera indica* also damages the vegetables. In Himachal Pradesh, serious damage to apple plantations was recently reported to me.

Soil Conservation

The desert gerbil is also a big threat for any soil conservation work due to its burrowing habit. Its burrows are extensive and have no fixed plan (Prakash, 1962). The burrow openings are scattered everywhere and as many as 14,000 have been observed in a plot of 100 m. x 100 m. By

tunnelling, it excavates out fixed soil which form small maunds (about 1 kg) near each burrow opening. According to this moderate estimate with as many as 13,860 burrow openings in a plot 90m. x 90m, it unearths about 17,000 kg soil per hectare and, being loose, it is blown away by strong winds. The desert gerbil by this activity ameliorates the desert conditions and even helps in spreading it.

Gerbils' tunnelling activity very adversely affects the grasses and trees as the burrows are situated under their hummocks. While digging burrows, the gerbil gnaws their roots and exposes them to the hot and dry environment, causing their death. It is very difficult to quantitatively estimate such damages but to a person standing in a gerbil infested range, its mere sight will give an idea of the extensive damage caused to the natural vegetation by the rodent, which is a deterring factor in establishing sanddunes and turning it green. No sooner, a mobile sanddune is fixed by planting grass and tree species, the desert gerbil also finds its way into it and starts undoing man's efforts to check the march of the desert.

II. The Rodent Species

For a control, it is essential to know the rodent species involved in the damage as one method of control may not be effective for all the species and in all the habitat conditions. We may examine this further by discussing rodent control in rural areas. Usually it is thought that in a village only two species of rodents are to be controlled, viz, *Rattus rattus* and *Mus musculus*. This is a grave error we usually commit. In fact, many more species of rodents are found in the village complex and in fairly appreciable numbers. Leaving aside the crop fields near the village, the mud walls, thorn fences, fire-wood dumps, backyards and animal sheds around rural houses harbour many other species. Our Ecological Survey of rodents in rural areas in Rajasthan Desert revealed that nine more species (Table 1) in addition to *R. rattus* and *M. musculus*, are to be controlled in village complex.

TABLE 1

Relative Numbers of Field Rodents in Village Complex in the Indian Desert

Rodent species	Percent of the total collection
1. *Funambulus pennanti*	4.2
2. *Gerbillus gleadowi*	13.4
3. *Tatera indica*	39.0
4. *Meriones hurrianae*	16.4
5. *Rattus meltada*	20.1
6. *Mus musculus*	0.6
7. *Mus booduga*	1.8
8. *Mus platythrix*	1.2
9. *Golunda ellioti*	3.0
10. *Nesokia indica*	present

This clearly indicates that not only the rodent control operations should be taken up inside the residential buildings but also in the surrounding areas. Inside the houses, anti-coagulants should be used but for other species this method will be rather expensive and toxic chemicals can be used if it is safe to use them.

For control of field rodents, it is important to know their habitat. In the Rajasthan

desert we have found that majority of rodents have a preference for habitat (Prakash *et. al.* 1971, Table 2).

TABLE 2

Habitat Preference of Various Rodents of Desert Biome of Rajasthan

Sandy	Rocky	Ruderal [1]
G. n. indus	*R: cutchcus**	*F. pennanti*
G. gleadowi	*M. C. phillipsi**	*T. i. indica*
M. hurrianae	*M. C. sbsp.*	*R. m. pallidior**
R. gleadowi	*M. p. sadhu*	*M. b. booduga**
		Culunda ellioti

* Occurs exclusively in the habitat.

[1] *Rattus rattus refescens* occurs inside the houses in the habitat.

If we have a thorough knowledge of this aspect, control operation will be much more effective. Likewise, the predominance of field rodents change from crop to crop and locality to locality. In India, the following field rodents are of proven economic importance.

1. The Indian crested Porcupine, *Hystrix indica*—Hilly terrains, foothills of Himalayan ranges in northern India, Madhya Pradesh, Andhra, Mysore—debarking of trees, damages tuberous crops.
2. The Five-striped squirrel, *Funambulus pennanti.*
3. The Three-striped squirrel, *Funambulus palmarum.*

   The former species lives almost with man in north India but the latter is a forest dwelling species in South India. Both are injurious to crop fields especially orchards and vegetable gardens.
4. The Indian Hairy-footed Gerbil, *Gerbillus gleadowi.*
5. The Indian Desert Gerbil, *Meriones hurrianae.*

   The two gerbils are predominantly found in the desert region in North India (Punjab, Haryana, Rajasthan and Gujarat). Both are extremely destructive to kharif crops and grasslands.
6. The Indian Gerbil, *Tatera indica.*

   Almost throughout India. Besides being a reservoir of plague bacillus, (Baltazard & Bahamanyar, 1960), losses due to its depredatory activity in kharif and rabi crops are severe.
7. The House Rat, *Rattus rattus.*
8. The House Mouse, *Mus musculus.*

   Usually found in residential buildings, godowns ; and sometimes in crop fields. All over India. Damages to foodgrains and other domestic articles are of a very high magnitude.
9. The Soft-furred Field Rat, *Rattus meltada.*

   Inhabits cultivated field in Gujarat, Rajasthan, Punjab, Haryana, peninsular India. Its population density can increase to plague measures. Very destructive to crops. Its population density can increase to a high level and it mainly damages the rabi crops.
10. The Lesser Bandicoot Rat, *Bandicota bengalensis*—It is found all over India, in the fields, and in the foodgrain stores.

III. Rodent Control

An important aspect which is often overlooked by control operators is that, in

the field one encounters mixed population of rodent species and, therefore, control programme has to be carried out for all the species occuring. It is only seldom that in fields a population of a single species is found. When control operations are undertaken in a mixed population of rodents, the more dominant and mobile species feed on poison baits and are eliminated but the smaller rodents having restricted range of movement will survive in appreciable numbers. Due to the subsequent elimination of larger rodents, their reproductive rate enhances and their density increases very quickly. In programming a field control operation, placement of baits is a very important factor which should be based on the thorough knowledge of habits of all the rodent species inhabiting the region.

For mixed population of rodents, selection of bait is also a very important factor for effective control. The medium for poisoning should be selected in a way that is acceptable to all rodent species. This should be adjudged experimentally or taken from literature. Like human beings, the field rodents possess individual tastes and unless we take care of them, the kill percent will tend to be very low. Secondly, addition of vegetable oils in a low proportion, usually, enhances the palatability of baits.

In India, we do not have an ample choice of toxicants for rodent control as only a few are manufactured indigenously. The proportion of rodenticides should be carefully determined for various rodent species and mixed with the bait thoroughly. On the basis of studies conducted in the Institute, on bait preferences, seed consumption, and lethal dosages of various toxic chemicals, two methods for the control of field rodents have been recommended.

The first method is an improvement of the old one in vogue. Our experiments revealed that mixing of 1.5 to 2 percent zinc phosphide in carrier, is sufficient for rodent control, as against 5 percent practised in the past. This decrease in the poison concentration not only increases the palatability of the poison-baits but also reduces the chances of secondary hazards and pollution of environment. The other improvement we have made is by replacing *Gur* (Jaggery) by 3 to 5 percent groundnut oil. The third change which we have found advantageous is that the poison-baiting done after three days of prebaiting results into significantly higher mortality of field rodents. The fourth improvement is that poison baiting should be done only one day. If it is continued for more than a day, not only the consumption of the poison-bait is so low as to be wasteful of labour and material but the rodents develop bait shyness.

The modified method is to prebait the active burrow openings in field for three days at the rate of 6 gms per rodent per day. Prebaiting is to be done with :

Bajra flour	97 parts
Groundnut oil	3 ,,

On the fourth day poison-bait the burrow openings at the same rate with :

Bajra flour	95 parts
Groundnut oil	3 ,,
Zinc phosphide	2 ,,

The second method is based on three principles. The food grains should be saved for human consumption instead of using them for baiting rodents ; the pre-baiting and poison-baiting should be done together ; and thirdly, the method should be fairly cheap. Having studied the food habits of desert rodents, it was found that *'ber'* (*Jhadberi*, dried berries

of *Zizyphus nummularia*) are preferred by them over seeds of most of the desert vegetation. These are usually collected by farmers when they prune the bushes of "Pala" (leaves of ber, are excellent concentrate for goats, and the thorn are used for fencing). *Ber* grows in the desert in wild abundance. Even if bought, the dried *ber* are cheap, 0.50 paise per kg. In addition to high palatability, the air-dried *ber*, our experiments indicated, possess sufficient soaking capacity. We, therefore, worked on this 'non-foodgrain' material for using it as a carrier of poison for rodent control. The air-dried *ber* are soaked in a solution of Compound 1080 (Sodium monofluoroacetate) having a dosage of 3 mg/kg.

The third method which has proved of some worth, at least in irrigated fields, is the fumigation of burrows with aluminium phosphide tablets. This method has not, however, proved effective as well as economical for burrow fumigation in dry soils as the moisture content in the soil is not usually sufficient to liberate phosphine gas from the mixture.

Time of Rodent Control Operation

For a rodent infestation in a localised area or to save the crops from a sporadic attack, control operation can be taken up at any time of the year. But when a massive rodent control operation is to be taken up in the fields of a district or a State, its timing has to be properly fixed to achieve best results at a relatively low cost. Our studies on the habits and behaviour of field rodents have helped us in arriving at a decision about this important aspect of rodent control which has never been hitherto thought over in our country. It has been found that the breeding rate of most of the field rodents is minimum during summer months and in the month of December. Studies on their population dynamics indicated that lowest numbers occur during May and June. Analysis of their food habits pointed out that acceptability of baits is maximum during summer months when there is paucity of natural food. These results lead us to postulate that summer is the most appropriate season when large-scale rodent control should be taken up effectively.

REFERENCES

Anonymous, 1965. Report of the Co-ordinated Scheme for research on the study of field rats, 1965-66, *Ind. Coun, of Agric. Res.*, Krishi Bhavan, N. Delhi

Baltazard, M. and Bahmanyar, M. 1960. Recherches Sur la peste en Inde. *Bull. Org. Mond. Sant*, 23 : 169-215

Bindra, O.S. and Prem Sagar, 1968. Study on the losses to wheat, Groundnut and Sugarcance Crops by the field rats in Punjab. *Proc. Int. Natl. Symp. Bionomics & Control Rodents*, Kanpur, pp. 28-31.

Gupta, K.M.; R.A., Singh and S.C. Misra. 1968. Economic losses due to rats. *Ibid.* pp. 17-19.

Jotwani, M.G. and Y.P. Beri. 1968. Economic losses due to rats. *Ibid.* pp. 9-16.

Kidavu Koya, P.I.K., 1955. *Bull. Ind. Cent. Coconut. Comm.* 9 : 104.

Krishnamurthy, K. 1968. Rats—Their economic importance. *Proc. int. Natl. Sympo. Bionomics & Control Rodents*, Kanpur, pp. 20-22.

Prakash, Ishwar. 1962. Ecology of gerbils of the Rajasthan desert, India, *Mammalia*, 26 : 311-331.

Prakash, Ishwar. 1969. Eco-toxicology and control of Indian desert gerbil, Meriones hurrianae (Jerdon). V. Food preference in the field during monsoon. *J. Bomhay Nat. Hist. Soc.*, 65 : 581-589.

Prakash, I., K.G. Purohit and L.R. Kametkar. 1967. Intake of seeds of grasses, shrub and tree species by three species of gerbils in Rajasthan desert. *Ind. For* , 93 : 801-805.

Prakash, I.; R.K. Gupta; A.P. Jain; B.D. Rana & B.K. Dutta 1971. Ecological evaluation of rodent populations in the desert biome of Rajasthan. *Mammalia, 35 :* 384-423. □

Rodent Control in Godowns

A. L. Batra*

In the realm of foodgrains, rodents are omnipresent farms, stores, houses and even streets are not spared by them. Apart from the health hazard, rodents eat away (in literal sense of the word) a major chunk of foodgrains which are already in short supply in our country. It is estimated that about 2.5 million tonnes of foodgrains go into the stomachs of rodents in godowns alone. How this loss can be minimised through the application of mechanical devices, chemicals, ultrasonic devices, sterilants, fumigants, predators etc. is discussed in this paper.

RODENTS are one of the most dangerous and expensive pests living and flourishing at human cost from times immemorial. In old Hindu scriptures references to the depredations caused by rodents have been made. They are considered to be one of the most destructive vertebrate animals on earth. Rodents not only consume our food but also are a health hazard to both human beings and domestic animals. They destroy our grain, contaminate it with their filth and cause many diseases. They are responsible for Bubonic plague, Murine typhus, Scrub typhus, Tularemia, Rickettsial pox, Leptospirosis, Trichinelleosis, Rabies, Rat bite fever and Bacterial food poisoning. They cause considerable damage in godowns and warehouses to valuable articles, merchandise, property and sometimes even cause arson by gnawing insulated wires. Physical damage is rather obvious and can be estimated to some degree while aesthetic and health values are intangible and beyond accurate assessment.

The damage caused by rodents both in the fields as well as to stored foodgrains is well recognised. It has been estimated that, on the average, an adult rat consumes about an ounce (25 gms) of dry food in a day and that six rats eat as much as one human being. Rats are omnipresent and are posing a problem to man all over the world. An expert committee estimated the rate of damage at 2.5 per cent to foodgrains in storage.

In the light of the threat posed by rats as pest of food and potential reservoir of human disease, the Government of India, in 1964, appointed a National Rodent Control

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Committee to study the various aspects of rodents and their control in the country. This Committee discussed at length the question of rodent population in India. It was of the opinion that there were no accurate estimates of rat population but as this animal reproduces very fast and a single pair can multiply to as many as 250 rats in a year, the population of rats should be considerable. According to rough estimates made in 1951-52, rat population in India was considered to be 2,400 millions and keeping in view the fecundity of this animal, the subsequent estimates made in 1961-62, placed the population at about 4,800 millions. According to the Committee, it is not possible to either agree to or to refute these estimates but it can be safely assumed that the rat population is very large and must be causing considerable losses to foodgrains.

When sufficient shelter and food is available, rats multiply rapidly and cause a lot of damage. In practice, the seriousness of the problem is not appreciated where large quantities are handled over short periods as multiplication by rats continues unnoticed in such situations. Rat control measures, therefore, need to be carried out with all seriousness in foodgrain stores. Even in countries like the U.S.A., about 200 million bushels of grain are reported to be lost due to the activity of rats every year. In India, this damage has been estimated by the National Institute of Communicable Diseases, Ministry of Health, at 26 million tons of cereals each year. In terms of money, the rats are responsible for annual loss of about 2,000 crores to the agricultural products alone.

Types of Rodents

About 10 species of rodents are of major economic importance in the country, viz., *Bandicota bengalensis* (Indian Mole Rat), *Tatera indica* (Indian Gerbil), *Rattus Meltada* (Soft furred rat), *Mus booduga* (field mouse), *Meriones harrianae* (the desert Gebril) *R. rattus* (the house mouse), *B. Indica* (the giant bandicoot rat) and *R. norvegicus* (The Norway rat). Out of these the types of rats that are encountered in the farm houses and grain godowns are *Rattus rattus* (black rat), *Rattus Norvegicus* (Brown rat) and *Mus musculus* (House mouse). These rodents are either known as domestic or commensal or filed rodents and they share man's food.

Behaviour

Rats are nocturnal animals and become active after dusk or after the premises have become quiet. They may also be seen during day time, when disturbed. Their concerted habit of following set regular routes or runways leave behind greasy spots. This habit, combined with sensitivity to change, causes a temporary avoidance of anything new. The avoidance lasts for varying periods. The rodents feed quite confidently on eatables on becoming accustomed, but food is always removed to a protected site before it is eaten.

The mouse, however, does not appear to show any long avoidance to new objects. Although rodents are nocturnal, yet feeding during day time is quite common. They cannot afford to live far away from food and water. But it is reported that mouse may live without water for long periods.

A knowledge of the habits of rats is of great importance in their control. Over and

above the experience of the field agencies which are responsible for rat control, a number of research institutions and organisations have undertaken work of the ecology of rats, their method of breeding, food and other habits, with a view to designing the method of rat control. Experiments have also been carried out on the most effective methods and poisons which could safely be used. Particular reference in this connection may be made of the work done at the following institutions/organisations :

1. National Institute of Communicable Diseases, Delhi
2. Plant Protection, Quarantine and Storage Directorate of the Department of Agricultue, Goverment of India
3. Department of Food, Goverment of India
4. Rodent Control Centre, at Sangrur in collaboration with the John Hopkins University, U.S.A.
5. Arid Research Institute, Jodhpur, and
6. Rodent Control Porject at Sidhpur, with assistance from USAID

Clues to the Presence of Rats in Godowns/ Stores

(a) The presence of fresh loose earth, shiny droppings or rat excreta lying about the stores. Moist droppings will indicate fresh infestation.

(b) Footprint marks on dusty floor.

(c) Greasy marks in wooden beams due to constant climbing of rats.

(d) Bags gnawed at and with grain spilled out on the floor.

(e) Presence of irregular holes in the wooden doors, windows, etc. gnawed by the rats.

If no rats are apparently visible, it does not mean that the premises are free from rodents, as the rats generally come out after dusk only. We should, therefore, look more for the clues indicated above rather than actual appearance of rats.

Control Measures

In rodent control, we are faced with two problems, viz., controlling an individual domestic rodent in any given premises and controlling a large number of the same congregating in groups, i.e. rodent population in homes and at the farms. It is one thing to kill a rat or a mouse in a house and quite another to control numbers of them in a grain market or on the vast acreage at the farms. Because of the difference between the individual rodent and the group population we have to deal with them differently.

In fact the rat control operations should preferably be considered as a community project. Although by constant individual efforts, one may succeed in reducing rat population in small area but elimination and stopping the threat of reinfestation will only be rendered possible through the joint efforts of the entire community.

Good housekeeping is the basic factor for a successful rodent control programme. Hygiene and sanitation are of very great importance so far as rat control is concerned. The two most important factors which increase rat and mice population are food

and shelter. If these are denied, rodents cannot flourish. Keeping food materials in rat-proof containers and proper refuse disposal should also help guard against the spread of diseases transmitted by rats. The stores should be kept scrupulously clean and the grain should be stored in rodent-proof containers. All sources providing access to rats into the godowns should be removed. The known methods of rodent control in the godowns are mechanical, chemical (single or multiple dose poisons), repellants, ultrasonic devices, fumigants, sterilants and biological (predator and bacterial control).

1. **Mechanical Methods**

(a) *Rat-proofing*—From a long-range point of view, construction of rat-proof warehouses and godowns is the most effecive method of rodent control. Rat-proof or the exclusion of rats is the real solution to rat control as all other methods give only a temporary relief. The permanent method of excluding rats in grain godowns is to make them rat-proof and keep them in good repairs. Most of the buildings can be made rat-proof at a very small cost, but even if expensive repairs are necessary, the expenses are worth it.

Rat-proofing of godown is best carried out at the time of construction. Rat-proofing comprises of closing all unnecessary openings that provide access to rats. Floors should be made of concrete. Tin plates should be fixed at the bottom of the doors. The plate should be taken below the edge and passed on to the inner side of the door upto three inches and then fixed. Windows within three feet of the floor level and all ventilators should be screened with ½-inch mesh wire nettings. Openings around drain pipes and wire conduits should be closed with wire nets. Rat burrows, if any, in the godown should be closed and cemented. Metal cone with a projection may be fixed to the pillars of the verandah so as to prevent the rats from getting entry into the godowns. Any branches of the trees overhanging the godown should also be cut.

All the new construction of the Central Government has been done so as to make the godown rat-proof. In addition, other agencies like warehousing corporations and cooperative societies also have rat-proof storage facilities. At the end of 4th Plan period, there will be on the whole about 10 to 11 million tons of rodent-proof storage with Governments, Cooperatives, and Corporations. Even in such godowns, negligence can make this method ineffective. I. S. I. has published a code of pactice for the construction of farmers' storage structures, viz., Bukhari, Kothar and Aluminium bins which are rodent-proof and also for the improvement of existing structures for foodgrains storage. The Indian Grain Storage Institute of the Department of Food at Hapur has also developed designs for a number of types of metal and R.C.C. bins as well as other types of bins, which all are rodent-proof. As mentioned earlier, good housekeeping, i.e., sanitation goes with rat-proofing and is the most economical and effective method of rat control.

(b) *Trapping*—Trapping animals and later disposing them off is one of the oldest methods of rodent control. Trapping is an effective way to reduce rats and mice population under certain situations. This method is specially effective while dealing with small

populations or as follow-up action after the use of other methods. It can also be used where dead rat smell is considered intolerable. The effectiveness of a good trap can be enhanced by the bait used. But, as observed in a good number of cases, the method fails either due to failure to remove dried baits, improper cleaning of traps, or due to release of the trapped rats away from the house or in the fields.

The traps that are in perfect operating condition only should be used. On the basis of the knowledge of animals to be trapped, traps of proper size should be selected.

For the use in godowns and in houses cage trap is preferable. The trap should be so set that the treadle is on the rat run and is close to the wall. Then some attractive bait is placed in the trap. Fried substances are liked by rats during winter and green vegetables and fruits during the summer months. Rat, being shy of new objects, it is advisable to keep the traps open so that the rats can conveniently get in, consume the bait and escape during first two or three days. This enables the rats to overcome new-object shyness, and subsequently traps are set and placed. In this way maximum catch is obtained. The trapped rats should be killed by submerging the traps in water.

However, with large populations of rodents, setting and attending to traps often prove to be a time-consuming and discouraging chore in addition to wastage of large quantities of bait material, and is impracticable for field rat control.

2. Use of Chemicals

Poisioning is the quickest way of reducing high rodent populations. In this method direct kill of the rats is attempted by feeding them with poison through some attractive food. Various chemicals used can be broadly classified as single dose (acute) or multi-dose (chronic) poisons.

(a) *Single dose poisons*—There are many poisonous substances belonging to this group but comparatively a few of them are widely used for rodent control work. Under this group, zinc phosphide is very commonly used due to its fairly good safety record, low cost and reasonably high effectiveness against rodents. It is a dark grey or blackish powder which is effective in all types of rats. In moist baits, particularly containing plant acids, zinc phosphide slowly releases phosphine gas, giving a garlic like odour which is repellant to man and domestic animals but, perhaps, attractive to rats. It is, however, not suitable for permanent bait stations as bait shyness is developed and it also decomposes chemically.

The main steps for single dose poison baiting are :

(i) Pre-baiting

(ii) Selection of the place of baits

(iii) Poison bait application, and

(iv) Post-baiting measures.

(v) *Pre-baiting*—Rats being very suspicious animals, a little change in surroundings or the food material will reduce their visits to the usual feeding places. The purpose of pre-baiting is to accustom the rats to a particular food material kept as bait so that they rapidly feed upon it even when poison is added to the bait. At first, the rats may not touch the plain baits and as such two to three days time should be allowed for the

rats to overcome their shyness to the new objects.

(ii) *Selection and placing of baits*—The more attractive and appetising the bait base, the more successful would be the control measures. Coarsely ground wheat with 1.5 percent salt added to it forms a generally satisfactory base. In addition, cooked rice, wheat soaked overnight in water, flour mixed with sugur or gur (jaggary) bread or chapati crumbs, tomato and banana can be effectively used as baits. The selection of sites for keeping the bait is equally important. Places seleted should be the same for pre-baiting as well as for poison-baiting. Rats always follow certain regular routes from their nests to the food places. It is, therefore, necessary that the baits be placed along these routes and nearer to the nesting sites, if traceable. If rat burrows are observed, baits are to be placed inside the burrows also. Depending upon the size of the premises, a large number of baits have to be kept for better results. Care should be taken to see that baits are not placed either on loose grains or on foodgrain bags so that they are not displaced, making it difficult to locate them later on.

(iii) *Poison bait application*—After selecting the bait material and the sites and after undertaking pre-baiting for two to three days, poison baiting should be taken up. The most common acute poison recommended is zinc phosphide. It does not dissolve in water and gives a warning garlic odour. One part of zinc phosphide mixed with 20-40 parts of bait material is sufficient to kill the rats. While addition of a little sugar and vegetable oil will increase attractiveness and acceptability of the bait, the use of edible oil in the preparation will extend the keeping quality of zinc phosphide prepared baits.

Poison baiting should be undertaken in the manner described below :

Only on the day of undertaking poison baiting, the required quantity of zinc phosphide should be mixed into the bait material which should be the same as was used for pre-baiting. Mixing should be done thoroughly so that the poison is evenly distributed in the bait material. The poison bait so prepared should be divided into so many parts as the number of the sites selected. At the selected sites, specially designed bait containers should then be placed and the poison baits kept in them. These bait containers can be conveniently made out of empty kerosene tins to have a triangular shape. These bait containers should be used at the time of pre-baiting also, so that the rats get accustomed to them and enter without shyness when poison baits are kept, The poison baits should be kept inside the containers after sunset and the number of baits kept should be carefully counted. The premises then should be closed for the night. The bait containers should be inspected the following morning and the leftover baits should be removed.

(iv) *Post-baiting*—An interval of at least 15 days should be allowed for assessing the results of poison baiting. During this period, only plain bait should be kept at the same sites and it is to be observed whether they are being eaten away. If such is the case, poison-baiting should be repeated with a different bait material. In case poison-baiting has been carried out inside the rat burrows, post-baiting need not

be taken up. In such cases, the holes closed after poison baiting should be inspected to see whether they are re-opened. If the holes have been re-opened, then only poison baiting should be repeated.

The widespread use of acute rodenticides has declined somewhat during the last decade, mainly due to increased usage of the newer anticoagulant rodenticides which came into general use in the early 1950's.

(b) *Multiple dose (chronic) poison*— These are known as anticoagulant rodenticides. Anticoagulants or compounds that prevent clotting of blood were introduced in the early 1950s to wipe out the rodent population and started a new era in this field with a new concept. The anticoagulant poisons include hydroxy comarius, viz., warfarin, fumarin, tomarin etc., to name a few. Trials carried out in India and in other countries have confirmed certain advantages for this group of rodenticides.

(i) Poisons like zinc phosphide bring about a sizeable mortality almost immediately, but this proves to be a temporary reduction in rat popula tion. Rats like other animals, are kept at a certain level of population through competition. A reduction such as caused by trapping, poison-baiting or gassing results only in reduction of competitive forces, since at the best, only 80 percent control is possible through these measures. The residual population then multiplies very fast on account of lack of competition. Multiplying rats generally exceed original level of population before competition is set in and the equilibrium is reached. Anticoagulants do not suffer from this drawback as entrie colonies of rats are killed and it is possible to make areas completely rat-free with their help.

(ii) Rats do not get alarmed as the anticoagulants cause slow death by fatal internal haemorrhage comparable to natural death.

(iii) Anticoagulants do not create bait shyness among rats and pre-baiting is not necessary while using them.

(iv) Anticoagulants are used in very small quantities and being slow acting, the risk of accidental hazard to human beings and domestic animals is remote.

Anticoagulants are generally available as (i) 0.5 percent dry concentrate, (ii) ready-to-use dry bait and (iii) 0.5 percent water-soluble compound in India under different trade names such as Rodafarin, Ratafrin, Ratax, etc. Simultaneous use of both dry and liquid baits is more effective where density of population is very high. In the case of 0.5 percent dry concentrate, one part of it is mixed thoroughly with 19 parts of dry edible material such as wheat flour, or crushed foodgrains and a small quantity of edible oil and sugar to make the bait more palatable. As the name suggests, ready-to-use dry baits do not require any further preparation and can be used as such. To prepare bait of water-soluble compounds, one part of such compounds is mixed with 19 parts of water. The prepared baits or the ready-to-use baits are kept in shallow containers at the rate of 200-250 gms per container, which are kept along rat runs. The baits are replenished as

and when necessary. To ensure maximum intake of baits by rats and to safeguard against any hazard, fixing of permanent bait stations is recommeded. A simple bait station could be prepared by cutting a four-inch diameter hole on two opposite sides of an empty wooden or tin packing box. This hole should enable the rats to enter and move out freely.

