SYMPOSIUM ON INVENTORY AND STORAGE PROBLEMS IN FOOD-GRAINS AND OTHER AGRICULTURAL PRODUCTS

Chairman : DR. R. D. NARAIN[1]
Convener : SHRI S. D. BOKIL[2]

The symposium was held during 32nd Annual Conference of the Society on 22nd December, 1978. It was presided over by Dr. R.D. Narain, Director, Statistics Division, F.A.O., Rome. In his opening remarks, Dr. Narain observed that the problems of storage and disposal of agricultural commodities needed urgent attention, especially in developing countries. In these countries the productivity of agriculture was comparatively low and with the mounting pressure of population, scarcity of agriculture products was a frequent occurrence. In the context of foodgrains this led to malnutrition and even starvation. The F.A.O. was aware of these problems and had been laying great emphasis on the development of post-harvest technology in these countries. This depended to a great extent on research in this field which should be undertaken by statisticians, economists and post-harvest technologists in collaboration. He congratulated the Society on choosing such an important subject for the symposium at this Annual Conference. He was a little disappointed that not many contributions had been received. However, he felt that it was important that this gathering of statisticians and other research workers become aware of problems and directed their researches to this field. He then invited the participants to present their papers. The extended summaries of the papers are given below.

Optimum Inter-State Movements and Storage of Wheat

By S. L. KUMBHARE[3] AND A. S. SIROHI[4]

In the present study, an attempt has been made to assess the optimum (peak) storage requirements of wheat and to work out the

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inter-state movements involved in the transitory phase of getting the optimum storage quantities. Data on procurement and distribution of wheat through Public Distribution System, inter-state movements, cost of storage and transportation were collected from various secondary sources. Multi-period linear programming model was used, in which the year November, 1979 to October, 1980 was taken as the planning period while each month constituted a decision period. The objective function of the model was to minimise the sum of the cost of transportation and storage subject to the existing available railway transportation capacity and the quantity balancing constraints.

The Model

The variables and constants used in the model had three specific subscripts. Subscripts i and j respectively denote the surplus and deficit states. Subscript t denotes the time period. The following variables and constants were used in the model:

x_{ijt} denotes the quantity of wheat transported from ith to jth state in tth period. The first subscript $i = 1, 2, \ldots\ldots, 5$; $j = 6, 7, \ldots\ldots, 19$ and $t = 1, 2, \ldots\ldots, 12$.

s_{it} and s_{jt} denote the quantity of wheat stored in ith and jth state respectively at the end of tth period.

c_{ijt} is the cost of transportation of a unit of wheat from ith (surplus) state to jth (deficit) state in time period t.

y_{it} and y_{jt} are the cost of storagh of a unit of wheat in ith and jth state respectively for tth period (month).

p_{it} and p_{jt}[2] refers to procurement in ith and jth state respectively during tth period.

n_{it} and n_{jt} refers to distribution requirements of wheat in ith and jth state respectively during the tth period.

z_{it} refers to imports of wheat at Bombay port during the tth preiod.

m_{ijt} denotes the maximum limit for movement of wheat from ith to jth state in the tth period.

$\sum_j m_{ijt}$ denotes the upper limit for total movement of wheat from ith state to all the jth states during the tth period.

$$\text{Minimize, } Z = \sum_{i=1}^{5} \sum_{j=6}^{19} \sum_{t=1}^{12} c_{ijt} X_{ijt} + \sum_{i=1}^{5} \sum_{t=1}^{12} y_{it} S_{it} + \sum_{j=6}^{19} \sum_{t=1}^{12} y_{jt} S_{jt} \qquad \ldots(1.1)$$