Because of the slow action of anticoagulants, the kill is obtained only after 8-10 days of continuous feeding. Mice takes as much as 20 days to show results. Affected rats run to open areas for fresh air and water. Consequently they die in the open.

3. Use of Rodent Repellents

Little has been achieved in the line of rat repellents for practical application even though encouraging results have been obtained in limited studies. Some success with Lauro-nitrile, Indonium compounds, Actidione and Zinc-di-melthyl-di-thio-carbamale and Malathion as repellants has been reported. However, the likes and dislikes of rats may not be the same in different places under changing food supplies or varied living conditions. This means that a single repellent may not be effective universally.

4. Use of Ultrasonic Devices

Rodent control by pneumatically generated ultrasonic waves was introduced by Henry Simon, Ltd. of Simon Engineering. It emits sounds unheard by humans but unbearable to rat and mice. The output frequency is continuously varied so that rats may not develop immunity to the sound through slotted deafness. This method of control has yet to be tried in India but it is claimed to be economic, humane and clean.

5. Use of Fumigants

It is possible to destroy the existing rat population from the grain stores by fumigating the whole store with MBr, EDB, EDCT, aluminium phosphide, etc. Such burrows which do not open outside the godowns can be fumigated with calcium cyanide powder or granules and aluminium phosphide tablets of 0.5 gms. The application is very simple. The fumigant at the rate of 30-70 gms of calcium cyanide powder or 1-2 tablets of aluminium phosphide tablets depending upon the size of the burrow and its network is introduced deep in the burrow with the help of a teaspoon or with a special type of bamboo applicator. The fumigant on exposure to the ground moisture liberates HCN gas in the case of calcium cyanide and phosphine in the case of aluminium phosphide. Since both these gases are highly poisonous, the burrows should immediately be closed tightly with stones or mud after the application of the fumigant to prevent any leakage. Reopened burrows should be fumigated again.

Before fumigation it should be ensured that none of the burrows open outside, particularly in residential premises.

6. Use of Sterilants

Encouraged by the success in achieving sterility in insects, attempts have been made to sterilize rats. Sterilization of rats is a simple and humane way of eradicating them. As such, greater efforts are warranted in developing an efficient sterilant. However, lack of special specificity has slowed down the actual use of this technique.

7. Use of Predators

Both field and commercial rodents are subject to attack by a wide range of predators,

parasites and pathogens ; the employment of these is generally called biological control. However, the method of control by using predators is handicapped because the predators, in general,. have low rate of reproduction. The predators also take the surplus, but rarely affect the breeding stock. They become pests by themselves by eating fruits, foodgrains and attacking poultry. Sometimes, as in the case of mongoose, a potential health hazard, viz. rabies, is also present. The use of either bacteria or virus for pest control is always faced with the danger of human poisoning. Therefore, the widespread application of this method, especially in grain warehouses, food industries and residential places has to be viewed with conservatism.

An encouraging news is that four strains of bacteria have been developed in Russia which are commonly known as 'Salmonellas' and the strains in question do not produce food poisoning in human beings as others do. The Russians believe that bacterial method has a number of advantages. It is also claimed to be cheaper than the chemical poisons. Because chemical pesticides often contaminate while acting on rodents and because in many cases resistance is developed, the method of control using bacteria, being harmless to human beings, seems to be a promising method for future use.

Conclusion

To summarise, the adaptability of rats is tremendous and they have been endowed by nature to overcome and survive even adverse circumstances. Since they have been living with human beings for centuries, people have taken them for granted as unavoidable companions. Their nefarious activities do annoy people but only after the mischief has been done. Their nocturnal and secretive habits make it difficult to observe their activities during day light except in the case of heavy infestation. More than one method of control has to be applied to obtain the desired results on long term basis. □

Micro-Organisms in Foodgrains

S. K. Bose*

The study of micro-organisms as a factor of spoilage of stored grain is comparatively of recent origin and great deal of research has to be done to understand fully its implication in grain storage and related matters. The aim of this paper is to highlight the role of micro-organisms in storage of foodgrains. After describing the general behaviour of micro-organisms, the author has gone into details of microflora present particularly in foodgrains, their function in it, nature and extent of damage caused by them and the method of controlling micro-organisms for arresting damages in stored foodgrains.

DURING the last few decades the methods of preservation and handling of foodgrains, other agricultural commodities and different food articles etc. have progressed tremendously. The scientists of different countries are not only engaged in isolating different factors of spoilage of foodgrains and other food articles, but they are also busy in finding out suitable methods by which the action of deteriorating agencies could be stopped and thus providing more food for hungry millions all over the world.

It is now known to the scientists, who are engaged in preserving foodgrains, that most important deteriorating factor of foodgrains are insects, rats, birds, moisture and micro-organisms. Out of these the last two factors are intimately related to each other.

The aim of the present article is to bring about the role of micro-organisms in storage of foodgrains, which have assumed importance recently, when compared to other factors damaging foodgrains in storage.

The micro-organisms of stored foodgrains consists of wide varieties of fungi and bacteria. They are same as the microflora that occur in soil, air and water and are either parasitic or saprophytic in nature. Their kind and abundance in stored foodgrains depend upon (a) climate under which grains are produced (b) conditions of storage (c) moisture (d) temperature. It has now been increasingly felt that the damaging effects of micro-organisms are considerable in storage of foodgrains. Their

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presence in foodgrains bring about heating, development of odours, kernel discolourations, loss of nutrient, change in palatability and, in many cases, produce poisonous substances in foodgrains which are harmful to both man and animals.

Principles of Classification, Morphology and Reproduction of Micro-organisms

Before going into the details of roles played by micro-organisms in stored foodgrains, it will be worthwhile to recapitulate, in short, the details of classification, morphology and reproduction of micro-organisms, since the activities of the microflora in stored foodgrains are intimately related to the general principles that govern their life-history.

The main groups of micro-organisms are : (a) fungi (b) bacteria and (c) actinomycetes, all of which come under the division of Thallophyta of the botanical kingdom.

The above three groups are further subdivided into different classes according to their life history. However, in this discourse, the classes etc. will be restricted only to those which are related to stored foodgrains and their products.

(a) *Fungus or Moulds* :

They are typically cottony or hairy growth, filamentous branched and connected with each other, forming mycelium. Protoplasm in them is young and more active at the tips of hyhpae where growth manifests itself in apical elongation behind which are formed cross-walls, and reproductive structures. Cross-walls with central pores are formed late in phycomycetes, but cross-wall with central pores are formed early in the hyphae of Ascomycetes, Basidiomycetes, Fungi imperfecti, and Mycelia Sterilia.

The reproduction of the fungi are through spores of either sexual or asexual

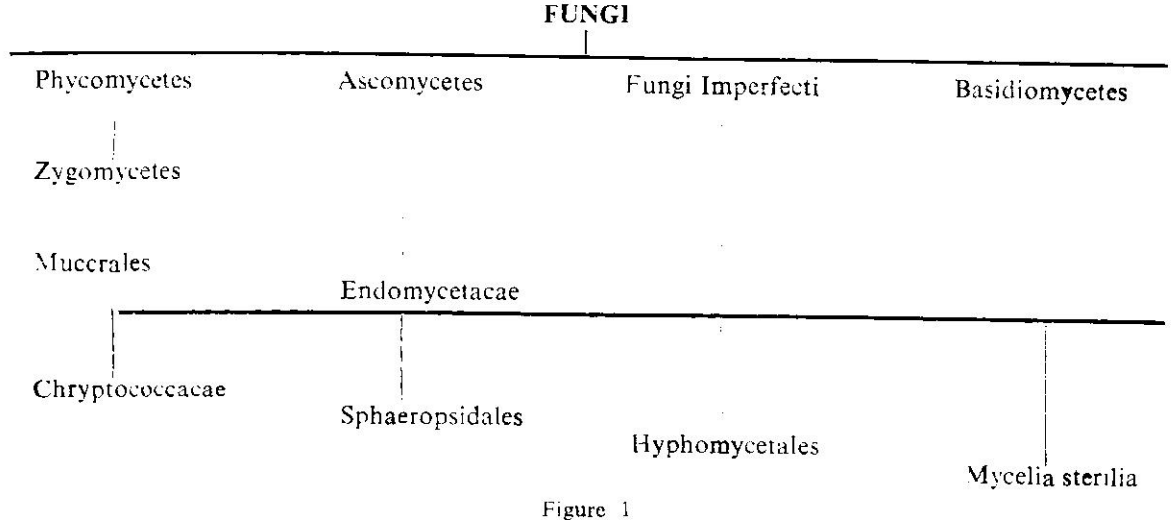


Figure 1

nature. Sexual spores are formed after the fusion of two cells, whereas asexual spores are formed without fusion of two cells. Spores may be unicellular or multicellular and of various shapes, and called as chlamydospores, conidia, sporangispores, zygospores, ascospores, etc. The spores vary in the length of time in their viability. In favourable environment viable spores germinate and produce one or more hyphae which invade cereal grain and grain product. The hyphae advances into the substrata by enzymological and mechanical action, and their being influenced by the availability of nutrients, moisture, temperature and aeration. The presence of toxic substances, other microbes, mechanical obstruction hinder their progress. The classification of fungi affecting stored foodgrains is as in figure 1.

The following are some of the important species of fungi under different class that affect foodgrains :

MUCORALES

Mucor spp	Rhizopus spp.
M. racemosus	*R. Modosus*
M. spinosus	*R. nigricans*
M. ambigus	*R. arrhizus*

ENDOMYCETACAE

Saccharomyces	*spp.*
Hansenula	*spp.*
Debaromyces	*spp.*
Pichia	*spp.*

CHRYPTOCOCCACEAE

Torula	*spp.*
Candida	*spp.*

SPHAEROPSIDALES

Macrophomina
Phoma

HYPHOMYCETALES

Aspergillus glaucus	*Penicillium notatum*
Aspergillus favus	*P. martensii*
Aspergillus repens	*P. expansum*
Aspergillus fumigatus	*P. cyclopium*
Mycelia sterilia	
Sclerotium spp.	

(b) *Bacteria and Actinomycetes* :

Bacteria comes under phylum schizophyta, class schizomycetes and are classified in five orders. Out of these five orders only two (1) Eubacteriales (2) Actinomycetales have mainly been studied in stored grain.

The bacteria are the smallest and most primitive of micro-organisms ; they are unicellular in structure or collection of single cells. Eubacteria consist of independent cells which are either rod or spherical in shape (0.2/u to 4.0/u). Their cells increase by fission and since they are incapable of penetrating intact cereal grain tissues but enter through damaged grain tissues, natural openings or damaged portions caused by insects. Out of the 13 families under Eubacteriales only 7 have been identified so far in stored grain.

Actinomycetales has been classified into three families :

(a) Mycobacteriaceae
(b) Actinomycetacae
(c) Streptomycetacae.

These bacteria produce elongated, branched cells or mycelium of narrow, branched, septate hyphae mostly less than 1/u in diameter. The mycelium are short-lived and divided by the segmentation into bacillary or coccoid elements in the family

of actionmycetecae whereas it remains in the family streptomyceteceae.

The following are some of the bacteria reported to be found in cereal grain and their product, grouped under 7 different families under the order eubacteriales.

PSEUDOMONADACEAE

Pseudomonas trifolii
Acetobactor oxydans
Acetabactor rancens

MICROCOCCACEAE

Micrococcus pulcher
Micrococcus Zeae
Pediococcus acidi lactici
Pediococcus lindneri
Sarchina maxima

LACTOBACTERIACEAE

Lactobacillus caneus
Lactobacillus buchneri
Lactobacillus xylosus
Streptococcus Lactis

ACHROMOBACTERIACEAE

Flavobacterium sp.
Achromobacterium sp.

ENTEROBACTERIACEAE

Aerobactor aerogenes
Escherichia Coli
Paracolobacterium Coliforme
Bacillus panificans
Bacillus maydis
Bacterium terme

BACILLACEAE

Bacillus cereus
Bacillus flavescens
Bacterium insulum
Clostridium viscifaciens
Clostridium welchii
Proteus vulgaris
Serratia marcens

BACTERIACEAE

Bacterium crenatum
Bacterium lineus

The following are the actinomycetes that have been reported from cereal grains :

1. *Streptomyces albus*
2. *Actinomyces albide*
3. *Actinomyces graminis*
4. *Actinomyces griseus.*

Factors Affecting Growth and Development of Micro-organisms in Stored Grain

Unlike bacteria, which follows a growth pattern, the growth and development of fungi are more complicated in nature due to their multicellular structure. The growth rate of fungus is determined in the laboratory in terms of rate of spread of fungal colonies e.g., mm/day. The growth of the colony does not necessarily accompany reproduction since fungal colonies are required to obtain certain degrees of maturity before either sexual or asexual spores are formed.

However, the unicellular micro-organisms like bacteria follows a well-defined pattern of growth phases. The first phase is called the lag phase which is an adaptive stage. The 2nd phase is the logarithmic growth phase where growth commences to accelerate. This growth phase is followed by a stationary phase which manifests itself due to want of food and accumulation of toxic waste product. After the stationary

phase, the phase of decline starts where numbers of living cells began to fall steadily.

It should be remembered that micro-organisms grow under favourable conditions and declines in growth, if the conditions are unfavourable. The conditions which are most important, among others, are temperature, moisture and oxygen supply.

It is to be examined now one by one the factors that affect growth and development of micro-organisms in a given substrate.

(a) **Temperature :**

This physical factor is one of the most important factors affecting the growth of micro-organisms. Most of them have a well-defined temperature range of minimum, optimum and maximum and of these optimum temperature range is most suitable for the growth of micro-organisms. However, optimum temperature varies from species to species. The micro-organisms can be grouped in three divisions according to the temperature in which they function (See Table 1).

The micro-organisms produce heat as a product during their metabolic activity which is influenced by temperature, moisture, oxygen concentration, nutrients, age of cells. The highest temperature is that maximum temperature at which a particular organism can grow. Micro-organisms die rapidly above maximum temperature and slowly below minimum temperature. It has been seen that generally, most fungi and bacteria die within 10 minutes at 55°C while some survive 65°C for 10 minutes. Spores of many fungi tolerate 87°C for 30 minutes. In these groups comes *Penicillium cyclopium*, *Penicillium oxalicum*, *Aspergillus flavus*, *Aspergillus fuscus*, *Mucor racemosus etc.* Bacterial spores are more resistant to moist heat than fungal spores and may withstand 95°C for 45 minutes or even 100°C for few hours. Heat resistance of bacterial spores are correlated with the bound water in the spore and the maximum temp in which they grow. Some of the minimum, maximum and optimum temp. for some important Psychrophilic micro-organisms is shown in Table 2.

Table 1

Temperature °C

Group	*Minimum*	*Optimum*	*Maximum*	*Origin*
Psychrophilic	9-0	10-20	25-30	Water, Cold Storage Growth etc.
Mesophilic	10-25	20-40	40-45	Pathogenes and many saprophytes
Thermophilic	24-45	50-60	70-80	Soil, manure etc.

Table 2.a

Psychrophilic	*Fungi*	*Bacteria*
— 8°c to 5°c	Aspergillus glaucas Thamnidium elegans	Flavobacterium sulfureum Bacterium lactis viscosum
— 4°c to 3°c	Mucor racemosus Penicillium digitatum	
— 2°c to 0°c	Saccharomyees intermedius Phycomyces nitens	
		Bacterium putidum Achromobactor sp.

Table 2.b

Minimum, Optimum and Maximum Temperature of some Mesophilic Micro-organisms

	Temp °C		
	Minimum	*Optimum*	*Maximum*
Fungi			
Aspergillus candidus	3-4	20-24	42
Aspergillus flavus	6-8	36-38	44-46
Aspergillus niger	6-8	35-37	46-48
Aspergillus oryzae	7-9	35-37	45-47
Bacteria			
Bacillus subtilis	6	30	50
Bacillus mycoides	10-12	28-31	38-41
Acrobactor rancens	6-7	34	42
Escherichia coli	10	30-37	45

Table 2.c

Minimum, Optimum and Maximum Temp. of some Thermophilic Micro-organisms

	Temp. °C		
	Minimum	*Optimum*	*Maximum*
Fungi			
Mucor pusillus	21	40-46	56
Rhizopus Chinensis	10-12	—	52
Aspergillus fumigatus	10-12	37	57-58
Penicillum sp.	35	—	60
Bacteria			
Lactobacillus thermophilus	30	50-63	65
Bacillus subtilis	—	30-37	50-56
Ckistryduym roseum	8	37	62

(b) Moisture :

The availability of proper quantity of moisture is one of the most important factor that governs the growth of microflora in a particular media. According to the need of water, the micro-organisms can be divided into three groups of hydrophytes, mesophytes, xerophytes. The classification is done on the basis of minimum moisture requirement for growth expressed interms of minimum relative water vapour pressure required or measured in terms of water activity and is expressed in terms of water activity which is a function of moisture content of food article. The following are the minimum requirement of relative water vapour pressure of different groups of micro-organisms.

Hydrophyte	*Mesophyte*	*Xerophyte*
90% or more	80% to 90%	less than 80%

Bacteria is generally hydrophytic in nature and grows best at water activities near unity or more than 90% RWVP. They generally do not grow well below this level. The bacterial colonies grow faster if the substrate is in a moist environment compared to a dry one which also depend on the available nutrient of the substrate. The bacteria live longer at subminimal RWVP at low temp. than at high temp.

It should also be remembered what is the minimum moisture requirement of xerophytes. Their minimum water requirement varies between 62% to 90% RWVP or water activity of 0.65 to 0.99. Generally fungi are more resistant to dry conditions, particularly, their spore form (which is the case with bacterial spore also) which can withstand low water activity or dessication.

It has been established by various workers that some species of the genus Aspergillus are xerophytic while some are mesophytic. Similarly many species of mucor and penicillium are hydrophytic. It has also been observed that spores of single mould population have minimum moisture requirement normally distributed, while hydrophytic and xerophytic fungi show a sigmoid distribution of spores germinating between minimum and maximum RWVP requirement. The following table shows the minimum relative water vapour pressure for some important fungi :

Rel. water V.P.	
90 to 100%	*Puccinia Graminia*
	Cladosporium fulvum
	Alterneria Tenuis
	Botrytis Cineres
	Ustilago hordei
	Penicillium brevicaule
	Rhizopus nigricans
	Mucor racemosus
	Alterneria brassicae
	Alterneria Solani
	Cephalothecium roseum
	Penicillium glaucum
	Cladosporium herberum
80 to 90%	*Aspergillus niger*
	Mucor racemosus
	Ustilago avenae
	Aspergillus flavus
	A. *Fumigatus*
	A. *Oryzae*
	A. *glaucus*
	Phycomyces nitens
	Penicillium Cyclopium
	Rhizopus nigricans
70 to 80%	*Aspergillus glaucus*
	A. *herbariorum*
	A. *Candidus*
	Aspergillus Versicolor
	A. *ruber*
	A. *repens*
	A. *niger*
	Penicillium Citrinum
	P. *rugulosum*
	P. *spinulosum*

It has been seen further that not only the mould spores have different water requirement for their growth according to temperature variation but also on the presence or absence of nutrient in a substrate. As has been seen in *Alternaria Citri* that water requirement is minimum when nutrient is present rather than when it is absent. It has been seen that germination spores are hyperbolically slower when RWVP is not optimum and spores take

much longer time to germinate compared to the condition when it is optimum and the spores germinate very quickly. Spores perish when moisture is below minimum. They also die at higher temperature e.g. *Aspergillus ruber*, *Aspergillus repens* perish between 10-12 months at 60% RWVP at 25°c; similarly *Urocystis triticia* die within 12 months at RWVP 72% to 89%, Helminthoum oryzae has been found to perish within 4-6 months when RWVP is 45%, 70% and 90% at temperature range 10°c to 31°c. Restricted water supply has been found to infuse abnormal vegetative growth in fungi when change of form also is found to have occurred. This is true for *Ustilago avenae* which changes from yeast-like form to mycelial form when RWVP changes from 100% to 96%.

(c) **Oxygen :**

Like all other living things micro-organisms also require oxygen to carry out their life processes by bio-chemical oxidation of food article. Some carry functions with O_2 some without O_2 and hence the micro-organisms have been grouped according to their oxygen requirement. They are (i) aerobes requiring O_2 as present in air at atmospheric pressure (ii) Anaerobes who require O_2 for their respiration purpose while the food decomposes and release O_2 (iii) Facultative anaerobes can adopt themselves to both aerobic and anaerobic conditions.

Bacteria of genus *clostridium* is a typical anaerobes while many species of *Bacillus* show facultative quality. Some actinomycetes are aerobes along with yeast and some mucors who are moderately aerobes and die when O_2 concentration approaches zero.

The majority of fungi are strongly aerobic. If the O_2 concentration is below minimum spores and mycelium of many fungi fail to grow. However at this subminimal O_2 supply the mycelia respire but spores remain more viable for a longer period than the mycelia. In a suitable media where nutrient is freely available O_2 requirement becomes low. Fungi can grow at a constant rate within a wide range of O_2 concentration.

Threshold O_2 Requirement of some Fungi for Growth

Fungus	*Minimum Vol %*	*Optimum Vol %*
Aspergillus flavus	0.002%	0.038%
Aspergillus niger	0.006%	0.056%
Penicillium expansum	0.003%	0.056%
Penicillium notatum	0.006%	0.08%

(d) **Light :**

Amongst the different quality of light that comprises the specture the ultraviolet ray is highly bactericidal and fungicidal while visible light is weak in this respect, when infra-red radiation has little effect.

Ultraviolet ray of 2500-2800A° have been found to destroy both bacterial and fungal spores, inhibiting the growth of the vegetative portion of the organism.

(e) **Acidity of Food :**

Micro-organisms are very much susceptible to the changes in pH value in a food media. It has been seen that majority bacteria will not grow at a pH value less than 4.5 but grows well at pH value 7.5

which is slightly alkaline. Yeast have an optimum pH value 5.5 while fungi grow in pH range of 1.5-8.5 but like a value around pH 4.0. Since pH value is selective in respect of micro-organism, their occurance will be more or less governed by the pH value of the media. pH has also an important part to play in the case of destruction of micro-organisms heat.

(f) **Sugar Content of the Media :**

It has been seen that high concentration of sugar in a media bring about reduction of water activity due to high osmotic pressure and thus producing an inhibitory effect on the growth of micro-organisms.

(g) **Salt Content of the Food :**

The amount of salt present in a media also causes inhibitory effects on micro-organisms either by reduction in water activity or by the effect of salt itself.

(h) **Inhibitory Substances :**

There is a long list of substances which cause inhibitory influence on the growth and development of the micro-organism. Their mode of action is complicated and discussion on this is little out of place for this article. However, as a passing reference it can be mentioned that SO_2, Sorbic-acid, Nisin etc. causes inhibiting effect and thus might have some bearing on the control of micro-organism in the foodgrains.

(i) **Nutritional Requirement :**

Nutritional requirement of micro-organisms are more or less similar as those required by man and higher animals. The micro-organisms have a wide range of nutritional requirement from most simple to most complex. Some primitive bacteria may use very simple chemical elements like CO_2 and NH_3 as a starting point of synthesis of protein and obtain energy from oxidation process of inorganic salt, whereas at the other end there are some parasitic fungi and bacteria which grow in living cells requiring unidentified growth factors and vitamins. It is a fact that micro-organisms can survive and grow with minute quantity of nutrients and hence there is a need for cleaning and good house-keeping in storage practices.

With the background of general behaviour of micro-organisms as has been described earlier we will now go into details of microflora present particularly in food-grains, their function in it, nature and extent of damage and the method of controlling micro-organisms and arresting damages in stored foodgrains.

Micro-Organisms in Cereal Grains :

Micro-organisms are found both internally and externally in the cereal grain throughout the humid and semi-humid areas of the world where high rainfall, high relative humidity, dew and high temperature favours development.

Micro-organism are carried both internally and externally in cereal grains. They are detected in a given sample of grain by (i) surface detection of growth in whole grain stored moist or in laboratory culture media, (ii) by examining infected seedling and older plant grown from whole grain, (iii) Examination of grain tissues under microscope (iv) examination of shrivelled and mumified grains, discoloured grains, damaged embryos, endorspem pericarp, fungal growth etc.

Micro-Organisms Borne Internally in Cereal Grains

It is now known that many parasitic and saprophytic fungi and bacteria are carried internally in the tissues of the kernel, e.g., *Nigrospora oryzae*, *Cephalosporium aerimonium*, *Microascus trigonosporus*, *Penicillium oxalicum*, *Aspergillus spp* and many other types of fungi are carried below the epidermal layer of grain fungi (Semeniuk 1954). *Ustilago nuda*, *Helminthosporium gramineum* of barely and *U. Tritici* of wheat was detected in the grain tissue (Russell 1950). The presence of the micro-organisms depend on their own aggressiveness in the action of true parasites, on the stage of grain development when they are present in air, on grain susceptibility and on the weather.

The following are some of the fungi and bacteria carried internally in the cereal grain (Dickson 1947 and Greaney F.J. et. al 1946) :

Fungi	*Found in*
Collectotrichum graminicoloum	Oats, Rye, Maize.
Diplodia Zea	Maize.
Fusarium Spp	Wheat, Oats, Barley. Maize.
Gibberella Zeae	Wheat, Oats, Barley. Maize.
Helminthosporium Sativum	Wheat, Barley.
Septoria Tritici	Wheat
Ustilago avenae	Wheat, Rye.
Xanthomonas translucens	Wheat, Barley, Rye.
Bacterium stewartii	Maize.

Micro-organisms Borne Externally in Cereal Grains

Mainly saprophytic and to some extent parasitic fungi are the components of external microflora in grain. The external microflora includes :

(a) Parasites partly on grain and partly in tissues.

(b) Saprophytes that have adhered to the seed.

(c) Saprophytes that have developed on the surface of grain as epiphytes.

(d) Saprophytes and parasites that are loosely associated with grain but not developed thereon (e.g. ergot, sclerotia, smutspores etc.)

External micro-organisms may be detected by visual inspection, microscopic examination of grain or aqueous washings or culturing the washing in gelatin or agar medium (James N. 1946 and Wallace R.H. et al 1951).

The moulds that have been found on grain surface are as follows (Semeniuk 1954): *Penicillium*, *Collectorichum*, *Aspergillus*, *Alterneria*, *Helminthosporium* species on wheat, *Gibberella Zeae*, *Collectorichum Cereale* in wheat and Oats. *Asperigillus flavus*, *A. Fumigastus* in wheat. *Aspergillus Oryzae* in paddy. Besides these, yeast and yeast-like fungi have been observed on grain. Desikachar et al 1956, reported occurence of *Penicillium islandicum* and *P. Citrinum* in rice.

Bacteria are found in more numbers than fungi in nearly all bulk quantities of grain and on moist kernels They are present in grain at various stages of development. The following are some of the bacteria found in cereal grains :

Pseudomonas maidis
Acetobactor rancens

Micrococcus zeae
Micrococcus pulchers
Flavobacterium
Escherichia coli
Proteus vulgaris
Bacterium crenatum
Bacillus maidis
Bacillus subtilis
Clostridium Moseum
Bacterium herbicoalaureum
Pseudomonas trifolii
Lactobacillus brevis

Actinomycetes are also frequently detected in cereal grains and had increased during grain storage and reported to have been carried by soil particles mixed with grain (Morgenthaler 1918 as reported by Semenuik 1954). The following actinomycetes are reported from cereal grain :

Actinomyces albido
Actinomyces globisporus
Actinomyces graminis
Actinomyces grisens

Function of Micro-organism in Stored Grain

It has been seen that fungi are more important agent of deterioration in stored grain at R.H. below 90% provided the temperature and O_2 concentration are favourable for their growth. Bacteria become important and come into play when R.H. is higher than 90%. Bacteria may be important at lower moisture level when metabolic water from moulds creates pockets of high moisture (Nogel C.M. and Semenuik G. 1947). It has been reported by Christensen (1969) that the following six major conditions influence the activities of storage fungi :

(1) Moisture content of grain
(2) Temperature
(3) Period of storage of grain
(4) Degree already affected
(5) Amount of foreign matter present in grain ; and
(6) Activities of insects.

Fungi slowly perish in stored grain when moisture is subminimum for growth. At 15% moisture level a 90% decline in fungal count has been observed in corn-meal stored for two months (Thom C, and le Fevere 1928). Moulds will grow at low moisture level in combined starch and protein medium than starch or protein medium than starch or protein singly. They will grow better in low moisture level better either in starch or protein than in fibre. In relation to fungal spoilage R.H. of 65% has been suggested as limit for 3-year storage at 60°F to 90°F. Whereas 3 months storage has been suggested at 72% R.H. (Snow D., et al 1944). The fungi appear in grain when the moisture, O_2 concentration, nutrient etc. approaches optimum level. They manifest themselves on (i) dead or weak kernels (ii) on grain with broken or cracked pericarp, (iii) on germ portion of wheat, corn etc. (iv) on bran than flour.

The fungi sporulate better when moisture, temperature and O_2 concentration are above the minimal level. They also sporulate better in nutrient medium best suited to them. At 1% O_2 concentration with 28° to 32°C. temperature coupled with 95-100% R. H. fungi sporulate faster and freely. The type of fungal growth is initially influenced by moisture, O_2 concentration, temperature, pH value, nutrient supply and other antibiotic substances. As the moisture and temperature

become favourable, more and more species appear in the grain. The influence of other factors on the type of fungus grown in grain is less known and require more study.

Mainly species of genera *Aspergillus, Penicillium, Mucor, Fusarium Candida, Botrytis, Helminthosporium, Alterneria, Monilia,* are found in cereal grains and grain products in storage. Milner Christensen and Geddes (1947) studied the growth of fungi at different moisture levels for 20 days at 30°C. They found the following fungi growing well in different R.H. % as shown below :-

Name of fungi	*% moisture in media*
Aspergillus glaucus	15.4%
Aspergillus flavus	
Aspergillus condidus	16.8%
Penicillium sp.	
Aspergillus flavus	
Aspergillus ochracens	18.5 to 20.8%
Penicillium sp.	
Aspergillus flavus	25.2%, 30.5%, 38.6%

Growth of penicillia and other fungi has been observed in wheat with 22.8% moisture when stored in open boxes for 3 months at —5 deg., 0 deg., 5 deg., 10 deg., and 20 deg. C (Semenuik G. 1954), Mazumdar S.K., Narasimham K.S. (1965) reported preponderence of *Aspergillia Penicillia* and *Mucor* in low moisture sorghum as compared to other group, while yeast bacteria, actinomycetes were relatively more in proportion to other micro-organisms in the high moisture sorghum. They further reported that due to fluctuations in temperature factor, the conidial heads did not develop in high moisture sorghum though filamentous growth of Rhizopus, Mucor and Aspergilli could be seen on the top of the grain when stored in bulk in above-ground storage structure. They have further established physiogenetic relationship of microflora with the micro-ecological conditions of the substrate for their growth. It has been further reported by Mazumdar S.K. et el, that average moisture of dry grain will not offer absolute immunity from fungal growth under the ecological conditions presented by the temperature fluctuations in the tropical and sub-tropical regions of the world. In dry grains, under warehouse conditions insect attack leads to the development of hotspot, increase in moisture and also mould growth. Filth and toxins are produced by their activities on grain. Microflora producing toxins are also many. Production of toxins, however, depends on the type of fungi that grow in the grain.

Bacteria require higher moisture level for growth in grain. It has been seen that number of bacteria decreases when the moisture is subminimum for their growth. It has been observed that bacterial flora changes along with increase in temperature in a medium. The activities of actinomycetes are little known in stored grain. Thermophiles were observed to increase on moist wheat that was being dried by air streams at 100 deg. C and with grain temp. of 50 deg. C. (Rautenstin J.I. 1939). The same author said *Actinomyces albus* has been observed frequently and *Actinomycetus griseus* less frequently in heated grain.

Damage to Stored Grain by Micro-organisms

The micro-organisms affect grain in the following manner (adopted from Food Storage Manual Part I. P 64-103. F.A.O. Pub.) :-

Table 3.a

Micro-organisms affect

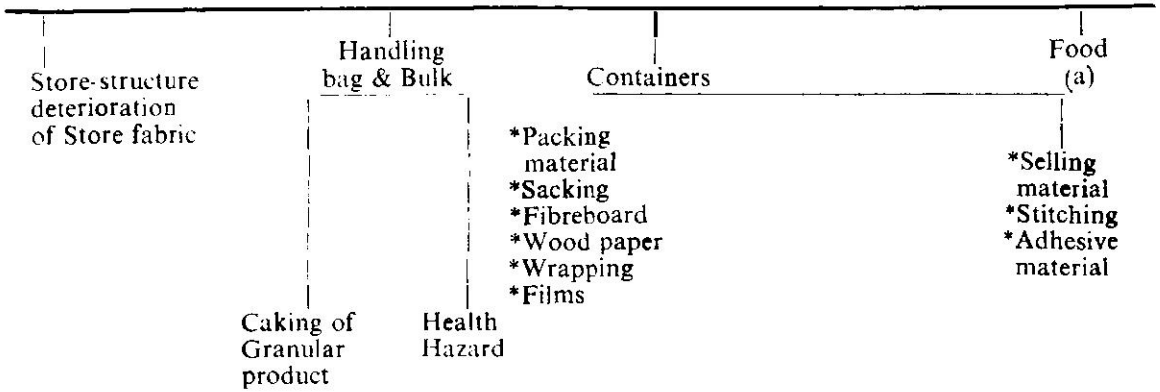
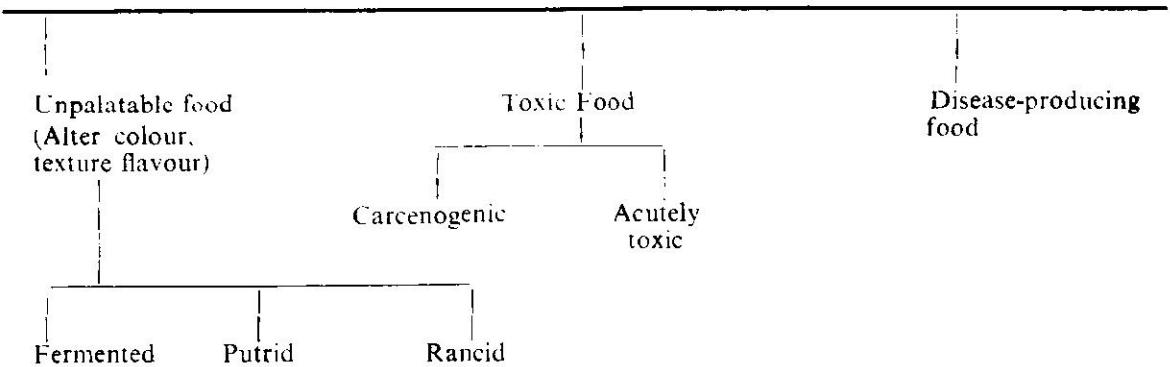


Table 3.b

(a) Food + Micro-organisms



Christensen C. M. (1969) reported 6 major types of losses caused by fungi that grow in stored grain. They are :

(a) Decrease in germinability
(b) Discolouration of Kernel
(c) Heading or mustiness
(d) Various biochemical changes.
(e) Production of toxins harmful to man and animal.
(f) Loss in weight.

Germinalibility

There is considerable evidence to indicate that viability of grain falls rapidly when the micro-organisms grow, although it has been a difficult point to establish that storage fungi is a direct cause of loss of germinability since germination percentage and vigour are affected also by a number of other factors like conditions of harvest, seed maturity, seed dormancy, mechanical damage to seed etc.

Discolouration : It has now been generally recognised that storage fungi can cause discolouration of germ of the seed or whole of the kernel. If we examine the embryos of sick or damaged wheat we will find abundant fungus mycelium in such discoloured germ portion or discoloured kernels.

Heating or Mustiness : Heating is associated with grain storage for a long time. Grain affected by micro-organisms exhibit greater respiration and heating rate. Such activities ultimately produce off flavour and mustiness in grain.

Biochemical Changes : The attack of micro-organisms on grain cause deterioration of fats and thus increasing fat acidity value. It has been reported that micro-organisms through enzymatic action breaks down protein, carbohydrates etc. in grains.

Production of Toxins : Some of the fungi during their attack on stored grain produce mycotoxin through their metabolic activity which are specific chemicals or mixture of chemicals.

The following types of toxins are harmful, found to have been associated with the fungal attack on grains :

Hepatotoxins or Liver Poison : This liver poison is aflatoxin, a toxic principle of *Aspergillus Flavus.*

Nephrotoxins or Kidney Poison : These toxins produce nephrosis and renal failure. Citrinin, a metabolite of Penicillium Citrinum is an example of this class of poison.

Neurotoxins or Brain and Central Nervous System Poison : These metabolites act on the brain and central nervous system. Patulin, a metabolite of *Penicillium patulum* is an example of this class of poison.

Phytodynamic, Dermatoxic Poison : These toxins produce dermatitis. Two dermatitic substances are produced by toxic strains of the organisms *Sclerotinia Sclerotiorum.*

Loss in weight : The invasion of micro-organisms ultimately has been found to manifest loss in total weight of foodgrains stored.

Control of Micro organisms : Before adopting any control measure it is necessary to detect and measure the fungus invasion which has got a bearing on storability or control measure that is to be adopted.

Indirect Method of Detection

(i) It has been seen that fat acidity value increases with the fungal attack and hence by estimating the F. A. V. in a given sample we can estimate the extent of fungi attack.

(ii) *Temperature :* During the attack of micro-organism, the temperature goes up to 55 deg. C. (131 deg. F). Thus an increase

in temperature in grain bulk to this degree indicates possible attack of fungi.

Direct Method of Detection of Fungus Attack

(i) *Microscopic examination :* By dissection of grain tissues and examining them under microscope we can detect the presence of fungi.

(ii) *Culturing :* By culturing, either putting whole grain or grain washing in suitable medium, we can reveal the presence of micro-organisms in grains.

Control Methods

Control of moisture : This method is one of the practical methods of controlling the attack of micro-organism in grain. This can be achieved by drying the grain and aeration. The inherent moisture associated with the grain itself is controlled by sun-drying or artificial drying, thereby bringing down the moisture content of the grain to safe limit below 12% in case of wheat and 13% in case of rice. It has been found that restricted aeration may retard fungal activity but will not prevent it altogether. It has been reported by Chohan J S., Danraj K.S., (1972) that forced aeration reduced the fungal activity to minimum

Control of Temperature : Reducing the temperature below the optimum for most fungi (23 deg. to 30 deg. C) will reduce the activity of the moulds. Similar is the case with bacteria.

Control of pH Value : The optimum pH for bacterial growth is 6.0 to 7.5 and for fungal growth is between 4.0 to 7.5. Now-a-days addition of sodium diacetate and sodium or calcicum propionate are widely used to control mould in bread and other bakery products.

Control by Chemical Methods : Chemical control of micro-organisms is still in infant stage. Many chemicals have been tried without success, but still then a good beginning has been made to find out a suitable method for chemical control of micro-organisms in foodgrains. It has been reported by Ragunathan A.N. (1973) the use of NH_3, SO_2 nitrogen trichloride, MBr., Chloropierin and Ethylene oxide for the control of grain fungi by different workers. Like insects, stages of fungi are also resistant to fumigants. The susceptibility or resistance of fungi to fumigant can be attributed to three factors: (i) Stages of fungi (ii) Location of fungi (iii) Environment of fumigation.

It has been reported that fungicidal activity of MBr. on several species of Aspergillus reveals that conidia are more susceptible than conidiophores It has been further studied that sclerotia of *A. Ochraceus* showed that it required 32 mg./L. about twice the amount of fumigant required for complete control of conidia by MBr.

A fumigant which is fungicidal in laboratory may not kill fungus in grain since the fumigant may not reach the seat of fungus, hence location of fungi is also important in controlling with fumigants. Environment of fumigation is also an important factor. It has been seen that at higher humidities when the spores are hydrated it increases the metabolic activity of fungi and with this susceptibility of fungus to the fumigant increases. Active stages of fungi which are having higher

respiration and metabolic activity than spores, would accumulate more fumigant, thus causing death of mycelial cells. The mycelium is also more susceptible than spores because of its involvement in sensitive growth procedure like nuclear division etc. The differences in susceptibility between conidia and sclerotia could be due to the variations in the cell wall and cell contents.

Conclusion

The present article is an attempt to present in a simple way the role played by micro-organisms in foodgrains. The information contained in the article is just enough to understand the role of micro-organism in foodgrains. There is vast amount of scattered literature which should be consulted if one wants to have a complete grip over the subject. The study of micro-organism as a factor of spoilage of stored grain as comparatively of recent origin and great deal of research has to be done to understand its implication fully in grain storage and related matters. ❑

Quality Control in Foodgrains

Hari Om Garg*

The history of quality control in foodgrains is now fifty years old and over these years a degree of sophistication has been achieved in devising methods to evaluate the various aspects of grain quality. Quality control in foodgrains not only ensures wholesome quality food to the consumers but also helps in reducing waste. In this paper, the author, in a systematic manner, defines the scope of quality control in foodgrains right from production stage to the processing stage. Further, an attempt has also been made to identify the main requisites of quality control in foodgrains at each stage : production, marketing, handling, storage, processing, etc.

EVER since the primitive man, having become sedentary, started using cereals for his food, he was faced with the problem of quality control in this seasonal raw material for using it as and when he required it. The remnants of millions of years old silos found particularly in Egypt are pointer towards this fact, although the scientific study of the problem started only about 50 years back. Today, the study of quality control has assumed greater importance because of several reasons. Foremost being to make available nutritionally sound foodgrains of good quality on the table of consumption and the second being in the line to minimise the losses in foodgrains to the maximum extent possible in view of the difficult food situation that the world in general and India in particular are facing because of population explosion that has outpaced the rate of production of foodgrains.

Quality assumes importance in relation to the end-product in view. Methods have now been devised to evaluate the various aspects of grain quality. In fact the term quality itself has vide connotations covering physical aspect such as appearance, freshness, mustiness, insect/fungus attack, bulk density, moisture content freedom from foreign matter etc; chemical aspect such as quality and quantity of protein, gluten, fat acidity, germination value, biological aspect, viz. pesticides residues, filth/uric acid content and hidden infestation and the milling aspect as determined by milliability, milling yields, baking/cooking quality etc. Consumers' preference also has a bearing on the determination of grain quality in the market. All foodgrains produced, procured, handled and stored need careful inspection and analysis to determine the quality with reference to the set standards and also to ascertain if they are fit for the intended use or otherwise. The inspection and analysis carried out indicate the composition of grain and extent to which refractions such as foreign matter, damaged grains, weevilled grains, moisture etc. are present. With the detailed inspection and analysis the price to be paid can be assessed and the interest of the producer as well as the consumer is safeguarded.

During the last few years, the losses of foodgrains both at the pre-harvest and post-harvest stages have been the subject matter

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of considerable criticism and adverse comments within the country and abroad. When we talk of the losses in foodgrains we mean loss in quality and quantity. The problem of estimation of correct quantitative and qualitative losses in the food crops in the fields and after harvest during handling and storage is a complicated one. Whatever figures could be put forth on records for such losses are nothing more than the estimates or the guess work of the experts. By and large, they also seem to be related to the climatic conditions. Such figures have been kept at a maximum for tropical and sub-tropical countries because insects, fungi, rodents and other non-insect pests thrive best in warm and humid climates of the tropics.

Proper pre-harvest care of the crop in the field and post-harvest care of the grain is essential not only to minimise the subsequent quantitative losses but also to reduce shrunken shrivelled, discoloured and damaged kernels as also the dockage, which bring down the quality, resulting cut in the market value and affecting milling yields and quality of end-products. Therefore, proper care of grain at various levels from fields to the consumption table is very essential with a view to ensure delivery of wholesome quality food to the consumers, handsome price to the producer and reasonable margin of profit to the processers. The various levels can be ascribed as :-

1. Production Stage
2. Marketing/Transportation stage
3. Handling Stage
4. Storage Stage
5. Processing Stage

Quality Control at the Time of Production

Some grain varieties are observed to be more susceptible to insect pests, fungus etc. than others and selection of such resistant varieties by farmers in consultation with plant breeders, who should rise to the occassion to develop many more resistant and high-yielding varieties of foodgrains to suit different agro-climatic conditions, is necessary. The attack of ergot on certain varieties of Bajra during last few years in India in fact posed a number of problems before the producers, procuring agencies and the Govt. with regard to the disposal of ergot-contaminated stocks as ergotoxin is found to be injurious not only to human beings but also to the cattle and the poultry. To proteet the grain from insects and fungus attack in the fields, use of such insecticides and fungicides, which only have minimum possible deleterious effect on mammals, should be intensified by the plant protection department or should be undertaken by the farmers themselves or through some pest control organisation.

Necessary attention during sowing, growth and harvesting of grain is called for to reduce the extent of shrunken, broken, chalky, diseased kernels, weeds, seeds and foreign matter in the grains because the presence of any of them, either alone or together, will affect the quality of the product and its storage life besides reduction in the price. The presence of poisonous weed-seeds like Dhatura causes concern and jeopardise the health of the consumers.

Presence of organic impurities in the form of dockage make the grain more attractive to stored grain insects; shrunken grains due to their higher rate of respiration than the sound grain, produce favourable

conditions for deteriorating changes by insects and micro-organisms and enzymatic reactions. Dirt/dockage present in the foodgrains also affect the penetration power of the fumigants.

At farmers' level adoption of proper farm management practices such as use of improved types of machines, implements, thrashing yards, storage structures, besides periodical inspection and timely disinfestation would go a long way to correct the present state of affairs and deliver quality grain to the market, which, in turn, will fetch a higher price to the farmer. The farmer would also have to ensure that the grain in his custody does not get contaminated and is dried properly before it is marketed or stored by him. Further, movement of grain swiftly from farms to regular warehouses, manned by trained technical personnel will help to protect the grain quality.

Quality Control at the Time of Marketing/Transportation

As the grain moves out of the farms for marketing, either to mandis or regulated markets, it is subjected to spoilage. Depending upon the topography of the area, quantity and distance involved, different modes of transport for the transportation of grain are employed. While the farmers use pack animals, bullock carts etc. the Govt. agencies and the traders use trucks, railway wagons, barges, ships and some times even aeroplanes. It is essential that the various types of grain carriers are subjected to periodical inspection and disinfestation, if necessary, so as to ensure that grain do not pick up insect infestation, contamination, moisture during transportation.

During peak months of marketing season huge quantities of stock accumulate in the mandis where adequate facilities for their proper storage even on a temporary basis do not exist. Every care has to be taken to protect grain not only from pests like insects, rodents and birds but also from vagaries of weather. Such a glut in the market also puts pressure on our transportation means forcing us to use such carriers which are not suitable at all for grain transportation. The grain transported in open wagons is a prey not only to theft and pests but also to damage by rains. Keeping in view the targets of foodgrain production marketed surplus and imports etc. requirements of standard wagons need to be assessed and proper planning for their manufacture is done. The wagons to be fabricated should be such in which grain can be fumigated, if necessary, during transit. Adoption of wagons of the type suitable for transportation of grain in bulk will help in faster clearance of the grain from the mandis flooded with foodgrain stocks. Construction of scientific storage accommodation in important grain mandis will also be useful in protecting the quality of the grain till such time it is moved to the consuming centres and will avoid huge losses that the food-grains suffer now at such mandis.

When we talk of marketing, we should keep one thing in mind that we shall always insist on purchase/sale of clean, sound, cool and dry grain only, in accordance with the laid down quality standards as this will greatly help in keeping the losses at minimum possible level during subsequent storage. The enforcement of quality standards need to be strengthened by providing a string of laboratories for grain grading and analysis.

Quality Control at the Time of Handling

Handling is an integral part of any operation either at farm, trader storage or consumer level. The grains are characterised by floability density, porasity, sorption capacity and thermal properties. Handling is possible because of the property of floability, which is related to the size, shape and moisture content of the grain. The grain is handled either manually, semi-automatically, by gravitational force, mechanically by buckets, elevators, conveyors, augers or pnuematically by grain conveyors During manual handling grain is lost due to bleeding of bags. The use of hooks by the labourers is need to be discouraged and in place improved type of bags with ears on all the corners to facilitate a firm hold by the labourers needs to be popularised.

Improper design or setting of handling machines is also likely to cause down quality on account of increase in breakage of grain kernels or dockage percentage and therefore, precautions at this stage would not only reduce losses but also help to maintain quality.

Quality Control at the Time of Storage

During storage the physical factors like temperature and moisture and pests are the most important ones which influence the keeping quality of the grains. The grain being hygroscopic in nature, picks up moisture from atmosphere and attains an equilibrium. Moisture and temperature produce favourable conditions for multiplication of insects and fungi. The insects and fungi produce heat and moisture on account of their respiratory activities. Thus this process is auto-catalytic in nature. The important deteriorative changes that take place in storage are either visible type such as sprouting, moulding, weevilization and discolouration, or invisible chemical and biochemical changes such as loss of viability, development of free fatty acids, loss of nutritive values, cooking, backing quality etc. Rodents and birds also cause qualitative and quantitative losses by direct feeding or contamination by their dead bodies, urine, faecal matter etc. In addition they are responsible for spreading a number of diseases also.

Fumigants and insecticides are widely used for effective control of infestation in storage, but, indiscriminate use of pesticides is not desirable as it may lead to health hazards to the consumers due to the contamination of pesticidal residues in the foodgrains. Use of moisture, rodent and bird-proof structures, which can also be made airtight to fumigate the foodgrain stocks for the control of insect infestation, as and when required can help in minimising the loss of grain in quantity and quality. Elimination of all sources of infestation, viz , infested grain, sweepings, old gunnies, dunnage, cracks and crevices in the storage structures etc. by improving the traditional storage practices needs no emphasis.

Hygienic and sanitary conditions in and around the storage structure is an essential requirement for the scientific storage management as clean surroundings can do away with 70-80 percent of the infestation problem. Pesticides when used on dusty surfaces do not give desired results also.

The main requisites of quality control in foodgrains during storage are :

(i) Selection of suitable and adequate storage facilities ;

(ii) Preparation of godowns for receipt of grain by elimination of all sources of infestation ;

(iii) Planning for proper storage by acquiring adequate quantity of dunnage material, pesticides and other pest control equipment well in advance ;

(iv) Inspection of grain at the time of receipt in warehouses/godowns with a view to have first-hand information about the quality of the incoming grain and also to segregate weevilled, damp or damaged and contaminated grain ;

(v) Care during stacking to build stable blocks standing on dunnage away from wall with sufficient alleyways around ;

(vi) Periodical inspection and categorisation/analysis of foodgrains during storage with a view to draw up disinfestation programme and priority list for issue of stocks;

(vii) Implementation of preventive and curative disinfestation measures regularly during storage ;

(viii) Upkeep of the storehouse throughout the stroage period;

(ix) Issue of stocks according to drawn out priority list. Necessary care at the time of despatches / issues needs to be exercised to segregate the deteriorated grain, with a view to avoid any complaint from the receipients;

(x) Timely reconditioning/salvaging of sub-standard stocks segregated at the time of receipt/issue and during storage in isolation sheds, so as to recover good grains;

(xi) Wherever necessary categorisation/ disposal of damaged/sub-standard grains according to set rules to avoid such grain finding its way in the market for human consumption; and

(xii) Safer handling of pesticides and their judicious use to avoid contamination of foodgrains beyond prescribed tolerance limits.

We can divide the storage, in fact, into three categories according to the agency undertaking it. These categories are : (i) Farm Storage (ii) Commercial Storage and (iii) State Storage. It is at farm storage where bulk of the production—say 2/3rd of the total foodgrains produced in the country—undergoes storage at least till such time next crop is harvested. It is only 1/3rd of the total production that is marketed in India and undergoes storage at commercial and state levels for varying storage periods ranging from few days to few years, depending upon the demand and supply position. The storage conditions at farmers and traders levels are far from satisfactory and it is at these levels where huge quantitative and qualitative losses occur. The reasons being the use of defective storage structures, which fail to protect grain from moisture, insects, rodents and birds attack, and lack of knowledge of scientific storage practices. Indian Standards Institution, New Delhi and Indian Grain Storage Institute of the Department of Food

at Hapur along with its sub-stations at Ludhiana and Baptala are engaged in developing and designing improved types of storage structures for different foodgrains under different climatic conditions in the country. The latter is also being engaged in the development of pesticides suitable for use at farmers and traders levels. The propagation of improved storage practices and insect control techniques amongst the farmers and traders is being done by the 'Save Grain Campaign' unit of the Department of Food, the activities of which needs further intensification. Under foodgrains traders licensing and control order it has been made obligatory by the Govt. on the part of traders to protect the grain from damages by insects, rats, and moisture. The enforcement of the clause needs to be ensured.

Quality Control at the time of Processing

The quality of grain is also impaired at the processing stage due to defective drying and cleaning techniques employed in the rice and flour mills. Improper drying of paddy is known to cause checking of rice which ultimately leads to increase in broken grains. The small brokens and the fragments are known to mix into hull and bran fractions and are lost as human food and the loss depends upon the efficiency of aspirators and separators. Similarly, improper conditioning of wheat results in poor milling yields. Old and obsolete machinery in most of the rice mills in the country is not responsible only for the lower outturn but also for the poor quality as the rice milled in these mills contains higher percentage of brokens, dehusked grains etc. and improper polish. Replacement of the obsolete machinery in the rice mills as well as in the flour mills in the country is a must besides adoption of improved techniques of milling by the millers.

Like foodgrains traders it has been made obligatory by the Govt. on the Rice Millers and the Flour Millers also under the respective Licencing and Control Orders to protect the grain handled by them from moisture, insects, rodents etc. Enforcement of the above clause in its right perspective and proper attention during various stages of milling will help a lot in obtaining products of better quality.

Conclusion

A grain saved is a grain produced. Adoption of quality control techniques by the persons engaged in production, marketing, transportation, handling, storage and processing will go a long way in tackling the problems of scarcity of foodgrains and malnutrition in the country.

In order to implement quality control in foodgrains effectively, the production of adequate quantites of suitable pesticides, equipment, rice mill/flour mill handling machines within the country has to be ensured. The other, nevertheless equally important, requisites are setting up of necessary machinery for their proper distribution/supply and making available the necessary technical knowhow to the persons at all levels of production, marketing, transportation, handling, storage and processing. A quality conciousness has to be developed amongst the people and importance of quality control techniques need to be widely published. Any effort in this direction will provide beneficial results to the Nation on economy, food and health fronts. □

Processing and Milling of Foodgrains

S. P. Virmani*

Scientific processing and milling of foodgrains is as important as increasing the foodgrain production. Milling is a general term used for processing of foodgrains into consumable form, keeping in mind the nutritive quality of the products as well as consumers' preferences. It facilitates storage of foodgrains and reduces wastage. This paper, mainly dealing with the milling of rice, surveys the existing milling processes in the country and brings out the relative advantage and disadvantage of each system. Finally, the author builds up a case for modernisation of milling of foodgrains in India.

INDIA'S Food Problem is a legacy from British rule. It received serious attention in the first few years of Independence. The Grow More Food Campaign, started during the war, was intensified. Agriculture received the highest priority in the plan outlay of the First Five-Year Plan. The results were encouraging. We came almost in sight of the final solution of the food problem. Controls were withdrawn. Imports shrank to the figures of less than a million tons in 1954-1955 but then began the massive food aid from the U.S.A. This made the country complacent. Agricultural production was put in lower gear. Heavy and basic industries came to receive the highest priority. Consequently the rate of agricultural development slowed down.