Subject to :

$$S_{it}-S_{it-1}+\sum_{j=6}^{19}X_{ijt}=P_{it}-n_{it} \qquad ...(1.2)$$

$$S_{jt}-S_{jt-1}-\sum_{i=1}^{5}X_{ijt}=p_{jt}-n_{jt} \qquad ...(1.3)$$

$$S_{5t}-S_{5t-1}+\sum_{j=6}^{19}X_{5jt}=z_{5t} \qquad ...(1.4)$$

$$\sum_{i=1}^{3}X_{ijt} \leqslant \sum_{i=1}^{3}m_{ijt} \qquad ...(1.5)$$

$$\sum_{i=1}^{3}\sum_{j=6}^{19}X_{ijt} \leqslant \sum_{i=1}^{3}\sum_{j=6}^{19}m_{ijt} \qquad ...(1.6)^{iii}$$

$X_{ijt} \geqslant 0$, $S_{it} \geqslant 0$, $S_{jt} \geqslant 0$ for all i, j and t.

Note. (*i*) State's numbers are: 1. Punjab, 2. Haryana, 3. Uttar Pradesh, 4. Madhya Pradesh, 5. Bombay port, 6. Bihar, 7. Assam, 8. Gujarat, 9. Karnataka, 10. Maharashtra, 11. Tamil Nadu, 12. West Bengal, 13. Delhi, 14. Jammu-Kashmir, 15. Kerala, 16. Andhra Pradesh, 17. Rajasthan, 18. Himachal Pradesh, 19. Orissa.

(*ii*) For estimation purposes, for the country as a whole, it was assumed that the procurement plus marginal imports were equal to the distribution requirements for the reference year. Expected aggregate procurement was apportioned among the states based on their relative share in aggregate procurement for the past three years (1971-72 to 1974-75 except for the year of nationalisation of wholesale wheat trade). Imports were envisaged to bridge the gap between the estimates of aggregate conssumption requirements and production. The coverage and distribution requirement of wheat through PDS were calculated considering recommendations of the National Commission on Agriculture in this regard.

(*iii*) Constraints (1.2), (1.3) and (1.4) are the quantity balancing constraints for surplus, deficit state and Bombay port respectively. Constraints (1.5) and (1.6) are upper bounds for movements.

The magnitude of inter-state movements depends upon the initial stocks, and therefore, optimum plans were prepared at varying levels of initial stocks. It was observed that some minimum level of initial stock was required for the feasibility of the program-

ming solution. The four levels of initial stock which were studied in depth were designated as levels, I, II, III and IV denoting 5.6, 8, 9.6 and 12 million tonnes of wheat stock in the country. Statewise initial stock quantity was assumed to be in proportion to the storage capacity in each state available with Food Corporation of India in 1975.

Results and Discussion

The results revealed that optimum storage space requirements closely followed the trends in initial stocks. Aggregate peak storage requirement of wheat increased from 7.3 to 13.7 million tonnes when the level of initial stock was increased from 5.6 to 12 million tonnes. Further, the analysis revealed that surplus states need increased storage facilities in the states themselves to minimise the transportation and storage costs. The results also revealed that if temporary storage facilities are to be created by the Central Procurement Authorities, then June-July should be considered as peak months in wheat surplus states. Aggregate peak storage requirement coincided with the peak procurement season.

The magnitude of inter-state movements involved in the transitory phase of getting the optimum storage quantities, declined from 3.07 to 1.07 million tonnes when the aggregate initial stock level was increased from 5.6 to 12 million tonnes. Considerable part of procured grains from Punjab had to be stored in Punjab itself to acquire the optimum storage pattern. Haryana needed to supply the largest portion of its supplies to Delhi followed by Gujarat. Uttar Pradesh needed to supply considerable portion of its supplies to Bihar whereas Bombay port confined its supplies to Maharashtra and Karnataka.

Average cost per tonne of wheat movement decreased with an increase in the size of initial stock whereas the storage cost increased from Rs. 3.95 to Rs. 4.30. The analysis was also carried out after relaxing the upper limits on movement activities. Temporal and marginal spatial reallocation of wheat supplies took place as a result of exclusion of movement constraints. At low level of initial stocks relaxation of transportation constraints resulted in reduction in the average cost per tonne of movement.