A new agricultural strategy, however, was evolved in 1966. This consisted of the concentrated use of high-yielding varieties of seeds, together with massive uses of fertilizers and pesticides in areas with shortages of water supply. The new strategy showed promising results as could be seen from Table 1.

Agricultural production in India increased by 6.7 percent in 1969-1970 and 7.3 percent in 1970-1971. There was, however, a setback in 1971-1972 when production declined by 1.7 percent. There was a further decline in 1972-1973 when agricultural production suffered marginally due to unprecedented droughts and floods in several parts of the country. Total output in 1972-1973 is estimated at about 100 million tons.

The substantial improvement in agricultural production during the last few years was primarily due to the new strategy to develop high-yielding varieties,

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Table 2 brings out these achievements in different types of crops during the Fourth Five-Year Plan.

It will be noted that the programme for achieving increased foodgrain production was to raise the coverage under the high-yielding varieties of cereals from the base level of 9.2 million hectares in 1968-1969 to 25 million hectares in 1973-1974. The

Table 1
Agricultural Production (million tons)**

	1967-1968	1968-1969	1969-1970	1970-1971	1971-1972
	1	2	3	4	5
Foodgrains	92.05	94.01	99.50	108.42	104.66
(a) Cereals	82.95	83.60	87.81	96.60	93.60
Rice	37.61	39.76	40.43	42.43	42.73
Wheat	16.54	18.65	20.09	23.83	26.48
Jowar	10.05	9.80	9.72	8.10	7.75
Bajra	5.19	3.80	5.33	8.03	5.36
Other Cereals	13.56	11.58	12.24	14.42	11.28
(b) Pulses	12.10	10.42	11.69	11.82	11.06
of which gram	5.97	4.31	5.55	5.20	5.11

**Figures are provisional and subject to revision.
Source : Economic Survey (1972-1973)

serious pests, diseases, decentralized water management system in a large part of the wheat growing area, a sure market and the price policy adopted by the Government in the last few years. In contrast, rice, jowar, bajra, and maize are all high-risk crops, both sensitive and exposed to shortage, or excess of water, greater susceptibilities to pests and diseases. According to the Agricultural Prices Commission, however, overall progress in this regard is satisfactory, though it is not uniform for all the foodgrains. The pace of progress in the case of wheat is faster than scheduled. In the case of rice it is more or less according to the schedule. For hybrid varieties of maize and jowar it is slow.

High-yielding wheat has proved to be a low risk crop because of the absence of "the high-yielding varieties of rice have been consistently successful when raised as a summer crop".

"Aided by a vigorous expansion of irrigation, a progressive shift of emphasis in the production of food grains from the kharif to the rabi season ought perhaps to form an important plank or re-orientation in the production strategy."

As important as increase in production is scientific processing and milling of foodgrains. The term milling is used generally for reduction of grain into flour or meal or any other consumable form. Processing or milling includes size reduction by polishing, sorting, mixing and also in some cases some chemical reactions. Milling is a general term used for processing of foodgrains into consumble form for human beings or animals. The factors to be taken into account in milling are the nutritive quality of the products, its cooking quality and consumers' preferences.

Dealing first briefly with wheat, it may be stated that this is a most versatile cereal put to diverse uses all over the country.

Wheat milling process consists of four different steps: (1) cleaning, (2) conditioning, (3) milling into flour and (4) storage of finished products.

Milling of wheat is a physical process which consists of bran, germ and endosperm in the following proportions:

Bran ... ... 12 percent
Germ ... ... 3 percent
Endosperm ... ... 85 percent

Table 2

Progress of High-Yielding Varieties of Cereals

(million hectares

Crop	*Base level 1968-1969*	*Fourth Plan Target for 1973-1974*	*Area coverage*		
			1970-1971 (Actual)	*1971-1972 (Estimated)*	*1972-1973 (Target)*
Rice	2.60	10.10	5.59	7.41	9.00
Maize	0.40	1.20	0.46	0.44	0.50
Jowar	0.70	3.20	0.80	0.69	1.10
Bajra	0.70	2.80	2.05	1.78	3.00
Wheat	4.80	7.70	6.48	7.62	8.50
Total	9.20	25.00	15.38	17.94	22.10

In India we have three different types of grinding :

(i) Domestic Stone Chakkis : In stone chakkis grinding is done by crushing action. These chakkis are common in villages for domestic consumption. These produce a coarse whole-meal atta which is used after sifting and removing 5-7 percent bran for making chapaties. Because of high admixture of bran and germ, the storability of flour is poor. The flour is not hygienically satisfactory and has a relatively dull white colour.

(ii) Power-driven Chakkis : In power driven chakkis grinding is also done by

crushing action. To some extent the urban power-driven chakkis do grind atta for local consumption. There is no arrangement for cleaning of wheat. The flour produced is heated in the process of grinding. The whole-meal flour obtained from these grinders is used as such after removing 5-10 percent bran by sifting the flour. It has relatively poor storability and also is dull in white colour hygienically. It is of a lower quality as compared to flour obtained from a roller flour mill.

(iii) Modern Roller Flour Mills : In Roller Flour Mills the grinding consists of tearing of wheat kernel apart, removing certain parts of kernel and then turning the rest into flour. Roller Flour Mills produce different types of wheat products to meet the requirements of various consumers.

The aim of the modern wheat milling system is to obtain the maximum wheat flour from the endosperm without contaminating the flour with bran or germ. Effective separation of bran from endosperm depends upon two principles :

(a) When wheat is conditioned, i.e. soaked in water, the bran becomes tough and rubbery while the endosperm becomes soft and friable.

(b) When wheat grain is sheared by the corrugation of first break roll in the process, it will split open releasing small endosperm pieces and thus exposing remaining endosperm which could be scrapped off the toughened bran in successive break rolls.

Most of wheat milling obtains 70 percent yield of white flour from the wheat, the byproducts of milling the germ and the bran altogether amounting to about 30 percent by weight.

Modern roller flour milling is in every way much better than either the domestic chakkis or the power-driven chakkis. Table 3 brings out comparative hygienic data obtained from Home Ground, Chakki Ground and Roller Mill Ground types of grinding.

In addition, chakki atta is neither cleaned, washed nor impurities eliminated. Chakkis also destroy 3-4 percent of wheat in their milling operations. There is also wastage of bran as the bran cannot be separated effectively from the wholemeal atta when it is ground by chakkis. On all these accounts it will be noticed that modern roller flour milling is most to be desired.

Coming now to rice, it may be stated that approximately half of the world population eats rice as its daily staple food. The world area under paddy is about 93 million hectares, producing 166 million metric tons of paddy. The value of the world rice crop is estimated to be over Rs. 100,000 million. In India 23 percent of the area under cultivation is devoted to rice. The total output is about 43 million tons of paddy. The consumption of rice in India varies from 100 kgs to 250 kgs per person per year. Rice continues to dominate the Indian economy as it is a favourite of the Southern, Eastern and Middle States.

Rice Research is carried on in a number of Agricultural Universities and

Research Institutions spear-headed by the Central Rice Research Institute, Cuttack. Several promising new varieties have been released such as Taichung Native I, IR-8, etc. in addition to Jaya, Vijaya, Bala, Cavery, Kanchi, Krishna, Padma, Pankaj and Jagannath.

However, different types of rice are popular in different regions. The Northern region States prefer long and slender types of strains whereas the Southern, Western and Middle States have a preference for coarse rice.

Rice being the staple food of the vast mass of the population its nutritive value is of immense significance. Rice supplies protein, minerals and vitamin B complex. The most important vitamin present in rice is vitamin B-1, that is thiamine. Deficiency of thiamine produces Beri-Beri, a vitamin deficiency disease.

The tastes of the people and the cooking quality of the strain is also a matter of no small significance. IR-8, a high-yielding hybrid strain from which much was expected, is now found to be not so popular except in Punjab and Haryana, as it does not suit the taste of the rice eaters and is reported to turn rockhard when cold.

Paddy is milled to remove husk, bran, germ and the aleurone layer. Paddy yields approximately 20 percent husk, 6-8 percent bran and 2 percent germ giving 70-72 percent milled rice.

The different methods used in milling rice are as under:

(i) Hand-Pounding: According to First Five-Year Plan, 65 percent of the paddy produced in India was hand-pounded. Hand pounding continues to be a very important village industry, giving considerable employment to women in particular. Work is in progress in improving the hand pounding processes for increasing the recovery of rice and production of bran in a pure form by the introduction of paddy

Table 3

Comparative Hygienic Data

Type of grinding	*Colour grade*	*Total ash per cent*	*Ash insoluble in HCL*	*Alcoholic acidity as percent of* H_2SO_4
1	2	3	4	5
Home Ground	41.0	1.47	0.06	0.048
Chakki Ground	42.2	1.51	0.05	.055
Roller Mill Ground	47.0	1.32	0.02	0.043

husking stone chakkis in place of the pounding method. In hand pounding different types of implements are used in different parts of the country. These are pestle and mortar and wooden chakki, stone chakki, clay chakki and dhenki. Generally wooden, stone and clay chakkis are used only for dehusking paddy, while pestle and mortar and dhenki are used for polishing dehusked rice and also for combined process of dehusking and polishing rice. Dhenki is used mainly in Assam, West Bengal, Orissa, Bihar and some other parts of M. P., U. P. and Punjab. Pestle and mortar is used mainly in Kerala, Madras and the South Hand-pounding is uneconomic as the recovery is low and much of the bran is lost.

(ii) Power-Driven Chakkis : In rice milling by power-driven chakkis there are two main types—huller and sheller.

In the huller, the machinery consists of a small size huller driven by electric or diesel oil motor of 5-20 H.P. The huller consists of two cylinders set side by side in an outer casing. These cylinders revolve at a high speed. One of these receives the paddy while the other discharges it after the husk is removed. The actual dehusking is effected by steel blades set in the outer cases against which the cylinder revolves. The blade is adjusted according to the size of the paddy and the degree of husking required. The product may be passed again through the same huller for polishing.

In the sheller type of rice mill, the dehusking is done by grinding the paddy between the two stone discs which resemble the stone chakki. The polishing, of the husked rice is done by automatic cone polishers. The cleaning, dehusking, winnowing, polishing and sieving are automatically performed one after another in a continuous process and the various products—rice, husk, bran, etc.— are separately delivered. The sheller type mill with a single sheller generally employs about 10 persons.

In the huller type of mill, dehusking and polishing being combined in the same process, the polishing cannot be controlled to the same degree as in the sheller type, operating with a cone polisher. There are some rice mills which combine the sheller and huller types, the dehusking being done by the sheller and the polishing by the huller.

(iii) Parboiling : In States like West Bengal, Assam, Orissa, and Madras, rice is milled after parboiling the paddy. The paddy is first soaked in water and steamed and double steamed and dried before it is pounded or milled. In the parboiling process the nutrient (vitamin B) of the rice is infused into the kernel and the outer shell is cracked. In this process the kernel gets gelatinized and when dry becomes hard and is not easily broken. This process of parboiling requires considerable open space as compared to the huller and the sheller and more labour. By this process the brokens and the wastage during milling are reduced to the minimum and the nutrients in the rice are preserved. In some areas there is a prejudice against parboiled rice. This has two reasons : religious and the other faulty methods of dehusking which produces a bad smell in the rice.

When the paddy is milled in parboriling, there is not much difference in the percentage

of recovery between the huller type and the sheller type rice mill. The bran yielded in a sheller type rice mill is, however, purer than in a huller type, because in the huller mill, the dehusking and polishing are done in a single process, and the bran gets mixed with broken husk.

In India there are 48,000 rice mills out of which 43,000 are hullers, 2,000 shellers and 3,000 huller-cum-shellers and 200 modern rice mills with capacities of about 2-4 tons per hour. The Indian Government's proposal to establish 500 modern rice mills and modernize another 1,000 during the Fourth Five Year Plan has encouraged fresh thinking of utilizing the byproducts from these mills. A huller mill produces only one product, i.e. a mixture of grounded husk, bran and finely ground rice particles which have little economic value and are used as animal feed. Modern mills, on the other, produce separated byproducts namely husk, broken rice and rice bran. Hullers are now prohibited by Government.

The fine weather conditions, which were favourable enough to increase rice production in Asia in recent years, have currently caused the "world's worst shortage ever". Thailand, previously the largest exporting nation, has been forced to impose curbs to preserve domestic supplies on account of drought and a late monsoon. Floods in the Philippines and the war devastations in Indo-China have cut crops further and boosted world demand and prices. U.S.A., however, has emerged as the world's largest exporter of rice, mainly because it is not a major rice consuming nation, American consumption of rice is hardly 8.5 pounds per head yearly.

The recent meeting in New Delhi of the FAO international group on rice and the move at the just concluded ECAFE session to establish an Asian Rice Fund are significant. India has also expanded its summer rice programme to cover 3 million hectares as against last year's 1.8 million hectares, as the new high-yielding varieties show considerably better performance during the summer season when rainfall is low and water management is easier. But along with a programme of increasing production of rice, a planned scheme for modernizing the milling processes are vital. The Government of India has recently sanctioned a scheme for modernizing and rationalizing the rice mills. The implementation of the scheme is being watched by all well-wishers of this biggest agro-industry in India. □

Packaging of Foodgrains

O. P. Garg*

A sound packaging system must ensure protection of the product; utility in the form of facilitating storage and transportation; motivation to selling efficiency; and profitability to the business. Perishable commodities like foodgrains present special problems for packaging since they are vulnerable to metabolism of tissue, micro-organism, insects, rodents and birds etc. How and in what manner these difficulties could be surmounted is the theme of this paper.

ANY commodity which is produced needs a suitable package for handling, storage and transportation. The idea of packaging is not new. It is prevalent since time immemorial, as there has always been commodities for storage, handling and transportation. In general terms, the object of packaging is to deliver goods at a minimum cost at the consumer's point in a condition in which they were produced and stored.

A suitable container for any commodity is that which facilitates handling, storage and transportation ; maintains the quality of the produce with minimum of effort ; creates confidence in the buyer ; and is economical in relation to the cost of the produce. These are the general basic requirements of a suitable package. The technology of packaging has made great advances in the present times. Packaging now is not only looked upon as a means of facilitating handling, storage and transportation but also as a means of advertisement and publicity for the produce. Moreover, with the development of more effective communication, the markets are not confined to small distances from the point of production. They have to be transported over long distances and in many a case they have to be exported outside the country. For successful competition in the markets situated at long distances in the country or abroad, the pattern of packaging that has to be adopted should be such that it not only gives utmost protection to the material but also generates an eye appeal, impulse buying and creates confidence in the buyer. Moreover, the rising standards of living and the need to conserve and distribute food products economically demands that newer packaging concepts should be introduced in the industry.

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General Consideration in Packaging

In designing packages, care must be taken to ensure that they can be handled, stowed, stacked and transported easily. The introduction of mechanical handling devices

sometimes poses a limitation on the type of packages that could be used for a particular commodity for a particular purpose. The effect of climatic conditions and attack of pests or micro-organisms have also to be considered while suggesting a suitable package. For any commodity, various factors are to be considered while thinking of a right type of package. These are mainly : the characteristics of the commodity to be packed ; type of storage where they are to be stored, if at all ; markets where they are ultimately to be consumed, i.e., within the country or abroad ; statutory or physical limitations ; mode of transportation to be used and whether freight is payable on weight basis or space basis ; and the effect of climatic conditions on the commodity.

The design of the package should be such that it should be possible to store them properly in a minimum space and in a countable position. It should also be possible to inspect the packages periodically for any indication of deterioration due to any factor such as climatic conditions, pest attack, effect of moisture or leakage of water.

The above considerations apply to packaging for any commodity, i.e., for the industrial goods, such as machinery, etc. and for perishable commodities such as foodgrains, cereal products or such others. While fixed uniform standards can be laid down for packaging of industrial goods, the development of a package for perishable commodities like foodgrains and cereal products is slightly different. Complex factors not so important for consideration for packaging of industrial goods have to be taken into consideration in designing a suitable package for perishable products.

Factors Affecting Packages and Packaging of Foodgrains

Foodgrains are most susceptible to damage by climatic conditions, i.e. atmospheric humidity, pest attack, such as insects and rodents, and by moisture caused by rain water or leakage in the godowns or seepage of moisture from ground or from walls. Foodgrains are a living organism and all factors that sustain life affect foodgrains. For efficient maintenance from the time of production up to the time of consumption, utmost care is needed to sustain its life. Any deterioration in its quality or characteristic will lead to a loss in price, nutritional value, viability and even loss in weight depending on the factors affecting the commodity.

From the above discussion, it can be concluded that packaging of foodgrains cannot be considered without taking into account the nature of the product and its properties. Packaging in this case involves the problems associated with the storage and effect of various environmental factors. In storage, foodgrains are subject to the metabolism of tissue, micro-organisms, insects, rodents and birds : the latter causing foul odour on the grains or loss of material.

Moisture and temperature have a profound effect on the first three of the above-stated sources of loss. It can cause spontaneous heating, loss of material and adverse chemical changes. Higher moisture content may lead to micro-biological activitiy and an optimum temperature in moisture content may encourage insect infestation. In fact, the storage life of grain is determined by its

dampest point because spontaneous heating begins with dampness which generally initiates heating throughout the grain mass. The moisture content of foodgrains for safe storage must not exceed 14 percent. Lower moisture content is usually preferable. Very low moisture content, on the other hand, may render foodgrains brittle and, consequently, increase the percentage of brokens. Micro-biological activity comes into play at moisture content above 14 percent. The fungus spores germinate and grow at a moisture content above 14 percent, although some of the species may be able to do so even at lower levels. Clean and high quality foodgrains are less vulnerable to the attack of fungi and insects than unclean grain mass.

Most insects thrive actively at temperatures between 28°C and 35°C and most of them die or stop reproduction at temperatures between 35°C and 40°C.

The packaging of foodgrains whether for storage at the production point, at the mill level, for transport, for export in large packaging or for export in small consumer packages involves storage for varying periods of time. It should be such wherein the optimum conditions for damage due to metabolic activity of grain tissues for development of micro-organisms or for development of insect infestation can either be avoided or controlled by giving special protection in packed condition.

Other factors like damage by rodents and birds are external and have to be taken care of by maintaining good hygienic conditions in the premises.

Overall requirements of sound packaging for foodgrains have been classified as follows :

1. *Protection*—It should be able to provide sufficient protection from the environment during anticipated conditions and period of use.

2. *Utility*—It must identify contents and quality. It must facilitate transport and distribution to more effective and convenient use of contents.

3. *Motivation*—It must contribute to selling efficiency.

4. *Profitability*—It must be economical and must help assured sales at satisfactory level of profit.

In the case of foodgrains, aeration of the produce in the packages meant for transport or for retail sale is of importance. Otherwise, there may be chances of damage due to moisture accumulation and moisture migration. It is also essential that disinfestation of the product is undertaken in case insect development has set in The package must, no doubt, conform to other tests for testing its ability to withstand tension and hazards in handling and transport. It should be convenient in weight, keeping in view other factors.

In consumer packages, the design should be attractive with product convenient dispenser.

It should be reasonably economical although economy need not be the sole consideration. There will be no use for cheap packaging if the product inside gets spoiled

either due to environmental factors or damages in handling and transport.

Hazards in the distribution of the products are met in transport and shunting. There is compression in stacking and vibration in vehicles apart from damages during the period of storage and distribution. The nature, intensity and frequency of these forces are governed by the distribution system, mode of transport, methods of handling at various points and methods of storage and stacking. All these factors have to be taken into consideration while thinking of a suitable package for commodities like foodgrains or cereal products.

Types of Package Materials

As stated in earlier paragraphs the packaging of foodgrains and other agricultural produce is slightly different from their non-agricultural counterparts. Foodgrains are produced in the fields in the rural areas where there is very little protection against environmental hazards until they are harvested, cleaned and transported by the farmer either to his godowns or to the market. At the domestic level each farmer stores the foodgrains in small lots depending on the size of the holding, while in the marketed stocks large quantities are purchassed by the traders or the millers. Eventually these foodgrains find their way to the consumers either as foodgrains or as cereal products.

This system involves packing at the farmer's level for transport to his godowns or to the market, packing for storage in his godowns, packing for storage in the traders' godowns or in the mill godown. Ultimately, the foodgrain is transported to the retailers and on to the consumers. With the development of the storage science and with the isolation of the factors responsible for deterioration of the foodgrains, the trend of packaging has to change. Previously the small storage structures or the jute or hessian bags were considered most suitable for packaging products from the production point to the consumer point. It is now considered, for instance, that the old type of structures used by the farmers are not suitable and they need improvement. It is also considered that jute bags are not the best type of containers for handling and storage of foodgrains, at the apex level or at the mill level. Instead of bags, silo storage with mechanical handling devices are considered a better way for keeping foodgrains. Similarly, for retail sale, the trend in all the countries is to pack the product in uniform-sized packages made of attractive material, light in weight, economical and which could protect the foodgrains from various factors already discussed.

The small packages could be bags made of cotton, hessian, low-density polyethylene film bags or paper bags. In several cases, multi-layer paper bags with or without polyethylene film lining are considered quite suitable. Folding cartons made of paper board of various thicknesses are likewise considered suitable for packing foodgrains and their by-products in small quantities for retail at the super-markets or departmental stores.

In India, particularly, jute bags are the most commonly used packing material for foodgrains. They are used right from the farm level to the retail level. The shortage of jute and increase in the prices of these

bags is leading many users in India as well as abroad to think of alternatives materials. Woven type polypropylene bags are considered quite suitable for packing foodgrains in bulk for storage at farmer's level, at trader's level or for bulk transport either within the country or for shipment abroad. These bags have certain advantages in that they are light in weight, cheap and produced in large quantities in the factories and they allow aeration to the product in the same way as jute bags.

However, they have certain disadvantages as follows :

(a) Hooks cannot be used as the hooks damage the bags.

(b) Once damaged they cannot be repaired.

(c) Sampling tubes for taking out samples from the bags cannot be used.

(d) They are slippery and, therefore, suitable stacks in ship holds, in godowns and on transport vehicles do not generally form in the ordinary way.

Conclusion

The packaging of foodgrains and cereal products will continue to be affected by general trends in packaging methods. The demand for the retail packages of the self-service type has greatly increased the importance of the package as a merchandise tool. Modern methods of distribution have made it essential to have a package of most attractive appearance if the consumer's favour is to be won. Consumers desire a package which is convenient to handle and to open and which is adopted to the way in which the product is used. This is only possible if the construction is kept as simple as possible by the use of easy means of opening and re-closing. The trend in other countries for retail sale is towards the unit pack, i.e., a package containing the product only sufficient for one serving. A unit pack must be carefully designed and mass-produced because with these smaller packages, preservation becomes more difficult and more packaging material is required.

For the distribution of cereals and their products suitable packages could also incorporate the agents to increase the resistance of packages to insect and rodent attack as well as anti-mycotic agents into the package material. The main problem here is to provide the effective level of resistance without contaminating the product.

Packaging is now accepted as a vital and necessary part of the storage, handling, display and preservation of the goods in the economy of a country. The package must accomplish all its functions at the most economical cost. Unless this is done, it may not be possible to compete successfully in the sophisticated markets at the retail level. □

By-Product Utilisation

A. Austin*

The hitherto unutilised residues, wastes and by-products of foodgrains can be a potential source of wealth if research and development activities are intensified to discover more efficient and economically remunerative uses of these by-products. In India, for example, bran and husk as by-products of rice milling industry provide vast scope for development of new products. From bran edible oil can be extracted commercially as the oil content in it is as high as 15-20 percent. The husk can also be used as fuel, raw material for hard-board and wood adhesives. How they could be utilised and where they can be used is the basic theme of this paper.

ALMOST all kinds of agricultural commodities leave behind substantial quantities of residues, wastes and by-products during the course of processing and preparation for consumption. These materials have been successfully utilized in many advanced countries and have become important contributory factors to national resources and wealth. Research and development activities have to be further intensified to discover more efficient and economically reumnerative uses for hitherto unutilized by-products. The importance of stepping up these activities in developing countries needs no emphasis in view of the enormous possibilities for the economic utilization of the by-products of various agricultural commodities. The 'green revolution' recently achieved in India and several other developing countries has brought into sharp focus the serious deficiencies which exist in the production—consumption chain. An industrial revolution in processing and by-product utilization is most urgent if increased agricultural production is to be meaningful in developing countries.

The scope and range of by-product utilization and their economic impact are rather vast and hence it is difficult to give a full account of the utilization of the various by-products of different agricultural commodities and their possible uses and contributions to the nation's economy. Hence, in this paper attention is focussed on the by-products of rice only.

Bran and Husk as By-products of Rice Milling Industry

During the milling process paddy yields five percent to seven percent bran, 20 percent to 25 percent husk and two percent to five

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percent brokens as by-products (Desikachar *et.al.* 1971). Among these by-products, bran which consists of germ and outermost layers of endosperm, viz. aleurone and sub-aleurone layers is the most important as it contains about 15 percent to 20 percent of edible oil. Importance of rice bran as a potential source of edible oil can be realized from the fact that the annual world production of paddy is about 300 million tons valued at 15,000 million U.S. dollars, which would correspond to a yield of three million tons of rice bran oil with an estimated value of 750 million U.S. dollars and 12 million tons of defatted bran with 15 to 20 percent protein valued at 360 million U.S. dollars. These figures, indeed, stress the fact that the development of modern agriculture and the accelerated industrialization of processing methods are complementary and mutually supporting activities (UNIDO Report, 1971).

India is the second largest rice producing country in the world and hence the scope for the commercial exploitation of oil from rice bran is very high in this country. Production of paddy in India is estimated to be of the order of 60 million tons. It has been reported that about three million tons of rice bran is currently produced in India. In case even the available quantity of rice bran can be processed for oil, it can yield about three lakh tons of rice bran oil valued at about Rs. 750 crores (Laljeet Singh 1972). According to Desikachar *et.al.* (1972) oil worth about Rs. 1,000 million can be recovered from bran worth about Rs. 500 million. About 1 million tons of bran from the sheller process and 1.8 million tons from the huller are produced in India. In spite of the oil potential indicated above, the industrial utilization of bran resources in India has lagged very much behind. Only about 30 to 40 thousand tons of oil are being extracted and this even is of poor quality (Desikachar *et. al.* 1972). Even in other countries like Burma, Thailand and Japan, where extraction industries exist to a significant extent, only a small proportion of the potential source of edible oil is currently realized.

Bottlenecks in the Utilization of Bran Oil Resources

1. The major bottleneck to the development of a rice bran oil industry in many countries has been the high free fatty acid content of the crude extracted oil. This makes refining for edible use almost economically impossible. The free fatty acid content arises because the bran contains an extremely active enzyme, viz., lipase which hydrolyses the triglycerides of the oil, releasing free fatty acids.

The enzyme lipase becomes active as soon as the bran is removed from rice and the stabilization (destroying the activity of the lipase) must, therefore, be done at the mill site soon after milling, using simple practical methods. If no method of stabilization is used, the free fatty acid content rapidly increases in bran, particularly in countries where temperature and humidity are high. As such, rice bran in those countries becomes unsuitable for edible oil production. The destruction or inactivation of the enzyme as a method of stabilizing rice bran has been considered and systematic studies on this aspect have been conducted in several countries. One of the most successful methods is the application of some form of heat treatment which inactivates the lipase and peroxidase and also destroys micro-organisms.

2. The mobilization of oran resources is a great problem. The availability of raw material for continuous solvent extraction plants is not assured because of the difficulties in bran procurement due to seasonal rice milling, scattered nature of small-scale mills and transport difficulties. This problem should be solved by providing incentives to millers, i.e., by offering a better price or partnership in cooperative oil extraction industries. Organized efforts should be made to collect bran from small mills.

3. Another factor which comes in the way of economic utilization of rice bran is its poor quality as available from many mills. Very often it is highly mixed with husk and broken rice. The sheller mills produce pure bran free from husk and this contains about 22 percent to 25 percent oil while the bran obtained from huller mill is mixed with nearly twice its weight of husk and contains only six percent to eight percent oil. Parboiled bran may contain up to 25 percent to 50 percent more oil than raw rice bran provided it is not diluted with husk (Desikachar *et. al.* 1972). It is the usual practice in many mills (where parboiled rice is produced) to add husk with a view to aid in the polishing process and for getting better finish. The huller bran can be successfully upgraded by sieving it either mechanically or manually. Removal of husk is also important in order to reduce the silica content in bran. It is reported that many samples of Indian bran do not, at present, satisfy the standards with regard to silica content prescribed for feed-grade rice bran.

4. Doubts have been expressed by the livestock feeders in some countries regarding the nutritional value of defatted rice bran. Preference is even now given to raw rice bran as a livestock feed.

5. Traditional use of various oils and fats like coconut oil or animal fats has adversely affected consumers' acceptance of unfamiliar oil.

With the recent advances in technology, there appears to be no insurmountable difficulties in refining rice bran oil for edible use The rice bran oil refineries should be encouraged to use modern technology. Lack of technical advice and expertise is a great barrier. To overcome this, training programmes in extraction and refining techniques for rice bran oil should be introduced in each country.

Economic Extration of Oil from Bran

According to Vasan *et. al.* (1971) the potentially available quantity of oil may amount to over a million tons while the present annual production is only of the order of 20,000 tons, mostly as industrial oil with free fatty acid content of about 50 percent. Concerted attempts must, therefore, be made to achieve the full potential. A large volume of the rice milling in India is done by hullers. The bran produced by this process is highly admixed with husk and other foreign matter. The average oil content of huller bran is hardly of the order of four percent to six percent. Extraction of oil becomes uneconomical at this concentration. The bran produced by the sheller *cum* huller process has an oil content of 10 percent to 12 percent. Sheller *cum* polishers yield bran with oil content ranging from 15 percent to 30 percent depending on the variety of paddy used and on whether it is milled in the

raw or parboiled condition (Vasan *et. al.* 1971).

A major part of the paddy produced in India is parboiled before it is milled. There is generally an improvement in the milling performance of soft varieties if they are parboiled. Because of popular preference, hard varieties are also increasingly parboiled. It has been reported that raw rice bran obtained by milling brown rice in a polisher without any admixture of husk yields about 15 percent to 20 percent oil, whereas the recovery from parboiled bran with similar extraction process is 23 percent to 28 percent. Depending on varietal differences, oil yields as high as 30 percent to 32 percent have been reported.

Detailed studies on the scope of improving the recovery of oil from bran have been undertaken recently by Vasan (*et. al.* 1971). Some of the important results are summarized as follows :

1. The top layers of parboiled brown rice which are removed during polishing contain more oil than the corresponding samples from raw rice. The higher oil content of the bran from parboiled rice was considered to be due to the upward movement of some of the oil from the lower portions of the aleurone layer.

2. Different degrees of polishing have a marked effect on the recovery of bran oil. Three varieties of paddy, namely : IR-8, GEB-24 and CO-33 milled to the same extent, i.e., bran after polishing to two, five and five percent, showed that at each level of polishing the parboiled rice bran contained more oil than the corresponding product from raw rice. About eight percent polish is required to remove the major portion of the oil in all the varieties. Varietal differences were very marked. As shown in the table on page 467, raw and parboiled brans of IR-8 obtained after two percent polishing yielded 20.1 percent and 27.0 percent oil, respectively, while with eight percent polishing the respective recoveries were 75.0 percent and 88.0 percent. These results show that there is scope for improving the recovery of oil by developing appropriate technology.

Uses of Rice Bran Oil

The uses of rice bran oil are much the same as those of cotton seed, corn or a wide variety of other soft oils currently engaged in world trade. Its particular areas of utilization in the edible oil field would be as salad oil, cooking oil, manufacture of shortening and as the liquid portion of margarine blend. Its high linolenic acid content and high tocopherol content impart an oxidative stability and reduce the formation of rancidity and off-flavours which can limit the use of other soft oils in a fat product. High linolenic acid content is reported to be responsible for the blood cholestrol lowering effect and this fact will make the oil to take advantage of the current world-wide swing towards cooking oils and softer margarines.

In the industrial field, soap from rice bran oil is soft and readily soluble. However, it is unsuitable for the familiar hard bar soap unless hydrogenated or blended with tallow or a lauric oil (UNIDO Report 1971). On the other hand, it can be used in liquid or soft soaps, shampoos for hair or washing of delicate surfaces which require lower temperature.

Oryzanol is extracted from rice bran oil. This is used for medicinal purposes.

The medium-to-high iodine value fatty acids produced from rice barn can be used in the protective coating field as components of alkyds or epoxy resins and for the plasticizers incorporated into polymer resin formulations.

Utilization of Rice Husk

Husk constitutes about 20 percent to 25 percent of the total weight of processed paddy. It is thus available in large quantities and for this reason a great deal of research has been done for converting rice husk into useful by-products. Extensive reviews and reports on industrial utilization of rice husk are available (Lanthrop 1952, Staackmann 1970, UNIDO Report 1971). These reports show that despite all efforts, the effective utilization of rice husk still remains a problem.

As regards the chemical and physical properties, husk has very low protein content and the proportion of digestible nutrients is low. The ash content goes as high as 15 percent. The ash has a silica content of 95 percent. It is highly abrasive and has a very low bulk density and a calorific fuel value of 5,000 to 6,000 BTU/lb. The current uses of husk are primarily based on these properties.

In view of the very large availability of this raw material (10 million tons in India alone) any husk utilization scheme should involve large-scale disposal. At present there is no single practicable solution to husk disposal. Programmes for the beneficial use of husk must be planned on the basis of local opportunity which is governed by the economic as well as social considerations of the particular area. Some of the major forms of use of husk are (1) as fuel, (2) for making hard-boards and (3) as raw material for furfural.

Fuel—The calorific fuel value of 5,000 to 6,000 BTU/lb. obtained in husk can be advantageously utilized for making it as a useful fuel. In most parboiling mills husk is being increasingly used as fuel for supplying steam for the process and also for producing heat required for drying paddy in

Effect of Polishing Rice on Oil Recovery from Bran of Three Varieties

Degree of Polish	*Rice Variety*					
	IR-8		*GEB-24*		*CO-33*	
	Raw	*Parboiled*	*Raw*	*Parboiled*	*Raw*	*Parboiled*
	Percentage of oil removed by polishing					
2%—level	20.1	27.0	19.0	20.8	15.5	19.0
5%—level	53.0	71.2	47.6	53.6	40.0	50.7
8%—level	75.0	88.0	67.9	73.4	64.2	80.0

mechanical dryers. Utilization of fully burnt white ash in the production of fire bricks, for making special glasses or for silicates has yet to be explored.

Hard-board and other similar articles—Wood flakes and chips are conventionally used for making hard-boards and other similar products. The use of husk as substitute for wood flakes and chips needs a brief discussion because of the differences between wood and bran with regard to their gross structural, chemical and physical properties. An understanding of these properties will be helpful in developing appropriate processing technology. Some of the major differences are given below :

1. Wood and wood chips derive their physical strength from long cellulose fibres woven so as to form a cellular structure. The fibres in rice husks are relatively small, about 0.3 mm compared to two mm to three mm in soft woods (Lanthrop 1952, Vasishth 1971). Cutting of wood to form chips or flakes can be controlled taking full advantage of grain orientation. This is not the case for rice husks.

2. Unlike wood, rice husk contains about 15 percent to 25 percent silica which is heavily concentrated on the surface. Because of this, husk is relatively brittle and friable and also abrasive in character. This will naturally affect the manufacturing process. For instance, in the manufacture of composite boards, wood chip interfaces collapse to form more or less continuous surfaces while this does not occur in the case of rice husks (Vasishth 1971).

3. Husk is easily attacked by free alkali. Therefore, all wood adhesives based on alkali solutions of phenol formaldehyde resins are not likely to perform satisfactorily with husk. Four most commonly used synthetic adhesives for composite board manufacture are (1) urea-formaldehyde resins, (2) melamine-formaldehyde resins, (3) phenol-formaldehyde powder resins and (4) phenol-formaldehyde liquid resins.

At present most composite boards based on wood products are manufactured with urea-formaldehyde resin as a binder. However, the use of phenol-formaldehyde resins is fast increasing. They prolong shelf-life of finished product and permits exterior use. The exact amount of adhesive used for particle board manufacture varies from plant to plant.

Detailed studies by Vasishth (1971) on the use of husk for the manufacture of commercial size boards show that boards of varying thickness can be produced from husk using equipment and procedures currently familiar to the particle board industry and at resin levels and press times acceptable to present day economics of the particle board industry. The physical properties of the board are such that it is potentially usable for furniture, wall panelling and as floor underlayment.

Other uses—Some of the other suggested uses of rice husk are insulating material, packing material, for the manufacture of furfurol and activated charcoal, as seed and feed diluent and as abrasive cleaner.

Scope of Further Research and Developmental Activities

With the advance of modern technology, refining of rice bran oil for edible purposes

has become a commercial proposition. The processes of degumming, dewaxing, neutralization, bleaching, winterization, deodorization and hydrogenation must be fully exploited for this purpose. As suggested in the 1971 UNIDO Report research on inter-regional basis should be undertaken on the following aspects :

(1) Stabilization of bran

(2) Refining and utilization of rice bran wax

(3) Blood cholesterol lowering action of rice bran oil and pharmaceutical use of oryzanol

(4) Use of rice bran oil fatty acids as potentially valuable by-products

(5) Preparation of protein isolates from defatted bran

(6) Comparative studies on defatted bran and raw rice bran as an animal feed-stuff

(7) An economic and technical evaluation of the X-M (extractive milling) process as to the suitability of its adoption in developing tropical countries

(8) Initiating research on varietal improvements for increasing the oil content of bran.

Some of the potentially productive rice husk utilization areas requiring further investigation are :

(1) Animal feeding

(2) Incorporation of husk into the soil

(3) Pressing aids

(4) Fuel source (with silica as an end-product)

(5) Production of furfurol

(6) Building materials

(7) Low temperature carbonization (destructive distillation), the resulting by-products being coal tar, light oil, methanol and carbon.

REFERENCES

1. Desikar, H.S.R. and Viraktamath, C.S. (1972) : "Technological problems in the utilization of the by-products of rice milling in India." National Seminar on Post-Havest Technology of Cereals and Pulses, 21-23 Dec. 1972, organized by Indian National Science Academy, Indian Council of Agricultural Research, Council of Scientific and Industrial Research and Food Corporation of India.
2. Laljeet Singh (1972) : "Economic impact of by-product utilization." National Seminar on Post-Harvest Technology of Cereals and Pulses.
3. Lanthrop, E.C. (1952) : "The industrial utilization of rice hulls", Rice Annual, pp 13 (1952).
4. Staackman, M., *et. al.* (1970) : "Rice hull utilization". Final Report, URS Research Company, 155 Bovet Road, Sen Mateo, California 94402.
5. UNIDO Rrport (1971) : Report on the Inte-regional Seminar on the Industrial Processing of Rice, Madras, India, 11-16 Oct. 1971.
6. Vasan, B.S., Iengar, N.G.C., Subrahmanyam, T.V., Chandrasekaran and Subrahmanyan, V. (1971) : "Effect of processing on the movement of oil in the rice kernel and its relation to the oil content of paddy and the yield of oil from rice bran", Inter-regional seminar on the Industrial Rice Processing organized by the United Nations Industial Development Organization, Madras, India, Oct. 11-16, 1971.
7. Vasishth, R.C. (1971) : "Water-resistant composite board from rice husks". Inter-regional Seminar on the Industrial Processing of rice, organized by the United Nations Industrial Development Orgonization, Madsas, India, Oct. 11-16, 1971.

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Transportation of Foodgrains

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The problem of transportation of foodgrains assumes critical importance in a country like India which measures 3214 kilometers from North to South and 2933 kilometers from East to West and inhabits about 550 million people. It is estimated that presently 15 to 20 million tonnes of foodgrains are transported from one part of the country to another every year. The magnitude of the problem would go on enlarging as production of foodgrains increases. In this paper, the author has made a survey of the existing facilities for transportation of foodgrains, projected the future needs, and has dealt with such issues as the priority in movement of foodgrains, pattern of movement, rationalisation of movement, rail transist losses, storage in relation to movement, bulk transport, road transport, coastal movement etc. In the end, the author argues for a comprehensive Movement Plan for greater co-ordination of transport facilities for foodgrains.

ON food and friendship depends our freedom, in fact our very survival. As geography influences history, so does climate affect food crops. Between production and consumption of food is an important and inseparable link : transportation. Whatever the mode of transport, animal or mechanical, this link has to be sufficiently strong, well-connected, mobile and reliable.

Our food policy is to increase production and to make foodgrains available to consumers in adequate quantity at reasonable prices. In this process, arises the need for adequate procurement, movement and storage.

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Production

Agriculture is the largest single industry in India. There are two principal categories of crops in India, viz.—(a) Kharif (crop of rice, millets, maize) which begins to come to the market at the end of October and (b) Rabi (crop of wheat, barley and gram) which begins to come to the market at the end of April. The farmers' fortune has fluctuated violently during the last eight years. India suffered in 1966-67 from the worst drought since 1899. These years of trial and toil were fortunately followed by a favourable period (May, 1968 to July, 1972). "A Green Revolution" during these years in a few States, viz., the Punjab, Harayana and U.P. brought us on the threshold of self-sufficiency in food. Unfortunately, the drought in several States

since July, 1972 has once again put the clock back. However, scarcity and plenty has enriched our experience to forge our future with courage and determination.

The uncertainties in the production of foodgrains are largely due to the vagaries of weather. Climatically, in so far as rainfall is concerned, no particular year is a normal year in all States. Therefore, even if we were self-sufficient in food grains, the balance of deficits and surpluses will, year after year, vary from State to State. The movement of foodgrains, therefore, would also be affected by these factors.

The soil characteristics and climatic conditions vary in different parts of the country. In certain regions, only a particular variety of foodgrains can be grown. These foodgrains provide the staple food to the local population, the movement of which is mostly intra-State by rail and road.

In order that the distribution system would not be adversely affected, the shortage in production is made good to some extent by importing foodgrains. The public distribution system of foodgrains has been in existence for the last 30 years to protect the vulnerable sections of the population from high prices by supplying foodgrains through fair price shops. The other objective of foodgrains importation is to prevent rise in prices of foodgrains in the open market. The total distribution of foodgrains in the country in 1966 was the highest (14.1 million tons). When the food situation improved, the public distribution of foodgrains came down to 8.8 million tons in 1970 and 7.8 million tons in 1971. But in 1972, due to drought, the distribution increased to 10.5 million tons. The success of the public distribution system depends upon the efficiency with which foodgrains can be transported. It is, however, our experience that in years of good production and easy availability of foodgrains, the public distribution and movement showed a downward trend enabling the Government to build up sizable buffer stock. Table 1 shows the trend in foodgrains from 1964 to 1972.

The increase in the production of foodgrains is projected from 120 million tons by the end of the Fourth Five-Year Plan (1973-74) to 150 million tons by the end of the Fifth Five-Year Plan (1978-79). Looking at the spurt in production from 74.23 million tons in 1966-67 to 95.05 million tons in 1967-68, it may not be impossible to achieve the target for the Fourth Five-Year Plan or the anticipated increase in the Fifth Five-Year Plan. Allowing for seed, feed and wastage at 12.5 percent of the total production, the net quantity of foodgrains likely to be available for consumption towards the end of the Fourth Five-Year Plan may be about 105 million tons. However, taking into consideration, the need for maintenance of operational and buffer stocks up to a certain level, the total movement of foodgrains in any year during the Fifth Five-Year Plan has been estimated at 16 million to 18 million tons. The pattern of movement will, however, depend very much on the location of the areas producing the surplus, pockets of consumption as well as the exports and other means for disposing of the surplus.

Consumption

About 80 percent of the people in India are living in the rural areas. The population has increased from about 494 million

TABLE 1

Trends in Production and Movement of Foodgrains, India, 1964-1973 (Million tons)

Year	*Total production of foodgrains*	*Total foodgrains imported in calendar year (1964-1972)*	*Total availability*	*Issues in the public distribution system* (1964-1972)*	*Total movement*
1964-65	89.33	6.26	95.59	8.25	13.70
1965-66 Drought	72.34	7.46	79.80	8.30	14.51
1966-67 Drought	74.23	10.35	84.58	11.48	16.45
1967-68	95.05	8.67	103.72	10.07	14.70
1968-69	94.01	5.69	99.70	7.62	15.85
1969-70	99.50	3.87	103.37	6.90	15.10
1970-71	108.40	3.63	112.03	6.95	15.10
1971-72 War	104.60	2.05	106.65	6.39	15.50
1972-73 Drought	100.0 (Provisional)	0.58	100.58	9.80	15.78

* Includes wheat exportation of 0.81 million tons.

(401 rural and 93 urban) in 1966 to about 559 million (448 rural and 111 urban) in 1971. While the increase in the rural population was about 12 percent, the population in the urban areas increased by about 20 percent. An increase in population implies an increase in the consumption of foodgrains. Apart from population, the other factors which influence consumption are prices and competition with other foods.

The cereal in India is generally a central item of diet. In 1954-56, the average per capita consumption of foodgrains in India was 130 kg., including about 66 kg., 21 kg. and 43 kg. of rice, wheat and other grains, respectively. In 1971, it was 152 kg., including about 71 kg., 37 kg. and 44 kg. of rice, wheat and other grains, respectively. The per capita consumption of pulses was about 18 kg. Even at this scale and allowing for 12.5 percent for feed, seed and wastage, we now need 110 million tons of foodgrains. Unfortunately, due to severe drought, the production of foodgrains dropped to about 100 million tons in 1972-73. For the urban population alone, the requirements in 1972-73 were of the order of about 20 million tons of foodgrains. Even if the per capita consumption in urban areas were to be 100 kg., about 11 million tons of wheat and rice alone would be required in such areas. The total movement of foodgrains by the Railways in 1972-73 was, however, only of the order of 15.78 million tons. The balance, if at all available, moved either by road or by other means of transport.

Urbanization is leading to an increase in the per capita consumption of wheat in India which has to be transported from the Northern States, viz., the Punjab, Haryana and U.P. throughout the length and breadth of the country. This has been straining the Railway capacity to a considerable extent.

During the last few years, the available supply and withdrawals of foodgrains in India from *Central Stocks* is presented in Table 2.

Movement

The gaps between production and consumption cause regional imbalances which have to be bridged by moving indigenous and imported foodgrains from the surplus States and ports to the deficit States. Varietal preference has to be met by transporting foodgrains from other areas. In a free market, price includes considerable rational and irrational movement by rail and road. However, if the cost of transportation is high, it acts as a deterrent to some extent in the movement of foodgrains.

Seasonal pressures are felt in the transport system because the harvesting period of various crops are different. In an organized sector, therefore, surplus and deficit areas in foodgrains would need to be identified and linked, so that the movement is within economic radii. Of all the important means of transport, the railways and roadways are the major carriers of foodgrains over long distances. Coastal and inland water transport is known to take place in some States but statistics on the subject is very scanty.

The movement of foodgrains from the farm to the barn, from the barn to the local storage depots or mandi (market) or the railhead or the areas of consumption involves various modes of transport including carts, trucks, tractors/trailers, railways and waterways.

Railways

In India, the Railways are nationalized. Indian railways have assumed the responsibility of a "common carrier". The railways carry the largest load over the longest lead at the cheapest rate.

In the movement of foodgrains by rail, the procedural aspects require (i) depositing of wagon registration fee for a wagon, which is refunded on completion of loading or adjusted against railway freight, (ii) tendering of a forwarding note which is the basis for the contract between the consignor and the carrier at the dispatching station. It indicates the conditions under which the traffic is accepted for carriage, including the compliance of the packing and other special conditions, etc. (iii) Granting of railway receipt for the consignment. The railway receipt is a negotiable instrument with the weight and description of the consignment, conditions under which the traffic has been booked, the rate applied and the freight, packing conditions, station from and to, name of the consignor/consignee, etc. noted on it. The booking is by the cheapest route. The forwarding note and railway receipt are the basic records for dealing with claims for compensation for losses, if any, in rail transit. Foodgrains are required to be loaded and unloaded by the owner.

TABLE 2

Available Supply and Withdrawal of Foodgrains, India, 1967-1973 (Million tons)

Item	*1967-68*	*1968-69*	*1969-70*	*1970-71*	*1971-72*	*1972-73*
Wheat :						
Production (Crop year)	16.54	18.65	20.09	23.82	26.47	N.A.
Procurement (Crop year)	0.89	2.29	2.38	3.19	5.10	5.0
Imports	6.4 (1967)	4.76 (1968)	3.09 (1969)	3.40 (1970)	1.81 (1971)	0.58 (1972)
Withdrawal from Central Stock	6.99	5.67	4.88	5.19	4.28	6.22*
Rice :						
Production	37.61	39.76	40.42	42.22	42.73	N.A.
Procurement	3.23	3.43	2.94	3.19	3.11	2.43
Imports	0.45 (1967)	0.44 (1968)	0.48 (1969)	0.20 (1970)	0.24 (1971)	0.13 (1972)
Withdrawal from Central Stock	1.14	1.27	1.56	1.64	2.05	2.30**
Coarse Grain :						
Production	28.79	25.18	27.30	30.56	24.39	N.A.
Procurement	0.77	0.46	0.27	0.48	0.18	0.24
Imports	1.81 (1967)	0.48 (1968)	0.29 (1969)	—	—	0.1
Withdrawal from Central Stock	1.94	0.69	0.46	0.12	0.06	0.37
Total withdrawal from Central Stock	10.07	7.63	6.90	6.95	6.39	9.80

Note : * Add 0.81 million tons from importation=7.03
**Add 0.10 million tons from importation=2.40

More than 60 percent of the movement of sponsored foodgrains is by special trains. The specials are of 70 wagons to 100 wagons, each carrying about 1,600 tons to 2,300 tons of foodgrains. Sponsored foodgrains are those that are accorded high priority for

movement. Movement by special ensures quick transit and reduces the losses and the operating expenses. And if there were to be "train-load" rate for foodgrains, the loss to the Railways at the "wagon load" rate may, perhaps, get narrowed down to a considerable extent, provided the loading and unloading operations are completed within the permissible free time.

In dispatches by rail, additional terminal charges are involved. The speed is slow and

TABLE 3

Movement of Foodgrains by Railway, India, 1957-1973 (Million tons)

Year	*Total production of food-grains*	*Total food-grains imported*	Quantity Moved by Railways					Quantity Moved By		
			On Government Account							
			Imported	*Indigenous Total (Calendar year)*	*Total*	*On trade account*	*Total*	*Broad gauge*	*Metre gauge*	*Narrow gauge*
1957-58	66.5	3.58	2.33	0.21	2.54	8.46	11.0	—	—	—
1958-59	78.7	3.17	3.10	0.49	3.68	8.22	11.9	—	—	—
1959-60	76.7	3.86	3.65	0.52	4.17	8.33	12.5	—	—	—
1960-61	82.0	5.13	3.64	0.62	4.26	8.34	12.6	—	—	—
1961-62	82.7	3.49	2.95	0.38	3.33	8.90	12.23	—	—	—
1962-63	80.15	3.64	3.40	0.44	3.84	8.50	12.34	—	—	—
1963-64	80.6	4.55	4.09	0.53	4.62	8.58	14.20	—	—	—
1964-65	89.33	6.26	5.50	0.77	6.27	7.49	13.70	—	—	—
1965-66	72.0	7.46	5.58	1.79	7.37	7.14	14.51	—	—	—
1966-67	74.23	10.35	7.27	1.09	8.36	8.09	16.45	—	—	—
1967-68	95.0	8.67	7.41	1.47	8.88	5.82	14.70	10.37	4.09	0.24
1968-69	94.0	5.69	4.25	3.53	7.78	8.07	15.85	11.54	4.00	0.31
1969-70	99.5	3.87	2.61	4.39	7.0 (1969)	8.10	15.10	11.02	3.70	0.38
1970-71	108.4	3.63	1.85	5.19	7.04 (1970)	8.05	15.09	11.28	3.48	0.33
1971-72	104.6	2.05	1.11	6.11	7.22 (1971)	8.28	15.50	11.49	3.70	0.31
1972-73	100.0 (Provisional)	0.58	—	—	8.20 (1972)	7.58	15.78	Not available		

transhipment of foodgrains from one gauge to another is hazardous. In 1970-71 and 1971-72, out of 15.10 million tons and 15.50 million tons of foodgrains transported by railways, 3.63 million tons and 3.55 million tons, respectively, were transhipped. The quantity transhipped from metre gauge to broad gauge wagons was slightly higher than from broad gauge to metre gauge. About 50 percent of foodgrains booked on metre gauge were transhipped.

Whenever open wagons (in block rakes) are used for transporting foodgrains, adequate steps are taken for proper protection of foodgrains, in rail transit by using tarpaulins of suitable size to fully cover the consignment, lashing the tarpaulins and providing escorts throughout. Frequent checks are also exercised during transit of the foodgrains.

In an emergency and during the procurement periods when the railways are required to concentrate on the clearance of a particular traffic such as foodgrains, howsoever short the duration may be, more often than not bottlenecks develop in the movement of other essential commodities. Such a situation affects the life of the community. Major bottlenecks in the transport and handling system have to be identified and removed because congestion easily paralyses even the most efficient transport system.

The position in regard to the movement of foodgrains on Indian Railways during the years 1957-58 to 1972-73 is shown in Table 3.

Lead of Traffic

The lead of foodgrain traffic is the longest for all traffic on the Indian Railways It has increased by about 73 percent during the last 15 years.

Table 4 shows the average lead of all Goods Traffic (Revenue and Non-revenue) and foodgrain traffic on the Indian Railways during the last few years.

TABLE 4

Lead of Traffic on Railways, India, 1960-1973
(Million tons)

Year	*ALL TRAFFIC*		*FOODGRAINS*	
	Originating tonnage (Revenue and Non-revenue)	*Lead in km.*	*Originating tonnage*	*Lead in km.*
1960-61	156.2	561	12.6	760
1965-66	203.0	576	14.51	789
1966-67	201.6	578	16.45	792
1967-68	196.6	605	14.70	853
1968-69	204.0	613	15.86	849
1969-70	207.9	617	15.10	887
1970-71	196.5	648	15.10	961
1971-72	197.8*	674	15.50	1,059
1972-73	175.13**	—	15.78	1,170

Note : * Add 27.75 for non-revenue traffic.
** Revenue traffic (preliminary).

Of all the foodgrains moved, wheat, rice and pulses account for the largest quantity and their lead on the Indian Railways is indicated in Table 5.

TABLE 5

Average Lead (in kms.) for Selected Foodgrains, India, 1965-1972

Year	*Wheat*	*Rice*	*Pulses*	*All other foodgrains*
1965-66	848	649	1,061	789
1966-67	753	708	1,079	792
1967-68	922	566	1,095	853
1968-69	787	675	1,139	849
1969-70	807	883	1,188	887
1970-71	900	837	1,212	961
1971-72	1,035	989	1,200	1,059

For years the lead of pulses in India has been very long. Pulses are grown mostly in Central and Northern India but are in demand all over the country. Another noteworthy feature is the increase in the non-revenue traffic which has more than doubled during the last 15 years requiring supply of a larger number of wagons. This is shown in Table 6.