Storage Losses of Foodgrains in India—A Review*

By V.T. Raju[5]

Storage of farm commodities is an important activity as it protects commodities from deterioration, adjust the production and consumption, stabilizes prices, etc. However, proper storage requires adequate facilities and protection which may be costly to provide. If the storage facilities and practices are inadequate, then losses in quality and quantity will reduce the value of the product stored. In India, a major portion of the food grain production is stored on the farm itself and not enough is known about extent and types of foodgrain losses at the farms. As the subsequent literature review is showing there are hardly any studies about storage of ICRISAT's foodgrains, *i.e.*, sorghum, pearl millet, pigeonpea, chickpea and groundnut. In an attempt to get an idea of storage losses and their variation across commodities, regions and structures, 25 studies were reviewed. Among these studies 18 were about on-farm storage losses and the remaining were related to storage off-farm. Most of the studies estimated storage losses commoditywise ; and the commodity most frequently studied was wheat followed by paddy. These studies primarily concentrated on Uttar Pradesh followed by Punjab and Andhra Pradesh. With the exception of a few, most studies reported losses also structurewise and at different periods in time. The causes for the losses reported in these studies were mainly insects followed by rodents. Losses due to moisture, moulds etc. were not studied.

The studies reviewed revealed a variety of methods and approaches for estimating storage losses, although some have not specified the methodologies adopted. The methods reported range from best estimates based on the information from farmers or traders on storage losses to representative sampling and detailed measuring at regular intervals. A number of workers have suggested different formulae for deriving estimates of storage loss. Though different formulae were suggested with different notations, examination of all formulae amounts to more or less same. As an example one formula is specified below :

$$LP = IP\frac{(UK-IK-K)}{UK}$$

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* Abstract of the paper presented at the 32nd Annual Conference of the Indian Society of Agricultural Statistics held at the Punjab Agricultural University, Ludhiana on 21-23 December, 1978.

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where LP=actual percentage loss in weight
IP=pecent infestation
UK=weight of equal number of uninfested kernels
IK=weight of equal number of infested kernels
K=weight of kernels from equal number of infested kernels that would yield no flour.

Some formula specified infested kernels as weeviled, germeaten, etc. and used different notations for them. All the formulae used are limited for quantitative (weight) loss estimation only, that too due to insect infestation. Moreover, these formulae assume that all kernels are equal in weight and they do not take into account different stages of insects that may be present in the kernels and of frass and dead bodies.

The estimates of storage losses reported by different studies, reviewed in this paper are summarised as follows. The storage losses vary from commodity to commodity, from area to area and depending upon the type of storage structure used and the period of storage. For wheat the estimates varied from 0.1% to 9.92%, for paddy from 0.03 to 9.26%, for jowar from 1% to 4.64%, for maize from 0.35% to 9.84%, for gram from 0.11% to 5%, for mong (green gram) from 0.41% to 1.74%, for urid (blackgram) from 0.26% to 2.07% and for peas from 0.73% to 12.84%. The above estimates seem to indicate that storage losses in the case of cereals are higher than in the case of pulses and among cereals the losses would appear quite similar. However, the research on storage reported for ICRISAT's crops is not sufficient to allow any conclusions, especially in view of considerable ranges in the estimates of storage losses reported in Table 1. One of the factors contributing to the wide range of estimates might be the lack of an adequate methodology for reliable estimates of the grain loss in storage. Standard methodologies for estimating storage losses for cereals and for pulses should be established. These methodologies should include estimates of quality changes, *e.g.* losses due to mouldiness developing in storage (price discounts) and gains due to seasoning (price premium). Another problem requiring attention is that of determining how the losses occurred could be economically avoided. There was only one team of authors who had paid attention to the costs and benefits of improved grain stores and they found that the storage losses of paddy of less than 5% could economically be reduced to about 3% by improving traditional stores. Reduction of farm storage losses to 1% or less with the help of steel bins was not economical. ICRISAT is planning to take these aspects into consideration when conducting storage studies of selected cereals and pulses at the farm level.