TABLE 6

Average Lead (in kms.) for Pulses, India, 1956-1972

Year	*All Traffic*	*Revenue Traffic*	*Non-revenue Traffic*
1956-57	362	380	286
1960-61	561	603	421
1965-66	576	611	438
1969-70	617	643	481
1970-71	648	659	583
1971-72	674	687	590

There has been a phenomenal rise in the movement of foodgrains from the Northern Railway (serving the Punjab, Haryana and Uttar Pradesh) during the last five years. Indigenous wheat from the Northern Region has moved to all parts of the country.

TABLE 7

Volume of Foodgrains on Northern Railway, 1967-1972 (Million tons)

Year	*Total Volume Moved (All India)*	*Volume Loaded on Northern Railway*
1967-68	14.7	2.65
1968-69	15.8	4.92
1969-70	15.1	4.97
1970-71	15.1	5.72*
1971-72	15.5	6.26**

Note : * Includes 5.09 on BG and 0.43 on MG.
**Includes 5.44 on BG and 0.82 on MG.

It would be noted that 40 percent of the total foodgrains traffic on the railways originated from the Northern Railways.

The lead in the case of foodgrains has varied from time to time depending upon the following factors.

1. Imports of foodgrains requiring distribution or storage only in the hinterland of each port.
2. Increase in population and migration of population from rural to urban areas.
3. Increased production.
4. Increased consumption.

5. Improved ability to buy foodgrains.
6. Reduction in imports, particularly of rice, requiring heavy movement of wheat and rice from the North Zone to the South, West and East Zones.
7. Drought, floods, and other natural calamities requiring movement of a large quantity of foodgrains from several sources to give relief within a short period, involving even irrational movements.
8. Varietal preference of foodgrains.
9. Regional imbalances in production and consumption occurring from time to time.
10. Storage capacity for buffer and operational stocks not being directly related to consumption in each State.
11. Storage of foodgrains in the procurement area itself longer than the crop year.

Since the total volume of foodgrains carried by the railways has not appreciably increased, an increase in the lead of foodgrain traffic is a disturbing factor in that apart from engagement of a larger fleet of wagons for foodgrains to the detriment of other important traffic, there is a heavy loss in the carnings of the railways, foodgrains being transported below the operation costs. It is, perhaps, equally necessary to go into the increasing lead of non-revenue traffic.

Railway Freight Rates

Commodity flows are to be so designed as to minimize the total social cost of transport. The social cost of transportation is the value of resources which are actually consumed in the transport of traffic from the dispatching point to the receiving point. Social cost includes not only carrier costs but also cost to the community.

In India, railways are the cheapest mode of transport for foodgrains. To have any regulatory system of coordination in the movement of foodgrains, is, therefore, not necessary. The social obligation of the railways, unconnected with the financial results of their operations, is to further economic development in the country.

The basic principle of railway rating in India has been one of charging on the "Value of Service" basis. The cost-based policy may lead to an undesirable increase in the prices of foodgrains which may not be in the national interest. The railway rates are, therefore, cross-subsidized. The "Value of Service" basis is to provide the ceiling and the "Cost of Service" basis the floor in determining the railway rates. The "Cost of Service" principle has never been enforced so far as foodgrains are concerned.

The chief characteristic of the railway policy is to charge what the traffic will bear. To quote Sir William Acworth, "the real meaning of the phrase charging what the traffic will bear is that the railway charges for different categories of traffic are fixed, not according to the estimated cost of service but roughly on the principle of equality of sacrifice by the payer. So regarded, "what the traffic will bear is a principle, not of extortion but of equitable concession to the weaker members of the community."

However, the investigation of the social

costs of each mode of transport is considered to be one of the most important and difficult facets of transport.

The freight rates are on a continuous mileage basis over the entire railway system and on telescopic principle, i.e., rates tapering with increase in the distance of hauling. In India, the position in regard to the average lead and the average rate charged per ton-km. of all goods (revenue) traffic and foodgrain traffic appears on Table 8.

The freight rates for foodgrains and pulses are the lowest in the Indian Railways' freight structure. The freight earnings from foodgrains do not meet fully the costs of operation. The Indian Railways are now incurring a loss of nearly Rs. 26 crores per year in the transportation of foodgrains. Table 9 indicates that the rate charged per ton-km. of foodgrains is much lower than the average cost of handling the same. The average rate charged per ton-km of all goods traffic (Revenue) is also much higher.

Foodgrains are moved either in "wagon loads" or as "smalls". In the general classification of goods, each commodity has been placed in a class. Principal cereals like wheat and rice are in class 30-A Special and other cereals in class 32.5 R. While there is

TABLE 8

Lead and Rate Charges, Indian Railways, 1968-1972

Item	*Total Originating Tons Revenue A (Million tons)*	*Average Lead (km.)*	*Average Rate per Ton-Km. (in paise) for Goods Traffic (Revenue)*			
			All gauges	*B.G.**	*M.G.***	*Earning (Rs. Crores)*
1968-69 All goods traffic	170.38	633	5.06	5.03	5.25	489.73
Food grains	15.85	849	3.58	4.12	6.25	47.97
1969-70 All goods traffic	170.83	643	5.07	5.13	5.32	548.97
Food grains	15.10	887	3.57	4.28	6.12	47.85
1970-71 All goods traffic	173.83	659	5.17	5.36	5.32	578.13
Food grains	15.10	961	3.69	4.63	6.45	53.51
1971-72 All goods traffic	167.91	687	5.43	5.55	5.70	655.69
Food grains	15.50	1,059	3.66	4.73	6.43	60.25

Note : * Broad Gauge.
**Metre Gauge.

TABLE 9

Comparative Hauling Charges, Indian Railways, 1967-1972

Item	Foodgrains					All Goods Traffic		
	Originating tons (million)	*Average Lead (km.)*	*Ton-km. (billion)*	*Rate per ton-km. (Paise)*	*Earnings (Rs. crores)*	*Cost of handling per ton-km. (Paise)*	*Rate per ton-km. (Revenue) (Paise)*	*Ton-km. (billion)*
1967-68 BG	10.36	815		3.37	32.09	4.00	4.78	
MG	4.09	521		3.40	10.08	6.25	5.15	
NG	0.02	93		6.57	0.28	—	—	
Total or Average	14.70	853	12.54	3.38	42.46	—	4.84	101.12
1968-69 BG	11.53	768		3.49	35.71	4.12	5.03	
MG	4.30	514		3.76	11.92	6.25	5.25	
NG	0.03	96		6.38	0.32	—	—	
Total or Average	15.86	849	13.46	3.58	47.97	—	5.08	108.12
1969-70 BG	11.02	813		3.51	36.07	4.28	5.13	
MC	3.70	501		3.89	11.46	6.12	5.32	
NG	0.38	102		5.69	0.32	—	—	
Total or Average	15.10	887	13.39	3.57	47.85	—	5.70	111.82
1970-71 BG	11.29	894		3.60	41.40	4.63	5.36	
MG	3.48	550		4.00	11.81	6.45	5.70	
NG	0.33	108		5.66	0.30	—	7.84	
Total or Average	15.10	961	14.50	3.69	53.51	—	5.43	110.69
1971-72 BG	11.49	1,008		3.55	47.03	4.73	5.55	
MG	3.70	572		4.16	12.92	6.43	5.87	
NG	0.31	104		6.31	0.30	—	8.35	
Total or Average	15.50	1,059	16.41	3.66	60.25	—	5.61	116.89

BG=Broad Gauge ; MG=Meter Gauge ; NG=Narrow Gauge.

a 9-percent supplementary charge on the freight payable on principal cereals there is no supplementary charge on other cereals. The minimum weight to be loaded in a wagon has been prescribed to avail of the benefit of the cheaper rate for "wagon-load". In the case of foodgrains, the minimum weight for the "wagon-load" rate is 220 quintals. The term "wagon" applies for purposes of charge to a 4-wheeled wagon. The weight loaded in a 4-wheeled broad gauge wagon is 23 tons and in a meter gauge wagon, 15 tons. A 6-wheeler is charged 1½ times the 4-wheeler and a bogie as for two 4-wheelers. Most of the commodities are being booked at Railway Risk though "owner risk" rates have also been quoted for a few commodities. Foodgrains are booked at Railway Risk. Sponsored foodgrains are not required to be booked as "smalls".

The minimum charge per "wagon-load" consignment is for a distance of 40 kms. and for "smalls", Rs. 1.50. The minimum weight for charge is "per-kolometer" basis, the rates are reckoned in blocks of 5 km. up to 250 kms ; in blocks of 10 kms. from 251 to 800 kms., in blocks of 25 kms. from 801 kms. to 2,400 kms., and in blocks of 50 kms. beyond 2,500 kms., the rate for each block being the rate applicable to the highest distance of the block.

Table 10 gives an idea of the freight payable, per quintal of foodgrains, (wheat, rice and coarse grains, etc. under class 30-A Special) for various distances at the rate applicable to "wagon load".

TABLE 10

Graduated Freight Charges, Indian Railways

Block Distance (km.)	*Rs. per Quintal*	*Rs. per ton**
40	0.48	5.20
50	0.53	5.78
75	0.64	6.98
100	0.74	8.10
160	0.97	10.60
200	1.11	12.10
250	1.27	13.80
300	1.41	15.37
320	1.48	16.10
400	1.71	18.60
500	1.99	21.70
800	2.73	29.80
900	2.95	32.20
1,000	3.15	34.30
1,100	3.35	36.50
1,200	3.56	38.80
1,300	3.76	40.00
1,400	3.93	42.80
1,500	4.11	44.80
1,600	4.29	46.80
2,000	4.97	54.20
2,400	5.53	60.30
2,500	5.61	61.10
3,000	5.84	63.70

Note : *Inclusive of 9 percent supplementary charge.

Movements may be single or multiple between the mandi (procurement market) and the consumer. The secondary and, sometimes even tertiary movements, take place from the buffer or operational stocks. Multiple movements add to the incidental expenses. Since this amount is usually considerable, it should be minimized. Such movements sometimes become necessary to standardize the weight and packing of foodgrain bags in the depots before issue to the consumers.

Priority in Movement

The Railways in India are regulated by the Indian Railways Act. This Act prescribes that the Central Government may, if in its opinion it is necessary in the public interest, by general or Special Order, direct any railway administration to give special facilities for, or preference to, the transport of any such goods or class of goods consigned to the Central Government or to the Government of any State or of such other goods or class of goods as may be specified in the Order.

The Central Government have directed all Railway Administrations to give special facilities for or preference to the transport of goods/class of goods specified in the Schedule as Priority A, B, C, D and E. Foodgrains, including fines of wheat, viz., atta, suji and rawa, coarse foodgrains, i.e. maize, milo, etc. programmed and sponsored by the Union Ministry of Agriculture or Food Corporation of India and approved by the Railway Board and pulses on Defence Account when sponsored by the Union Ministry of Agriculture/Food Corporation of India, are moved in Priority B. Agricultural produce belonging to the cooperative societies or agricultural produce procured by co-operative marketing societies under the Price Support Scheme of the Government of India as covered by the programme drawn up by the Government of a State or the Administrator of a Union Territory with the approval of the Railway Administration on whose system such produce is booked, is moved in the priority C. Pulses on State Government account sponsored by the Food Corporation of India and approved by the Railways are also accorded Priority C.

Movement of pulses on account of the Food Corporation of India when approved by Railways is entitled to Priority D. Wheat and its products, and decontrolled rice and paddy and their products, when required to be moved, intra-state or inter-state, on trade account, are entitled to Priority D.

All other movements of foodgrains take place in Priority E in accordance with the daily or periodical quotas as are given in the Special Order by the Railway Board to individual Railways, from time to time.

Pattern of Movement

The pattern of movement can be affected by the level of production during one or more seasons or the crop year. Cessation/suspension of imports and the "Green Revolution" in the North created several reverse trends in the pattern of movement involving long leads. As regards the direction of movement of foodgrains it is influenced by the requirements in circumstances, normal and abnormal behaviour of prices of foodgrains, need for turnover stocks sometimes involving even secondary movements, consumers' preference, storage and handling capacity available, need to

build up buffer stock, diversions to the next open cheapest route when the density of traffic on the shortest and cheapest route does not permit more traffic. The final pattern of movement will, however, very much depend on the location of areas producing the surplus, pockets of consumption as well as the exports or other means for disposing of the surplus. Sometimes, in periods of scarcity, new trends may set in when the short availability of wheat and rice is made good by coarse grains and *vice versa*.

The proportion of low-rate commodities in the total traffic carried on the railways has been increasing for the development of industries since the Five-Year Plans were planned. It would seem rather unfortunate that the high-rate traffic has found diversion to tbe road partly because of the inability of the railways to pick up the same promptly and to move it expeditiously.

The percentage of traffic in low-rate commodities to the total revenue earning traffic had gone up from 63.2 percent in 1956-57 to 72.8 percent in 1961-62. Of the total long distance traffic in 1960-61 about 92 percent was handled by the railways in 1971-72.

Rationalization of Movement

The production of foodgrains is seasonal and cannot be stabilized. The output is concentrated only in certain areas. In limited areas, operational difficulties are unavoidable. Sometimes, due to navigational problems peculiar to each port, foreign exchange position, difficulties in engaging tonnage, it may not always be possible to fix ships for certain ports suitable from the point of view of efficient distribution. In such unavoidable circumstances, some irrational movement might be inescapable.

These constraints notwithstanding, rationalization in movement of imported and indigenous foodgrains from ports, procurement areas and depots reduces the lead, transit time, losses and the cost of transportation. Any irrational movement is not to be accorded high priority save in cases of emergency or for turning over the stocks when deterioration sets in and the grain is soon likely to become unfit for human consumption. The Rationalization Scheme should apply not only to the movement from the ports but also to the movement from depots in the hinterland served by the group of ports.

Rail Transit Losses

The Indian Foodgrains Investigation Committee estimated that in 1949, in a movement of 7.5 million tons of foodgrains (3.5 imported and 4.0 indigenous) worth Rs. 350 crores, the loss was of the order of 2 percent in rail transit. For an equivalent of 1 5 lakh tons of foodgrains so lost in transit, the monetary loss amounted to Rs. 7 crores as against the earning of Rs. 15 crores towards railway freight.

The transit losses of foodgrains in various modes of transport ranged as follows : rail, 0.5 percent to 3.5 percent ; road, 0.25 percent to 1 25 percent ; and river, 0.5 percent to 1.0 percent.

In 1970-71 the losses of foodgrains in rail transit were estimated by the Food Corporation of India at about 1.0 percent. The

total quantity of foodgrains moved in that year was 15.09 million tons, including 7.04 million tons on Central Government account and 8.05 million tons on trade account. At one percent loss of foodgrains, about 1.5 lakh tons of foodgrains was lost in a year. The comparative position in regard to the number of claims for losses of sponsored foodgrains in 1971-72. When it is not feasible to satisfy all the conditions prescribed by the Railways at the time of booking and delivery, particularly during the peak procurement and peak movement periods, the booking is on qualified railway receipts

TABLE 11

Distribution of Volume of Foodgrains Moved by Railways, Revenue, Claims for Losses and Compensation Paid, Indian Railways, 1969-1972

Item	*1969-1970*	*1970-1971*	*1971-1972*
Originating quantity (million tons)			
Sponsored	7.00	7.04	7.22
Trade account	8.10	8.05	8.28
Total	15.10	15.09	15.50
Total freight earned (Rs. crores)	47.85	53.51	60.25
Number of claims settled			
Sponsored	16,538	18,539	5,345
Trade account	62,331	65,710	73,630
Total	78,869	84,249	78,975
Compensation paid (Rs. crores)			
Sponsored	0.81	0.90	0 33
Trade account	1.55	1.86	2.50
Total	2.36	2.76	2.83

claims lodged for losses of grains and pulses and settled by the railways in the years 1969-70, 1970-71 and 1971-72 appear on Table 11.

The movement of sponsored foodgrains is mostly on Central and State Government accounts. There was a sharp drop in the and, therefore, the claims for losses in rail transit are considered untenable. On trade account, the movement is in piecemeal wagons and, therefore, a physical count of the bags and supervision on loading and unloading is not difficult.

Losses of foodgrains in rail transit

generally arise from one or more of the following causes :

1. Shortage of complete bags.
2. Bags cut and torn in transit and spillage from bags not properly sewn or stitched.
3. Damage by rain.
4. Wagons getting unconnected in transit.
5. Pilferage, particularly when consignments are carried in open wagons.
6. Delays in transit resulting in deterioration of quality or loss in weight.

Shortage of complete bags is due to lack of proper supervision at the time of loading and unloading. Short-loading and accounting short-receipt, particularly when the booking is on a qualified railway receipt, must be prevented. At transhipment points, because of the difference in the carrying capacity of broad gauge and meter/narrow gauge wagons, part of some consignments get unconnected.

The bags get cut and torn when handled roughly, particuarly at the transhipment points. If no dunnage is used opposite the wagon doors, the grain is bled by miscreants through wagon door crevices. In open wagons, pilferage is not uncommon. If wagons are suitably designed to prevent interference, the losses can be minimized to a considerable extent. Careful handling is of course the best safety device. The labour uses hooks, big and small, to lift the bags. Often these hooks cause a hole or tear in the bags. Even if a small quantity of 10 gms per bag were to drop on this account, it usually results in a minimum loss of at least 1,500 tons of grain, per year, valued at not less than Rs. 12 lakhs. The hook needs to be replaced by some other device which will help in lifting and stacking the bags without tearing them.

Damage by rain can be avoided by using only watertight covered wagons.

Wagons get unconnected in transit when the seal cards and labels are blown away or when the entries thereon become illegible due to rain, etc. Proper protection of pocket labels and summary inside the wagons is very necessary. Sometimes when transhipment is involved enroute, particularly in open wagons, and the wagon into which the contents were transhipped cannot readily be connected with the invoice or the railway receipt for want of proper record or communication, the consignment suffers deterioration and other losses.

Certain other precautions and facilities necessary to minimize the loss of foodgrains in transit are :

1. Automatic bagging and stitching machines to avoid spillage due to loose or inadequate stitching. Where stitching machines are not in use, stitching should be readily available at the loading, unloading and transhipment points.
2. Standardization of bags so that losses are not transmitted in under-filled bags.
3. Spillage from the lorry and the wagon floors and the platform be collected promptly and properly accounted for.

4. The booking should be on "clear" railway receipts and the loading, unloading and transhipment properly supervised by the railway staff.

5. Wagons be rivetted and sealed immediately after the loading is completed.

6. Wagons be suitably redesigned to prevent loss of foodgrains through wagon-door crevices

7. Use of open wagons for transporting foodgrains be avoided. When the use of open wagons (in a block-rake) is indispensable there should be an adequate provision of tarpaulins of suitable size to fully cover each consignment, proper lashing and escorting of the wagons and frequent checks en-route.

8. All avoidable delays be eliminated.

9. In case of transhipment, complete particulars be promptly communicated to the forwarding and destination stations.

The Claims Prevention Organization on the Railways also continues to take the following measures for the prevention of claims :

1. Emphasis on correct packing and marking of packages, sealing and labelling of wagons to avoid their going astray or getting delayed in transit.

2. In-service training of staff and labour in careful handling of goods.

3. Special arrangements for carrying out repairs on wagons.

4. Emphasis on special precautions to be taken when goods vulnerable to damage are transported in open wagons.

5. Provision of additional covered accommodation in goods sheds on a programmed basis to prevent damage by moisture, etc. during storage.

6. Provision of better lighting and security arrangements in goods sheds and in yards.

7. Special watch to prevent delays in transit.

Storage in Relation to Movement

It was planned to create buffer stock of five million tons and operational stock of 2.5 million tons of foodgrains in the Fourth Five-Year Plan ending 1973-74. On the eve of the Fourth Five-Year Plan, the storage capacity in possession of various agencies was about 10.93 million tons, including 7.50 million tons owned (FCI 2.62, State Government 1.40, Central Warehousing Corpn. 0.65, State Warehousing Corpn. 0.23 and Co-operatives 2.60) and 3.42 million tons hired (FCI 1.26, State Governments 1.26, Central Warehousing Corpn 0.31 and State warehousing Corpn. 0.60). The Fourth Five-Year Plan envisages the creation of additional capacity of about 6.8 million tons, the financial outlay being about Rs. 117 crores. On the eve of Fifth Five-Year Plan the owned and constructed net capacity is likely to be 13.0 million tons distributed as follows : Food Corporation of India, 5.6; Central Warehousing Corp., 1.0; State Warehousing Corp., 0.6; State Governments, 1.8; and Co-

operatives, 4.0 million tons. The total quantity includes 12.6 million tons conventional and 4 lakh tons silos/bins.

This volume of foodgrains will take care of the buffer stock and operational stock as well of agricultural inputs and outputs by Co-operatives. Adequate storage capacity (permanent and temporary) would be available in the procurement areas so that in case there is any shortage in clearance of foodgrains by rail and road, the foodgrains would be under proper cover.

The Fifth Five-Year Plan target for additional storage capacity is 15 million tons estimated to cost about Rs. 324 crores. This would include a capacity of 1.7 million tons in silos/bins. This capacity is proposed to be on certain assumptions such as a stock of about 2.5 million tons of foodgrains on the eve of the Fifth Five-Year Plan; buffer stock of about 10 million tons, operational stock of about 4 million tons and procurement at 14.5 million tons in the first year of the plan (1974-75): increasing to 21.5 million tons by 1978-79. However, the requirement would depend upon agricultural pricing policy, food policy, supply and demand, movement capacity and level of procurement and public distribution.

After meeting the monthly requirements of foodgrains of deficit States from surplus States, railways prefer movement of foodgrains from heavily surplus areas to be spread evenly throughout the year instead of being concentrated particularly from the Punjab and Haryana, to eight months in a year. At 1971 prices, the expenditure on providing additional wagons and engines to move the given additional traffic from the Punjab, and Haryana within a limited period of eight months was estimated at twice the amount required for creating additional storage for the same quantity of foodgrains. For a quantity of 4 4 million tons of foodgrains to be moved from the Punjab/Haryana area in a period of eight months instead of 12, the cost of additional wagons and engines alone amounted to about Rs. 14.7 crores. Instead, if foodgrains could be stored temporarily for the movement to be completed in 12 months, the cost of construction of additional storage capacity was only about Rs. 7.4 crores. What, however, needs to be appreciated is that the time lag between the end of the peak procurement period of rabi and the beginning of the kharif procurement is only about three months. Besides, the supply of wheat and rice and coarse grains from the surplus States such as the Punjab and Haryana has to be arranged simultaneously and continuously in all months of the year. The crop season for rice and coarse grains being different in different States, spreading the movement evenly throughout the year from heavily surplus States, may, despite the availability of foodgrains, result in short supplies and, consequently, in considerable resentment and repercussion in the deficit States. Therefore, as far as possible, the movement of foodgrains has to be planned from the surplus States to the deficit States not only to meet the monthly allocations given by the Government but also to build up some stock in the deficit States and to vacate the godowns in the surplus areas for procurement of foodgrains from the ensuing crop.

Movement and storage has to be suitably coordinated in order to maintain reserve stocks at certain special points such as Port

towns and metropolitan areas; chronically deficit areas; areas generally affected by floods and drought and important centres from the point of view of transport and distribution.

Transportation of Foodgrains in Bulk

Not all foodgrains can be carried in bulk. Wheat, perhaps, is the most suitable for bulk movement.

For handling foodgrains in bulk the facility of silos with proper mechanical arrangements for filling, discharging and weighing would be necessary both at the dispatching and the receiving ends. As an alternative, a large number of evacuators will have to be provided. Trucks and wagons would have to be suitably modified. A railway siding and the operation along the silos would be necessary. Return traffic for the special type wagons would need to be provided in order for the operations to be economical. Distribution/delivery of foodgrains in bulk would reduce the incidental expenditure on gunnies, bagging, stitching, weighment and handling. Difficulties are likely to arise if special type wagons carrying loose grain are marked sick enroute, necessitating transhipment.

For foodgrains to be moved in bulk by integral trains from point to point on a daily basis to reduce the transit time and to minimise the delays at the loading and unloading points and the cost of handling, at least four lakh tons of foodgrains would have to be available at the point of loading. This is on the assumption that a block rake of 20 bogie wagons equivalent to 50 four-wheeler wagons will clear 1,100 tons of foodgrains every day. The availability of four lakh tons of wheat at a single point has been found to be not feasible without incurring additional expenditure on a long lead road feeder service. The investment in the bulk movement only during the peak period of procurement would be uneconomical. The cost of staff, operation, repairs and maintenance and loss of interest on capital would be considerable. Idleness of capacity in any form would be wasteful. It is also possible that when production in deficit States increases, long distance movement, as at present, may not be necessary. Shorter hauls may be by road.

There is yet another aspect. If, comparatively, the storage in silos is better and for a longer period, the duration for which foodgrains could remain in storage (conventional godowns or in silos) would depend on the domestic needs which may not permit storage for a long period. In that case the expenditure on bulk movement of foodgrains may be rendered infructuous. Still, some further thinking on things to come and the ways and means to tackle the same appears necessary. Considerable surpluses in foodgrains may emerge in certain areas as may permit of continuous movement of foodgrains in bulk. Let us hopefully prepare for that event.

Road Transport

It is true that road transport is faster, more mobile and safer but despite the loading and unloading cost at the dispatching and receiving end being less, it is, as compared to the railways, suitable only for non-bulk cargo over long distances, At one time the tax incidence alone in the road's

ton-km. cost of haulage equalled the average ton-km. traffic of the railways. The cost of movement of foodgrains by road is high. It makes the end-price of the commodity rise unduly. Movement of foodgrains by road on Central Government account is at present of the order of about three lakh tons in a year. Motor transport can run as a feeder service to the railways over short distances. The railways contribute a substantial sum to the Road Transport Corporations.

Road transport is competitive and often without reasonable relationship between rates and costs. Road freight is an open market freight and is not bound or legislated by any social obligations. Apart from the cost characteristics the profit motive is high. Road freight is not on the basis of the value of the commodity but is generally on its weight and volume. Road freight is generaly neutral between commodities and generally increases as the distance increases. The quotation of road freight depends also on the availability of return traffic. Whereas the railways are a cheaper mode of transport over long distances, road transport may be economical seasonally over short hauls. At one time the break-even point for rail and road freight was considered to be 60 kms, though for operational reasons, the radius was extended to even 200 kms. In 1968-69 the road freight per ton-km. was cheaper up to a distance of 112 kms. "This somewhat different pattern of cost in relation to distance of haulage is related to the nature of the transport and its cost characteristics." This precisely explains why, sometimes, the road freight for short distances is more than that for long distances.

Recently a committee was appointed to determine the point at which the cost (including incidental expenditure) for transportation of foodgrains by road and rail equalises. This study has been completed for the areas served by the Northern Railway. This Committee after taking into consideration the comparative cost data of 1972-73 related to the transport of foodgrains from Haryana to Delhi has come to the conclusion that the point at which rail and road cost equalise is 80 kms. in the case of wheat and 90 kms. in the case of rice. However, the economic radius is likely to change with the changes in the various cost factors, viz., incidentals including rail and road freight, handling charges, transit losses, etc. Table 12 shows the findings of a preliminary investigation undertaken in 1971 by the Indian Statistical Institute, New Delhi, on the transit loss by rail.

TABLE 12

Comparative Transit Loss by Rail, India, 1971

Item	*Rice*	*Wheat*
	Percent	
Average	1.01	3.27
Minimum	0.06	4.93
Maximum	3.06	24.67
No. of Railway receipts examined	15	41

Source of data: Indian Statistical Institute, New Delhi, 1971.

These results were based on a very small sample. In 1972, the National Council of Applied Economic Research, New Delhi, undertook a study of transportation of foodgrains at the request of the Food Corporation of India. The Council observed that the transit loss may be 0.5 percent for a distance up to 150 kms., 0.75 percent for

a distance between 151 kms. to 300 kms. and 1.0 percent for a distance over 500 kms.

even point will tend to be at a shorter distance. Therefore, for operational reasons,

TABLE 13

Comparative Cost of Moving Wheat and Rice by Road and Rail, India, 1972*

Distance (Kms.)	*Road Cost (Rs.)*	Rail Cost for Wheat		Rail Cost for Rice	
		@ 0.3% transit loss (Rs.)	*@ 0.5% transit loss (Rs.)*	*@ 0.3% transit loss (Rs.)*	*@ 0.5% transit loss (Rs.)*
50	13.86	18.21	19.89	20.19	23.19
60	15.95	18.53	20.21	20.51	23.61
70	18.03	18.97	20.65	20.95	23.95
77	19.49	19.52	21.20	21.50	24.50
80	20.12	19.52	21.20	21.50	24.50
87	21.58	19.95	21.63	21.93	24.93
89	22.00	19.95	21.63	21.93	24.93
90	22-21	19.95	21.63	21.93	24.93
100	24.30	20.49	22.17	22.47	25.47
108	25.97	20.93	22.61	22.91	25.91
110	26.38	20.93	22.61	22.91	25.91
120	28.47	21.48	23.16	23.46	26.46
130	30.56	21.80	23.48	23.78	26.78
140	32.65	22.35	24.03	24.33	27.33
150	34.73	22.68	24.36	24.66	27.66
200	45.17	24.53	26.23	26.53	29.53

Source of data : National Council of Applied Economic Research, New Delhi, 1972.

Note : * The cost of wheat is less than that of rice.

The cost of transportation by road and rail for distances ranging from 50 kms. to 200 kms. is given in Table 13.

In the years to come, as the cost of transport and labour increases, the break-

equal cost of transportation by rail and road may not be the primary consideration for resorting to the road movement.

The Committee has also observed that road movement up to 100 kms. should be

freely resorted to, to supplement rail movement and to utilize the available rail capacity for long distance hauls. Further, road movement should not originate at point (s) where adequate rail capacity is available. The Committee has recommended that road movement should be more liberally utilized from saturated or more difficult rail sections and where, in the over-all distance which is to be covered by road-rail movement, the lead by road is greater and by rail comparatively much shorter, the movement should originate and terminate by road. The movement from the procurement points to the nearest depots should be so planned as would avoid congestion at the terminals.

The Report of the Committee on Transport Policy and Co-ordination on the comparative rail and road costs is shown in Table 14.

This data includes a sum of Rs. 3.50 per ton for bulk commodities moved by rail as the cost of local transport at the originating end only. The Food Corporation of India agreed with the road costs but in the case of rail costs they were of the view that to make the rail-road comparison more valid, all "incidental charges" should be added to the freight. The incidental charges up to distances of 150, 300 and 500 kms. were estimated at Rs. 8.10, Rs. 10 and Rs. 11.90, respectively, to be added to the rail freight. Trucks of higher pay-load were considered cheaper. The National Council of Applied Economic Research, New Delhi, have recommended that road transport ought

TABLE 14

Distance km.	Rail Costs Bulk Commodities		Road Cost	
	Broad Gauge	*Meter Gauge*	*13-ton Tractor and Semi-tractor*	*8-ton Truck*
		RUPEES PER TON		
50	6.53	7.59	5.67	9.76
100	7.35	8.93	9.72	17.12
150	8.18	10.28	13.27	23.22
200	9.00	11.62	16.60	29 56
250	9.83	12.97	19.88	35.35
300	10.65	14.31	22.59	42.16
400	12.36	17.00	29.85	55.77
500	13.95	19.69	37.10	69.38

Source of data : Committee on Transport and Coordination, New Delhi, 1972.

to be preferred for all movement below 100 kms.

In hill States, the road transport cost is very high, ranging from Rs. 2.35 to Rs. 14.72 per quintal for distances varying from 40 kms. to 280 kms. Even the rates are different in the monsoon and non-monsoon periods. During the monsoon period the rate goes up by about another 70 paise a quintal. In order to reduce the hardship to the consumers on this account, either the extra expenditure on road transport could be included in the issue price for sale of government foodgrains in the country or the road freight could be reimbursed to each hill State

The road transportation cost is also high particularly in Regions in which there is an imbalance between the goods traffic moving in and out of a Region.

Road transport is a State subject. Motor transport is regulated by a Code of principles and practices. When operated under the Central Authority by a Public Undertaking, it has been found to be uneconomical. The availability of foodgrains is not uniform throughout the year. If the fleet of trucks and staff were to lie idle, the cost of operation would be unnecessarily high. The cost of staff, repairs and maintenance, taxes, insurance, etc. would be much higher than that of private operators. Road-worthiness of vehicles in use by certain public undertakings was estimated at only about 51 percent to 65 percent as compared to about 90 percent of the fleet ratio by private trucking companies. The control and supervision by private companies is more rigorous and effective. Hired trucks have been less costly.

Coastal Movement

Since surplus quantities of wheat are available only in the Northern Region, the movement of wheat to the States in the South Zone poses certain problems due to limitations of rail capacity on the North-South routes. The railways are increasing the route capacity in which the density of traffic has already reached the saturation point. The shortage between the requirements in the South Zone and the available rail route capacity from the Northern Region is estimated at about 50 thousand tons per month. This is being covered, as and when necessary, by rail-cum-sea movement from the Northern Region via the West Coast ports at considerable cost; the difference between rail freight and rail-cum-sea freight (including incidentals) amounting Rs. 45 to Rs. 74, per ton. Coastal shipping can be relied upon for moving only a small quantity of foodgrains by the rail-cum-sea route from the Northern Region via the West Coast ports in Gujarat and Maharashtra.

Organizational Set-up

In general, the movement plan for supply of foodgrains against demand and for suitable storage envisages linking of movement from surplus areas and ports to the deficit areas by the shortest, most economical and fastest route. The imposition of restrictions on the inter-State and/or intra-State movement of food grains or on low priority traffic to facilitate procurement and to control prices of foodgrains would require decision at a high level.

Maximum co-ordination and co-operation can bring about excellent results. With rapid industrial development the pressure of the transport system would continue to be heavy, necessitating proper planning of movement of foodgrains to the deficit areas.

A Central Movement Organization may be necessary to co-ordinate and facilitate the movement of foodgrains by all available modes of transport. Regional Offices may be set up according to need. Route and terminal capacity are important factors to be kept in view. At ports, Port Operating Committees, comprising of representatives of the Railways, Port and the Food Department may meet periodically to allocate suitable daily wagon quotas for movement of foodgrains and other commodities. The Central Organization can also assist the Provincial Governments as and when necessary and even trade, in case of serious hold-up of traffic, by making ad-hoc arrangements with the railways for the clearance of accumulated traffic. Detailed movement plans could be drawn up at the district level jointly by all the procuring agencies. The co-operatives also play an important part in the procurement and the distribution of foodgrains. There should be an adequate provision for protecting their interest in the national schemes.

Summing Up

Foodgrains are priceless. We must save them to save ourselves.

An efficient movement organization can economize on the transport costs and the public distribution system a great deal. Seasonal pressures need to be reduced to the extent possible without affecting the public distribution system.

Multiple movements involve heavy losses in cash, kind and capacity. For greater use of the available transport capacity and to reduce the increasing incidentals on transport, storage and handling, movement of the same grain for the second and third time must be minimized. Major bottlenecks in the transport and handling system have to be identified and removed.

Reduction of lead of foodgrains is a matter for urgent consideration. If foodgrains is a low-rate traffic covering not even the operating expenses of the railways, would its movement at the "train-load" rate instead of "wagon-load" rate redeem the situation ?

Ways and means have to found for counting of bags and supervision on loading even when 70 to 100 wagons on a special are to be loaded with foodgrains at the same time so that the booking is on "Clear" railway receipts and compensation for loss of complete bags can be claimed from the railways. Further, admitting that losses are also due to the inherent characteristics of the commodity or the deficiencies in the transport machinery, there is the paramount need to guard against the weaknesses of the men involved. Can there be a foolproof system or a system very near it ?

Whether foodgrains should be moved preferably in bags or in bulk is the question. It may be worthwhile going into the economics of this operation.

Road transport may be an operational necessity. Its use from the private or public sector is debatable. □

RESOURCE UTILIZATION IN INDIAN MANUFACTURING: A MATHEMATICAL ANALYSIS : By Dr. Gary L. Bergstrom; Progressive Corporation (P) Ltd., Bombay, 1973, Price : Rs. 24/-.

This is a serious study arising out of the author's doctoral dissertation submitted at the Alfred P. Solan School of Management at the Massachusetts Institute of Technology, and contains the basic results of that document with certain modifications. The author deals with a subject which is highly enigmatic to say the least. He deals with resource utilization from the point of view of determination of capacity and its utilization with reference to different factor constraints. Discussing the capacity measurement problem and the current state of knowledge on the subject, the author seeks to measure capacity on the basis of a detailed technical measurement of the relevant production processes. This he does on the basis of two cases chosen from Eastern India—cases of two large size multi-product private sector firms, known for their effective management. He explores the details on the basis of rigorous mathematical analysis, particularly a linear programming model and a multi-item decision rule model. The exhaustive operational data belonging to these two firms have been culled for fitting into the models drawn and for finding solutions to compare with the overall plans of management for some years, particularly for 1967-68. He shows that his findings had been very close to the profitability plans chalked out by management. The factor utilization criteria used by the author in capacity determination should evoke serious interest among researchers in the field.

It appears, however, that the author does not deal with certain other fundamental questions inherent in technological assessments of capacity, apart from factor utilization criteria. Capacity is signified in terms of a technically determined key process in a chain of processes of production. When, like the weakest link in a chain, this key process is more or less than a specified

capacity of other processes, it creates constraints of several kinds. This is so, particularly when the key process has capacity less than some of the other processes. By whatever definition it is considered the key, it creates problems of under-utilized capacity of the other processes, irrespective of whether the capacity of the key process is fully utilized or otherwise. To some extent, this is taken care of through accounting for individual resources but if resources other than process capacity are not seen in direct relation to the latter, finer points are likely to be missed. The point is that even when, by this definition, an enterprise has utilized hundred per cent capacity, there may be processes which are idle. This is a general phenomenon in certain industries. Examples may be given with reference to textiles, engineering and chemicals.

In the context of cotton spinning mills, for instance, there are partly manual and partly mechanical processes constituting the flow. Whereas any of the mechanical or manual processes may comprise the key process, the other processes are faced with problems of under-utilization. This arises at times also because the machine is not available in a smaller size. Mechanization of the manual process is also not easy. In the circumstances, many mills have sought to utilize individual unutilized factors like management, labour, etc., by hiring out jobs concerned with these processes. On the other hand, when the key process capacity is sought to be brought on par with the other processes without a permanent commitment of extension of capacity in this process, services have been purchased from outside for fitting into other processes in the flow. This practice poses problems inherent in capacity estimation. The author, however, does not deal with this kind of problems and his two case studies though elaborate in themselves, fail to capture the general mood accompanying capacity utilization in Indian manufacturing industries.

This criticism, however, should not detract from the value of the book, which should be considered a welcome addition to the meagre Indian literature on the subject.

—P. MUKHOPADHYAY

SIGNIFICANCE OF PUBLIC INVESTMENT FOR BACKWARD REGIONS: By Mahesh Pathak; Gujarat Mineral Development Corpn. Ltd., 1973, Price : Rs. 20/-.

Identification and development of backward regions have engaged serious attention of the Government and the planners rather recently. Somehow, the emphasis on industrialisation of under-developed regions in the country has been intimately connected with the recommendations of the Wanchoo and Pande Committees. Since then, district-wise backward regions have been identified. The process of economic development followed in this country has inevitably resulted in sidetracking certain regions in spite of the fact that they do not lack raw materials and labour. That we have at long last been conscious of this need is a healthy sign. In this respect, a debate has been initiated on the method of industrial development that should be adopted for the uplift of these regions. In addition, there are choices open regarding the approaches that may be made in this regard. While on a general plane a good deal of discussion has already taken place, we have

not done much on the brass tacks. Dr. Pathak has presented in this slick volume a case study of the impact of the Flourspar Benefication Project in Baroda district of Gujarat State on the local community. He has shown how the economic, social and cultural life of a community in a backward region of Gujarat State have changed over time, as a result of the introduction of a major public sector project in the locality.

The Study is divided into six Chapters. The first chapter, on development of backward areas: problems and prospects, narrates the underlying factors of development of backward regions, the growing significance of such development, the changes in official policy and the specific measures taken in different context. Chapter two, devoted to project appraisal, outlines the significant factors that should be applied in such appraisal and the current state of the theory on the subject. He notes in this respect that "The traditional rate of return approach does provide a useful efficiency criterion for project appraisal. However, the work of project appraisal will not end with these estimates. This work has to be carried further, first, by adopting wider concepts of costs and benefits associated with a project and second, by relating the results of development projects to certain specific socially accepted objectives such as the saving of scarce foreign exchange resources, development of certain vital segments of the economy having powerful backward and forward linkages, generation of larger national income over a period of time, provision of more employment opportunities, attainment of a better inter-personal distribution of income or the development of a backward region". The third chapter, relates the significance of the industrial projects in question to the backward economy of its location. In this context, he gives a short description of the project and the locational factors, particularly the socio-economics of the region. The fourth chapter, underlines the impact of the project at the macro level with particular reference to the direct and indirect benefits that have accrued to the region. The fifth chapter stresses the impact of the project at the micro level, attempting to assess the more specific benefits for the tribal employees of the project. The ultimate chapter, which is an epilogue, gives an overview of the analysis with particular reference to the benefits that have arisen to the areas in which project has been established. The epilogue reflects the methodology of appraisal of investment towards uplift of backward areas, measurement of costs and benefits and the provision for incentives that has been made by the Government of the Centre and the States. He has emphasised the need for better co-ordination of these different policies for desired effect.

Though the Study relates to the establishment of only one industrial project in backward areas, that also on a limited scale, it throws significant pointers that should be tested in the context of similar projects in other areas. The author's primary emphasis has been on the socio-economic development of the people in the influence areas. However, a closer look on the economics of project appraisal, particularly the efficiency factors could have given some more light on the useful analysis made by the author. In the context of economic development of backward regions on which literature is still meagre, the author

has been somewhat unkind to the readers insofar as his analysis and narration have been rather telegraphic in brevity. However, as a case study, the volume commends itself for wider readership.

—P. CHATTOPADHYAY

IN THE WONDERLAND OF INDIAN MANAGERS : By Sharu Rangnekar ; Published by Associated Personnel Services, Tardeo Road, Bombay-34 ; First published in 1973; Pages 134 ; Price Rs. 30.

With a magnifying glass in one hand and a human gauge in the other, Sharu Rangnekar sets out to explore this strange land of Indian Managers. The journey through this wonderland with Mr. Rangnekar is a very thrilling experience. He is full of wit and humour. His observations make you laugh and at times take you by a surprise. He is very straight and courageous in putting the facts. Mr. Rangnekar's understanding of the practices of Indian Managers is very thorough. His style of recording the observation is educative while it is an entertainment for the reader. The book is meant for light reading. The writer is witty when he tells you how to avoid decisions or promote without promoting, but on the other hand he is very serious about the snags in the system. His observations are sugar-coated capsules. While one enjoys reading every page of the book he is bound to feel sad about the managerial practices in vogue in recruitment, selection, training, promoting, public speaking and decision-making. The last alphabet in Management i.e. theory 'Z' is an example of Sharu Rangnekar's creativity and satire. Illustrations by RK Laxman have added a third dimension to the Philosophies discussed by Mr. Rangnekar. Sometimes it appears that in a bid to make it humourous Mr. Rangnekar has exaggerated the facts but at times this exaggeration is necessary so as to make the matter more palatable. In short, for every enlightened managers a trip to wonderland of Indian Managers is a rewarding experience.

—RAKESH KUMAR

MANAGEMENT ACCOUNTING: By N. L. Hingorani, A. R. Ramanathan and edited by T. S. Grewal ; Published by Sultan Chand & Sons, 4792/23, Daryaganj, Delhi-6; First published in 1973 ; Pages 484; Price Rs. 15.00.

Management accounting is the technique for acquainting non-technical persons with the information revealed by official accounts of a business organisation. It is not easy to comprehend the underlying significance of formal accounts. As such, the science of management accounting becomes the next step beyond financial and cost statements. Built out of a harmonious combination of several kinds of accounts, it gives the top management of business concerns a clear grasp of the trend of progress in their concerns.

This plump and powerful volume vigorously poses issues which have either been neglected or only cursorily handled by writers on the subject in India. It can, therefore, be ignored by students of management accounting only at their peril.

A detailed treatment of topics like financial ratios, budgetary control, marginal and standard costing, and capital budgeting has been done by the authors in a style

that is lucid and illustrative through and through. An interesting chapter is on quantification in conditions of uncertainty wherein the decision process through probability techniques has been explained with several mathematical examples.

The topic of financial statement analysis has been most elaborately handled, and rightly so. In recent times, this analysis has assumed importance in India with the growing popularity of institutional financing in industries. However, the managements of several large concerns do not as yet appreciate the utility of financial analysis of accounting data. Besides, there is no conceptual clarity on what the several ratios imply and how they are related to one another. The authors have done a singular service by taking up as many ratios as possible and explaining the implications in unequivocal terms.

The chapter on standard costing explains the methods for determining standards and the various variances in them. Similarly, the analysis of cash and funds flow indicates how useful these tools are in determining profitability of projects.

All in all, the book warrants wide readership. Students of the subject will symmetrically benefit from its clear discussion. The practitioners of the science will be stimulated and refreshed.

—NAVIN CHANDRA JOSHI

BRAIN DRAIN : INEQUALITY FACTOR IN THE WORLD : By V. A. Gaitonde; Commerce Pamphlet No. 71, Price Rs. 1.50.

In this short exercise, the author raises a basic issue haunting many different nations, particularly those which have to put up with the condition of qualified people tucked away to other countries both in the developed and the developing world. The demand for skilled personnel throughout the world has been caused by the scientific and technological revolution. To cope up with the demand, individual countries have been exploring all avenues to get qualified persons from different other countries at times at high cost though in different ways to both the importing and the exporting countries. The context of brain drain has been neatly put in this short essay in a highly objective manner. The author acknowledges the presence of diverse factors in the volume, intensity and directions of the brain drain but in his view, the outflow of the national personnel from the developing countries to the developed countries is based on an aggregation of socio-economic factors which are of a primary, objective character. The exodus of national personnel from the developing countries has been snowballing in scale and pace, providing a visual demonstration of the increasing exploitative role. He quotes figures of influx of specialists in different disciplines from the developing countries to the USA and the figures of countrywise outflow to the individual countries like the USA and Canada.

In his view, brain drain entails collective demoralizing consequences. Brain drain erodes the socio-psychological situation, the moral atmosphere in the affected countries specially in view of the effect that this creates on the potential of following up such revolutionary changes as are noticed in the advanced countries. In the author's view, to try to explain it in terms of pure economic criteria of demand and supply

is not quite logical and more important factors inherent in brain drain are not adequately probed. The net result of all this is that the rich countries tend to grow richer and the poor countries, poorer.

—P. CHATTOPADHYAY

MANAGERIAL ECONOMICS : By R. L. Varshney and K. L. Maheshwari, Published by Sultan Chand & Sons, Delhi-6 ; Third edition August, 1973 ; Pages 460 ; Price Rs. 15.00.

This third edition of the book is in an expanded form in as much as several chapters have been revised and enlarged along with the addition of further two topics on linear programming and input-output analysis. In seven sections containing 29 chapters, the authors usefully discuss subjects like cost analysis, profit and capital management, pricing policies, demand analysis, etc.

The book is studded with insightful observations on factors that go to make managerial decisions practicable and sound. It is valuable for the breadth of its coverage and the knowledgeable treatment of the whole complex of managerial economics for the benefit of readers who have no clear grasp of the fundamental tenets involved. A serious study of the book makes the result rewarding and enriches one's horizon in the cybernetics of business decisions.

After explaining the various aspects of the law of demand, the authors describe the approaches to forecasting along with its statistical measurement. Similarly, a reference to cost concept is followed by cost-output relationship in differing conditions of production. The topics of production function and linear programming have been given a mathematical treatment though the latter has been handled in a sketchy way.

Pricing policies and methods sufficiently make home to us the techniques involved. However, to this reviewer the most thrilling portion of the book is on profit management wherein the break-even analysis has been thematically handled in its diverse ramifications with the help of several examples. How much we wish that the appraisal of project profitability had explained complicated arithmetical formulae other than the interpolation method in so far as calculating the rate of interest in discounted cash flow is concerned.

The addition of a description on input-output analysis in this edition of the book is quite welcome. The authors have drawn heavily on Leontief model. It would have been worthwhile to have attempted examination of recent developments that are in abundance in the field.

One good feature of the book is that it makes explanations simple without being simplicitic. Secondly, the book does not remain merely theoretical as several problems solved at the end manifest its practical approach to the subject.

In sum, the student is challenged by the book and will find it highly rewarding.

—NAVIN CHANDRA JOSHI

APO Symposium on Productivity and Industrial Relations

(Tokyo, 22-26 October, 1973)

THE 5-day symposium on Productivity and Industrial Relations, organised by the Asian Productivity Organization, concluded in Tokyo on 26th October 1973 by adopting the following lines of action which, according to the Symposium, would contribute to productivity improvement consistent with harmonious industrial relations :

1. Vocational training, management development and worker education be oriented to productivity. This implies that the employers, managers, trade unions, and workers accept training as necessary and effective means of raising productivity through improving knowledge and skills of employees. The National Productivity Organisations of member countries in collaboration with enterprises, technical training institutes and management education institutes can initiate action.

2. Organisation and policy changes in management as well as trade unions be effected wherever necessary with a view to coping with economic and social changes. This involves a study of existing organisational set up and redesigning of organisations' structure and policies.

3. Sharing of gains of productivity be such as to give workers a feeling that the sharing is equitable and that it is not unduly deferred. APO is in the position to initiate action to develop awareness of the need for evolving models for sharing productivity gains. This can be done in association with the National Productivity Organisations.

4. Adequate and mutually acceptable procedures for joint consultation at all levels with particular emphasis on shop floor is essential for ensuring mutual understanding and joint effort for introducing changes leading to higher productivity. This implies unreserved acceptance of trade unions by the management and also acceptance of the capacity of workers to make contribution to improved productivity.

5. Harmonious industrial relations and improved productive systems are rooted in

community and national attitude. Industrial action cannot succeed without community support nor can efficient production be organised within a community without its being conscious of its need. For this purpose education of the community and also promotion of suitable institutions should be the responsibility of the governments.

6. The governments' initiative in promoting productivity improvement and also suitably developing industrial relations structure is crucial for every effective action. This is possible when governments actively support popularisation of productivity movements and facilitate in introduction of suitable technological changes, application of productivity techniques at enterprise level and protecting workers against adverse effects.

7. International organisations active in the field of productivity and industrial relations can effectively contribute to significant improvement in raising productivity at both enterprises as well as at national levels. The APO should encourage the national productivity organisations to take interest in organising tripartite meetings for analysing industrial relations factors which help or hinder improved productivity. Such technical assistance as is needed for this purpose should be provided by the APO in collaboration with the International Labour Organisation. The APO should also sponsor research projects and provide a platform for exchange of experiences among different nations.

8. Availability of the required type of specialists and technical services are essential in view of the fact that managements and trade unions do not generally have such specialists on their rolls. The APO should provide required type of specialists as well as help in developing such expertise within the member countries.

9. The role of effective communications in securing industrial harmony cannot be gainsaid. Both employers and trade unions have a responsibility in this regard. Such assistance as trade unions need in fulfilling this responsbility should be made available to them by government. International experience in this regard should be capable of analyses in a form which could be adapted to national needs. The APO and the ILO should jointly explore how these needs should be met.

10. The steps taken by the APO in including in its long-term plan two programmes: (1) grains symposium on sharing of gains of productivity and (2) a symposium on productivity bargaining, are welcome.

The symposium took note of the work done and proposed to be done by the ILO in collaboration with the Norwegian agency for international development and hoped that this collaboration will be continued for analysing some specific aspects of industrial relations in the context of productivity and in a manner suitable to individual countries in the Asian region.

The Symposium, which was inagurated on 22nd October 1973, was attended by practising top managers and trade union leaders from the APO member countries of the Republic of China, Hong Kong, India, Indonesia, Iran, Japan, the Philippines, Thailand and the Republic of Vietnam. It was convened with the active cooperation of the Japan Productivity Center and the National Trade Unions Productivity Congress.

In the following pages two papers presented by the Indian representatives, Shri R. P. Billimoria and Shri V. G. Gopal are published.

Industrial Peace and Productivity

R.P. Billimoria*

In this paper which was originally submitted to the Symposium on Productivity and Industria Relations convened by the Asian Productivity Organisation in Tokyo from 22-26 October 1973, the author attempts to outline long-term solutions based on an integrated sub-system for the management of human resources. "The euphoria created by revolutionary processes or new developments which carry people beyond what has actually been proved or found to be practical has often resulted in discarding many proven techniques because of their age". Nevertheless, consistency in style arising from reasonable continuity in management, prompt and predictable decisions and management by objectives rather than by manipulation could temper old with new, maintains the author.

INDUSTRIAL unrest is endemic. Trade unions have come to stay. Their militancy is on the increase and their affiliation with political parties often leads to agitation and unrest on political grounds rather than on traditional issues. A new dimension has been added by ad hoc groups of workers cashing in on inter-union rivalry by stopping work and seeking the highest bidder among the unions to support their claim. All this may be lamentable but it is no use lamenting it. We have to find a way out. In developing countries, productivity is the first casualty. But not infrequently, inept management or just a failure of nerve on its part leads to continuing unrest. But it's hap to talk of peace. We have even invented a symbol for it, to be displayed on badges and buntings. The last decade has been known for deifying peace and at the same time doing everything possible in breaking it. Everywhere we are caught up in an explosion of violence against authority—thieving, sniping, fire-raising and generally rampaging, have been some of the outward symptoms. Hence, industrial peace, as a universal goal, has to be viewed as part of a total system. *A worker, or for that matter a supervisor, tormented and plagued by a wide variety of problems such as poverty, tension at home and trouble with his superiors cannot be expected to shed his worries and exude bonhomie in his work life.* The vicious spiral of anxiety-hostility-activity moves at an accelerating rate until a point is reached at which something must break. When it does, you face a man-sized industrial relations problem. The planners of the nation have, therefore, to devise a total corrective system for reducing, as far as is practicable, the extraneous tensions which adversely affect the worker in his work unit. Instead of offering

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platitudes and easy solutions we shall discuss industrial peace and productivity as objectives to be realised through a systems approach.

The task is not easy. Nor is it the end of it, for industrial peace as a static concept does not necessarily ensure industrial progress. Peace at all cost, with skeletons crowding cupboards, compromises galore and inconvenient sweepings under the carpet, is the peace of the grave. Many an undertaking has learnt this lesson at the cost of its existence. Let us not forget that industry exists to produce goods and services for the community while providing adequate wages and good working conditions for those who work in it. The nation will not accept from us assurances of peace, tranquility and brotherhood in lieu of the product we are supposed to produce. I, therefore, look upon industrial peace as a throbbing dynamic system, *where the emphasis is on the creation of formal and informal groups for the management of conflict rather than* its prevention: where the primary emphasis is on production and innovation for achieving higher efficiency; where constructive dissent from any quarter is not looked upon as a symptom of mutiny to be immediately snuffed out; where each employee is aware that he has to measure up to the tasks which have been jointly set if he is to remain as part of the team; and where reward and censure are commensurate with performance and not with the whims of those in authority.