A Study of the Storage Facilities, Practices and Problems in Cereals in Delhi State

By S.K. Raheja[6] and P.C. Mehrotra[7]

The farm level storage problems in foodgrains were studied with the help of data collected under the project Pilot sample survey to study the impact of new technology on crop production, its disposal and employment in agriculture in Delhi State'. The crops covered during the survey were bajra in *kharif* and wheat in *rabi* which are the main crops in this State. The different aspects on storage studied were (*i*) quantity and purpose of storage, (*ii*) type of structure/ container used for storage and their adequacy, (*iii*) constraints and difficulties in possession of improved storage facilities, (*iv*) nature and extent of protective measures adopted in storage. In order to examine whether these factors are in any way associated with the size of holding, the sampled holdings were categorised into five size classes according to the cultivated area in the holding. The classes were, very small (less than 1 hectare), small (1-2 hectares), medium (2-4 hectares), large (4-8 hectares) and very large (8 hectares and above).

It was observed that of the total production of bajra and wheat crops, nearly 60 per cent was stored by farmers for various purposes like self consumption, seed and later disposal. The proportion of grain production kept for storage showed a declining trend with increase in the holding size, although the quantity stored was positively associated with the size of the holding. Storage structures like pucca room or kotha were available mainly with large holdingss of 8 hectares and above. Use of metallic containers was also reported mainly from large holdings. Most of the cultivators in the small and medium holding size categories stored ther grain by the conventional method like gunny bags etc.

As many as 80 per cent of the cultivators canvassed were not satisfied with their existing storage facilities and were keen to change over to improved methods of storage. The main problems with existing storage were susceptibility to rodent attack, insect infestation on account of moisture and short life or temporary nature of the storage like bags or thekka. A sizeable number of cultivators were in favour of having metallic containers and pucca storage shed. However, the main difficulty in the way of this change was lack of funds, non-availability of desired type of container and, in some cases, unawareness about improved facilities of storage. Protective measures during storage were adopted by a majoriry of medium and large

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holdings while in the small holdings the frequency of such cultivators was relatively small. The main reasons for not adopting protective measures were high cost of chemicals as also lack of knowledge in the use of such measures. There is thus a need to augment the production machinery to ensure that appropriate and improved storage facilities like metallic bins, pusa bins etc. are available to meet the storage needs of farmers in different holding size classes. Also the extension effort would have to be strengthened to educate the farmers in proper storage as well as in adopting suitable protective measures to minimise the grain losses in storage.

Discussion and recommendations

There was a lively discussion on the various technical aspects of the papers presented. Many useful suggestions were made by various participants. The chairman observed that it was not enough to hold discussion on the subject but the conference might make some specific suggestions for the consideration of Government and various research agencies. The following recommendations were made :

1. The problem of post-harvest losses is very important and efforts should be made to develop suitably methodology for estimation of the losses of agricultural products at various stages during their flow from the producer to the consumer.
2. The problems of storage should receive particular attention as this is a stage in which losses are likely to be appreciable and also because they could be prevented by improvements in the method of storage. Studies may be conducted to find out the types of storage used by cultivators, traders and Government agencies for storage of various products and to estimate the magnitude of losses in different types of storages.
3. The perishable commodities like fruits and vegetables present problems considerably different from those presented by durables like foodgrains. In their case it is necessary to study the seasonality of supply, its effect on prices and storage needs of producer and traders. The needs of cold storage and food processing industry may be considered in this connection to ensure efficient utilisation of the production of those crops and to reduce the wastage to the minimum.

The Chairman called upon all the participants to bring these recommendations to the notice of the authorities concerned.