Isolation Within the Personnel Function

Let us first have a close look at how we function today in many of our organisations. First, we shall make optimistic presumptions that all companies have laid down company objectives and organisation plans. In spite of this and in addition to it, many sub-functions like personnel or research and development, often function within the total system as distinct empires pursuing their own separate objectives which may vary from time to time, depending not only on exigencies but on the personality and speciality of the man in-charge. For example, the chief may have a flare for training and he will bring along with him a superspecialist in this area, set up a vast department complete with gadgetry and gimmicks; highly sophisticated training programmes will be introduced and, with some pride, mention that never before have such programmes been run anywhere in this country. But there will be hardly any tie between the separate sub-functions within the personnel department, no logical flow of planning and action, and no explicit use of feed-back from performance in order to modify future planning. *Training is just an example.* It can occur in other areas also, such as industrial relations, welfare and employment.

Diagram 1, depicts this state of affairs. Mind you, this is not the organisation chart of the personnel department. Such a chart would be neat and tidy, showing the chief of personnel at the apex, dividing his function among neat little boxes down below showing various functionaries in charge of employment, training, welfare, industrial relations and other areas. According to the chart, all the different sub-functions are integrated and centralised in the position of the head of the personnel division. In some instances such integration may take place and each function may be related to the other in a logical and sequential manner. But

the mere holding of weekly or fortnightly meetings, does not necessarily lead to real integration. In my humble opinion, in many of our organisations such integration is the exception rather than rule and Diagram 1 does indicate the type of isolation that I have described. There is hardly any inter-connection between the different functions, nor is there logical flow of decision making from one function to another. In other words, in many personnel departments, employment training, development and wage and salary administration operate more or less as independent functions. The employment office, often recruits new workers in response to requests from line management without knowing precisely what kind of training and development the workers will later receive and without knowing exactly how each of these new workers will fit into the long range man-power planning of the company to meet company objectives five or ten years hence. This would also apply to other sub-functions. For example, the department dealing with wage and salary administration, more concerned with problems of changing designations and grades based on internal pressures and industrial trends, may hardly be aware in any depth, of the relevance of organisation development plans, long-range manpower plans and the changes that are to take place within the company for which a wage and salary administration system will have to be adopted. Very little concern may be shown towards evolving, what may be called, a total reward system.

Isolation vis-a-vis Company Objectives

Such isolation is not only in respect of the various sub-functions within the personnel department. It is my contention that overall company objectives and plans are also de-linked from the functioning of the personnel department. As indicated in the diagram, personnel functions, more often than not, do not flow from these objectives in any direct and precisely definable way. For example, is the personnel department always told in numerical terms, the objectives of the company over short and long-term periods, before it is asked to plan its employment, training development and wage and salary administration programmes? To give another instance, suppose the training department starts a training programme either because it has been conducted in the past, because some boss has read about it somewhere and expressed a vague need for it, or because another company runs this programme. Is sufficient thought given to enquire whether there is any direct relationship between the training and the specific requirements of the organisation?

Thus, the isolation is both from within and without and there is a tendency for each sub-function to look upon itself as independent, its goal being to optimise its own specific function and to measure its performance by its own internal standards rather than on the basis of its contribution towards the goals of enterprise. In turn, the whole personnel department or personnel management system tends towards sub-optimisation because the separate sub-functions are not logically fitted together and balanced with each other as an integrated sub-system pursuing a unified set of objectives directed towards the accomplishment of overall company objectives.

Trend for the Future

But personnel management cannot isolate itself from the growth of the total organisation. Recent researches in behavioural sciences have shown that ultimately it is the management of human resources which plays a key role in opening up new opportunities for increasing productivity. The application of this research, will provide challenging tasks for the personnel manager during the closing years of this century. We have now to combine this new knowledge derived by the behavioural scientists with the traditional approaches to personnel management The first task will be to re-define the role, objectives and structure of the personnel department.

In 1968, Frank Fisher in an article on The Personnel Function in Tomorrow's Company, indicated that the Personnel function is moving rapidly in the following direction :

* A growing orientation towards its role in the creation of trade surplus for the company ;
* A shift from standard personnel programmes given in textbooks to custom-made systems to fit the specific needs and objectives of the individual company ;
* Assuming responsibility for developing the organisation rather than just maintaining it. The emphasis has to be on planning and developing of the company's human resources as opposed to mere pre-occupation with record keeping ; and
* A more direct involvement with top management in deploying and developing human resources. The modern chief executive fully recognises that the development and effective utilisation of human resources is one of the chief elements of the overall management of the organisation, inextricably linked with the total management process.

Need for a Systems Approach

It will be noticed that these trends underline the need for an integrated systems approach which would emphasise the direct relationship between the personnel management sub-systems and the objectives of the company. We, therefore, start looking upon personnel management as a major supporting sub-system of the overall management system. It is this concept which will :

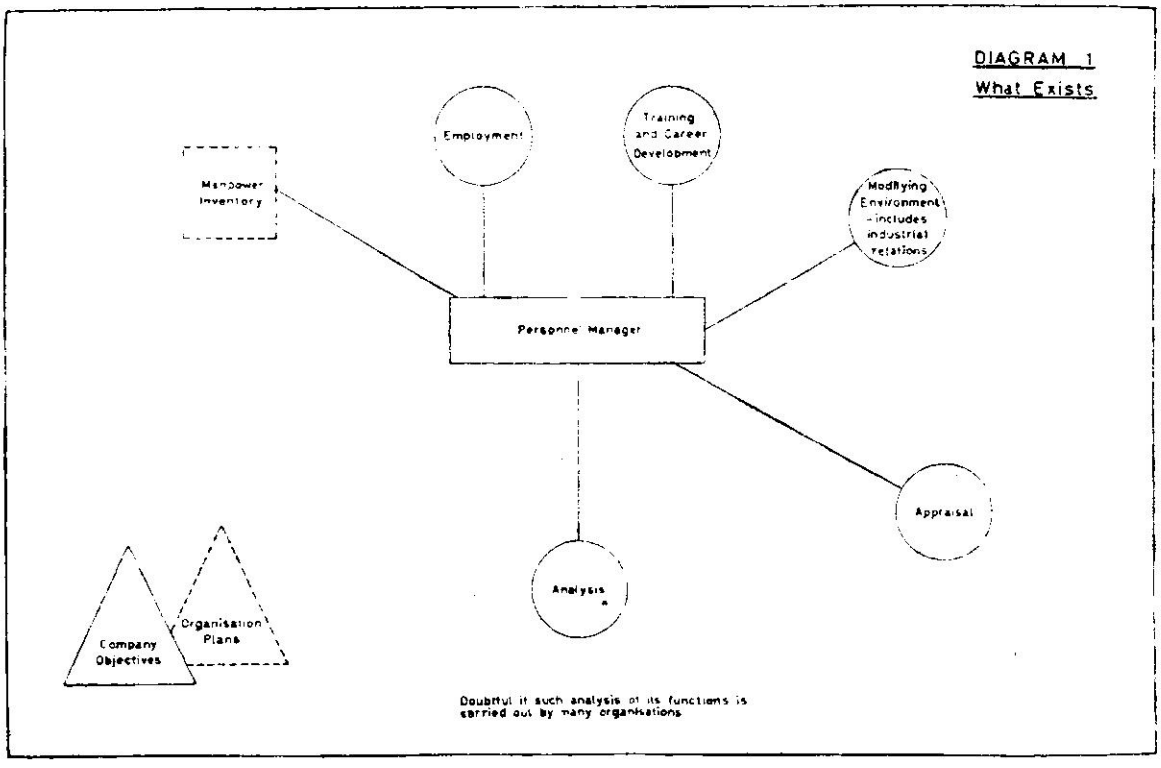
make us change from the traditional position which is indicated in Diagram 1.

help evaluation of specific sub-functions like employment and training in terms of how well they complement and support each other by being consequentially related and

ensure a thorough evaluation of the personnel management programmes and activities by the degree to which they are determined by and contribute directly to the accomplishment of company objectives.

A Closed-loop Feedback

We shall now try to propose a systems concept for personnel management based on the thinking of human resources management as an integrated, closed-loop feedback subsystem of the total management system in the company. G Petitpas has done some useful work which can be somewhat modified to suit Indian conditions. Such a system



would be extremely valuable in planning, designing, implementing and assessing the value of manpower management programmes more precisely than has been done in the past. This would lead us to question whether any individual programme is designed for its intended contribution to the organisation's objectives or whether it is of mere cosmetic value.

Diagram 2 schematically describes such a system or complex. The system has inputs from the larger total management system of the company. It produced outputs both for the organisation as well as for the individual within it. It contains employment, modifying of the environment including industrial relations, individual development, appraisal and analysis. As is obvious, some of these sub-systems may well have within each, several large sub-systems of their own. For example, the employment sub-system would contain recruitment, selection and placement sub-systems.

The Cycle

Diagram 2 indicates one complete cycle of the human resources, planning, performance and feedback process. It should be understood that this does not necessarily take place in discrete and cleanly definable cycles. Each sub-system is contantly in different stages of planning, performing and receiving

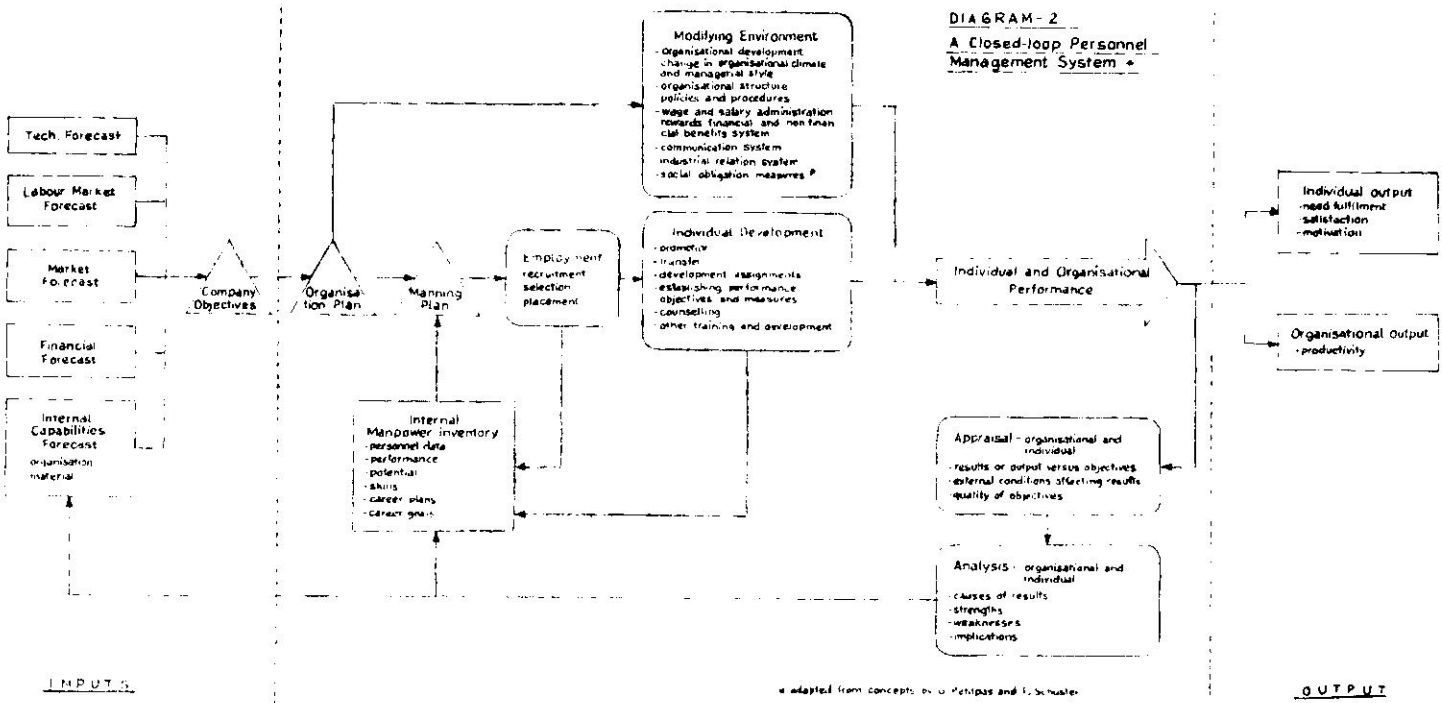


DIAGRAM - 2
A Closed-loop Personnel Management System *
Modifying Environment
- Organisational development
- change in organisational climate and managerial style
- organisational structure policies and procedures
- wage and salary administration rewards financial and non financial benefits system
- communication system
- industrial relation system
- social obligation measures
Tech. Forecast
Labour Market Forecast
Market Forecast
Financial Forecast
Internal Capabilities Forecast
organisation
material
Company Objectives
Organisation Plan
Manning Plan
Employment
recruitment
selection
placement
Individual Development
- promotion
- transfer
- development assignments
- establishing performance objectives and measures
- counselling
- other training and development
Internal Manpower Inventory
- personnel data
- performance
- potential
- skills
- career plans
- career goals
Individual and Organisational Performance
Appraisal - organisational and individual
- results or output versus objectives
- external conditions affecting results
- quality of objectives
Analysis - organisational and individual
- causes of results
- strengths
- weaknesses
- implications
Individual output
- need fulfilment
- satisfaction
- motivation
Organisational output
- productivity
INPUTS
OUTPUT
* adapted from concepts of O'Donnell and H. Schuster

feedback simultaneously Nevertheless for conceptualisation purposes, it is useful to think of the personnel or the human resouces management system as one discrete, continuous, closed-loop cycle. The company objectives are laid down on the basis of feedback of previous planning, technological market, financial, industrial relations and labour market forecasts as well as the forecast of what the company is capable of doing in terms of both material and human resources. These objectives would comprise of the total performance goals of the organisation for the next performance cycle, say one year or any other time span. The statement of company objectives will be the single major input into the personnel management sub-system. Notice how the existing isolation of company objectives as showa in Diagram 1 is remedied by its inclusion as an input in the closed-loop system in Diagram 2.

The Organisation Plan

The organisation plan will be based on these overall objectives. The plans will consist of statements of action which must be taken by the personnel department in order that the company objectives may be fully met. Such action will be principally of two varieties :

(i) manning of the organisation and

(ii) modifying the internal environment within which the organisation performs.

Manning, Manpower Inventory and Employment

Let us take the first part : the organisation plan on manpower required is combined with the inventory of internal manpower resources to produce the manning plan for the organisation. To do this, the inventory of internal manpower and the statement of manpower requirements must be specifically defined in terms of skill, training, accepted performance level and other requirements These two manpower statements, namely, needs and inventory are matched together so as to determine the manning plan which can be met by current manpower after specific training and development as also by employing new manpower. It will be seen from the diagram, that the employment subsystem comprises of the sub-systems of recruitment, selection and placement and that the performance of these sub-systems provides :

feedback to manpower inventory—an inventory which must be updated and expanded to reflect the new manpower resources employed and input to individual development.

Modifying Environment

Diagram 2 indicates that the environment modification system would consist of various sub-systems such as organisational development, change in organisational climate, change in the managerial style of the organisation and of individual managers in order to produce conditions favourable for improving

individual performance,

organisational structure,

policies and procedures,

wage and salary administration and reward systems,

communication system—formal and informal as well as upward and downward,

the industrial relations system, and

social obligation measures.

According to a system's view of human resources management all plans and action for the environment modification sub-system would be determined in relation to each other in order to ensure internal consistency and avoid overlap or conflict. Above all, any activity in a sub-system would be inappropriate unless it can be demonstrated to be related directly to and functionally for the accomplishment of company objectives. In other words, the organisation should not embark on the luxury of changing programmes of improving style or revising structures, merely because it is fashionable. For example, the benefit sub-system should be changed only if it can be shown that the changes will result in a better functioning of the system and will contribute to the accomplishment of company objectives.

Individual Development

It will be seen in the diagram that the modification of environment system is operating concurrently with the individual development system. This is so because the former focuses on developing the environment within which the individual will function and the latter system focuses on developing the individual himself. Such development would consist of promotion, transfer, development assignment, establishing individual performance objectives, counselling, formal training and development.

Output

As a consequence to the cycle of performance, the organisation *performs*, resulting in two types of output. The organisational output of productivity consists of goods or services produced, whereas the individual output consists of needs fulfilled, satisfactions and motivation for the future cycles of performance. The levels of these two outputs will vary, depending upon the efficiency of functioning of the system.

Appraisal

According to the systems view, the management process is not complete unless there is a performance feedback which can be used for control and analysis or self-regulation. The feedback from individual and organisational output thus flows into the appraisal system and then to the analysis system shown in the diagram. It may be recalled that we started off with the establishment of company objectives as part of the total management system. A comparison is now made between the objectives and results as the first step in organisational appraisal. Within the individual development system, personnel performance objectives and measures were also established for each individual These are matched with individual appraisals in the appraisal system called the preliminary appraisal. It is further modified to take into account both external conditions which affected the results—such as unforeseen circumstances, unrest or sudden market changes—and subjective judgement of the quality of the original objectives, thus leading to a final appraisal of both organisational and individual performance.

Analysis

This final appraisal of the organisation and the individual now become inputs to the analysis system. This system evaluates the causes of results, and spotlights and assesses the strengths and weaknesses of both the

organisation and the individual. Implications of the strengths and problems are thereby brought out. The output of the analysis system will now become the feedback to both manpower inventory and internal capability forecasts. Thus, the appraisal and analysis of results becomes a kind of self-control mechanism for the human resources system, since it leads to modification of the manpower inventory and the internal capability forecast for the next cycle of company planning. For example, results of the appraisal and analysis will show that some individuals are now having new skills that they did not have before and this information is added to the manpower inventory. Some individuals will appear to have fewer skills than had been presumed and the manpower inventory will also be updated to reflect this information. The results of appraisal and analysis will thus change the forecast of capabilities of the organisation for the second cycle of performance.

Results

What does this all lead to ? In an ideal situation, each planning performance and feedback cycle of this personnel or human resources sub-system will find the output and the capabilities of the organisation increased. The goal that we desire is that every cycle of performance will find productivity at a higher level both for the organisation and for the individual. Similarly one would desire that each appraisal and analysis will reflect an improved manpower inventory and a higher level of internal capability, thus making it possible for having more challenging and more demanding company objectives. It will be appreciated that this conceptual framework will be of greater use in visualising the inter-relationship of separate functions or sub-systems and in determining a logical sequence for their planning and modification.

Closed-loop Feedback

This human resources management system will, therefore, provide a closed-loop feedback helpful in evaluating separate sub-systems and programmes in terms of :

> Consistency with other sub-systems of human resources management process and degree to which they flow directly from and support overall company objectives.

One of the most tangible results which would flow out of the systems approach is that the personnel manager would begin to think of himself not as head of a separate and independent function but as a participant in a sub-system of a large total management system. He and his colleagues will start asking the following questions :

> Do all my activities and programmes meld optimally with the activities and programmes in other sub-systems, to optimise the functioning of the total system, instead of : do my activities and programmes conform with the latest thinking in personnel management and are they sufficiently extensive ?

> Do all the activities and programmes of my sub-system flow directly out of, relate to and support the basic objectives of the company ?

> Does my sub-system contribute exactly what is expected of it in the organisational plans of the human resources management system ?

Such questions about programmes and activities of the personnel management system would also help in planning new programmes and evaluating old ones on the basis of their pertinence to the total system. Thus the personnel manager takes on the role of a meaningful change agent. For, by better understanding the human resources management system he should be in a much better position to make changes in it. He would also be contributing to the true basic objective of developing the individual.

Ray of Hope

In the steel industry in India, we have tried an experiment in bi-partite negotiations which augurs well for industrial peace and productivity. Great expectations spring from democratic participation. But the steel industry was not satisfied by merely setting up joint councils and joint committees in its plants. During a period of shuttlecock diplomacy when it was convenient for employers to explain away poor performance as due to inter-union rivalry, and unions countered with an attack on managerial inefficiency, this industry, with great foresight set up in 1969 the Joint Wage Negotiating Committee, now known as the Joint Negotiating Committee (JNC) for the steel industry. With its 19 members representing so many apparently conflicting interests and ideologies, had the continuance of its existence been left to an opinion poll or a scholarly forecast, the JNC idea would have been aborted promptly on grounds of impracticality due to the traditional bogey of inter-union rivalry. Some wag chose to call it a cabinet of blood enemies. Credit must go to many workers and management representatives for doggedly pursuing this concept and insisting on setting up this bi-partite committee against the advice of prophets of gloom. The wage board or tri-partite machinery recommended by some experts was stoutly resisted as it was rightly felt that this would mean holding the wrong end of three seperate sticks, each trying to hit the other. There were difficulties aplenty in the beginning. But the success achieved by this committee in so short a period in arriving at comprehensive industry-wide agreement is now a broad silverlining on the hitherto gloomy horizon of industrial relations in India. Even the honest critic of this Committee from within the industry now begins to feel a shade uncomfortable—like the sceptic at a seance, he wonders if his scepticism may not itself obstruct the flow of ectoplasm.

Institutions such as these are delicate *rara avis* which need to be nurtured and encouraged during their formative years. This was done in ample measure by the late Shri S. Mohan Kumaramangalam, Union Minister of Steel and Mines, who went beyond the traditional role of making formal appearances at Committee inaugurations and valedictions. When workers' participation was still in the slogan stage, he gave prime status to this joint body, associated himself actively with its deliberations and using it as a sounding board and a national advisory council for the steel industry as a whole. In February 1973 he took a bold step by requesting the Joint Negotiating Committee to set the national target for steel production in each unit in 1973-74, instead of the management or the ministry doing it unilaterally as hitherto. The Joint Negotiating Committee, strong in its belief that workers' participation begins at the grass-roots level,

arranged for setting of targets to be done jointly with workers and management, as a chain reaction commencing right from the sectional level on the shop-floor in each steel plant and culminating with their integration at the level of the Committee. The task was completed by the Committee by the middle of March. It may be argued, that the gap between expectations and outcome is very wide ; that the targets fall short of installed capacity. True, our past failings have been many, and we have to cope with the residue of several decades of public doubt. But this is the first time in the history of Indian industry that workers and managers in different units have integrated from the shop-floor upto the apex level in jointly setting goals for a major sector of the economy.

We have to beware of the euphoria created by revolutionary processes or new developments which carry many people beyond what has actually been proved or found to be practical. This often results in discarding many proven techniques because of their age. Hence, while expounding on this breakthrough of bi-partite participation I do not wish to devalue the efficacy of a very old recipe without which any other exercise would be as futile as stitching a coat without thread. I would commend consistency in style arising from reasonable continuity in management ; prompt and predictable decisions ; and management by objectives rather than management by manipulation. Those that have broken these tenets have suffered with unerring consistency. Nothing illustrates man's weird state of walking backwards into the future more than the way he refuses to learn from experience. We try to invent the wheel again and again and break our knuckles in the process.

In the fields of industrial relations and productivity, as, elsewhere, the future is bound to contain morbid extensions of the forces that now can be seen to work. There is unlikely to be a shortage of men with grievances in the nineteen seventies and eighties. A long genius sitting at the apex of the corporate pyramid cannot counter them with potions of instant peace ; nor do the forces divide themselves conveniently into black and white for the traditional confrontation between evil and good. There are several shades of grey which may confuse and confound him. Heirarchical authority and the spirit of do-it-my-way is the openly identified villain in the saga of progress. When the halucinations of power have evaporated, we will find man's ability to cope with endemic ferment and accelerating change will depend entirely on his willingness to harness the energies and acumen of fellow human beings. We in the steel industry in India would say, we are doing it. It's worth a try. □

Productivity and Industrial Relations

V. G. Gopal*

In the task of national development, it is imperative that all concerned parties--government, employers, trade unions and consumers- should identify their respective obligations. In this paper the author has reflected the thinking of INTUC, the premier trade union organisation in the country, on what should be the obligations of these parties in creating the necessary climate conducive both to productivity and industrial relations.

THE Indian National Trade Union Congress (INTUC) is the largest national trade unions center in India, with a membership of a little over two million. This largest trade union organisation has all along recognised this fact that only by maintenance of industrial harmony and productivity, the industry, labour and the community can prosper. In a highly competitive world market of today, the quality and the price of the products determine its sale. To a developing country like India, which is confronted with multifarious problems such as language, illiteracy, populations, unemployment and pull by various political parties, there is no easy solution for attaining the objective of transforming a nation where 30% of its population live below the poverty line and the rest of the majority at only subsistence level into an affluent society within a short span of period. Even if the labour contributed its maximum for increase in productivity, there are other agencies which have to make a matching contribution if not more, to make the productivity drive a success. Amongst these the three most important agencies are : (1) Government, (2) Employers and (3) Consumers. We expect from these three agencies and the Trade Unions the following steps to be taken if the productivity drive and a high level of industrial harmony have to be achieved.

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I. Government's Obligations

(1) The Government must associate the Representatives of the Trade Unions in all its planning forums. The Association should be real and start from the very beginning, that is from the discussion stage itself.

(2) There should not be frequent and uncalled for interference by the Govt. in the internal matters of Trade Unions and also in the Management-union relations. The

collective bargaining system should be encouraged.

(3) Take measures to check the erosion of the real wages of the workers mostly caused by inflation.

(4) Ensure to the labour, civic amenities such as housing, medical care, educational facilities for the children of the workers, recreational facilities etc.

(5) Set up vocational and technical training institutions for the workers to be administered jointly by the Govt., Trade Union and employers' representatives.

(6) Set up, in conjunction with the Trade Unions, research institution to study : (a) productivity requirements (b) safety requirements and the proper environmental requirements at the plant level.

(7) Ensure management sharing the gains of productivity with the workers and consumers and since workers are also consumers, they should receive higher percentage in the share.

(8) Ensure full employment, because unemployment is one of the major causes for low wage rates and political unrest in the country.

II. Employers' Obligations

(1) The employers should treat the labour as equal partners in the industry. The labour should be fully consulted and agreement reached in all matters where management desired to make any alternatives in the service condition of the workmen.

(2) To make the productivity drive a success employers should discuss all technological and environmental problems, working conditions etc. with the representatives of the labour. For this purpose joint management councils could be set up.

(3) There should be frequent joint consultations in the matter of safety, welfare, safety appliances, canteen management etc. and joint committee with equal representatives for each side could be set up to achieve these purposes.

(4) Motivation is a very important factor for increased productivity. One of the various motivations given is incentive/production bonus scheme. Agreed incentive/production bonus scheme should be introduced. Work-norms must be a subject matter of prior discussion between union and management and once agreed, the same should not be unilaterally changed.

(5) Incentive bonus/production bonus schemes when introduced should not :

(a) result in retrenchment in the name of overproduction.

(b) curtailment in wage rates and

(c) increase in the workload

(6) If any workman becomes surplus as a result of rearrangement of jobs or due to technological change, such a surplus hand should not be retrenched and his total income should be protected till he is absorbed in a regular job where he is ensured of the same earnings. If necessary he is to be given necessary re-training facilities.

(7) No incentive bonus can work satisfactorily if the employer does not ensure regular flow of raw materials, maintain equipments in proper shape and keep pace with

rapidly changing technological and production methods.

(8) Employers with the concurrence of unions should formulate and set up a grievance procedure for quick and expeditious disposal of workers' grievances.

(9) There should be an agreed promotion procedure for the workers. Subject to other things being equal, promotions within the organisation should be on the basis of seniority.

(10) Lastly, one of the most important points for good industrial relations is to implement faithfully all agreements and statutory requirements.

Trade Unions' Obligations

(1) Trade Unions should offer their active co-operation to the Government and Industries in the productivity drive and not merely give its lip service.

(2) Organise classes, lectures, symposia, seminars for members, shop stewards and union executives to explain and determine productivity techniques and make them productivity conscious.

(3) Faithfully discharge its obligations in the matter of implementation of agreements.

IV. Consumers' Obligations

The consumer plays an important role in boosting the productivity drive : By refusing to buy sub-standard goods or services and resisting arbitrary price increases by employers/entrepreneurs, the consumer forces the industry to keep the productivity at a near-optimum level in order to survive in the public sector and public services too. The people, through the parliament, should exercise a control over this effective functioning. □

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