CHAPTER I

I N T R O D U C T I O N

Fertilizer is defined as any material, organic or inorganic, natural or synthetic, which supplies one or more of the chemical elements required for plant growth. There are sixteen essential elements for plant growth, of which nine are required in macro and seven in micro quantities. Chemical fertilizers, being synthetic in nature, normally provide the primary nutrients, viz. nitrogen, phosphorous and potassium to the plants.

1.1 Fertilizer Use in India

Use of chemical fertilizers is an essential component of modern agricultural farming all over the world. In India, in the period of 1970 to 1983 (April to March), the average rate of growth of consumption (over the previous year) of commercial fertilizers was 9.83 per cent, whereas the average rate of increase of gross sown area (over the previous year) was 0.675 per cent (45), indicating a positive increase in consumption per unit of sown land and consequently the acceptance of its utility in crop growth by the farmers. The total consumption of nitrogen, phosphorous and potassium based fertilizers per hectares of arable land in India (Table 1.1) has been quite reasonable compared to other continents in the world for the year 1980-81 and 1981-82 (42). The Government of India announced

Table 1.1 Fertilizer consumption in the World.

Country	Consumption, kg per Hectare of arable land *							
	1980-81				1981-82			
	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total
India	20.8	6.5	3.7	30.9	22.9	6.9	4.0	33.8
Africa	10.1	6.2	2.2	18.4	10.3	6.8	2.4	19.5
North & Central America	47.9	22.0	23.6	93.5	46.6	20.4	21.3	88.4
South America	11.4	18.6	11.8	41.9	8.4	11.7	6.8	26.9
Asia	46.7	11.8	5.4	66.9	47.0	15.4	4.1	68.5
Europe	101.3	60.5	59.6	221.3	102.9	59.6	62.5	225.0
USSR	35.6	24.1	21.1	80.9	36.1	25.3	21.1	82.6
Ocenia	6.1	26.2	4.9	37.2	6.5	25.7	5.7	38.0
World Total	41.5	21.7	16.7	79.9	41.2	21.1	16.3	78.5

* Arable land includes land under temporary crop (double cropped areas counted once), temporary medows or pastures land under market and kitchen garden land, temporary fallow or lying idle as also land under permanent crops.

a reduction of 7.5 percent in prices of fertilizers with effect from 29th June 1983 in order to promote further wide scale use of chemical fertilizer by the farmers.

1.2 Fertilizer Production in India

Fertilizer production in the country by various manufacturing plants still lag behind the consumption pattern forcing the Government to import significant quantity of finished product. The quantum of import is further increased as the technology of production of few varieties of fertilizers have still not been accepted by the industry due to various reasons. The quantum of fertilizer imported yearwise is shown in Table 1.2. It is seen that on an average, 42.78 per cent of fertilizer consumed had to be imported by the country.

Table 1.2 Import of fertilizer by India (45)

Year	Total import (in tonnes)	%age of consumption	Year	Total import (in tonnes)	%age of consumption
1971-72	997	37.52	1972-73	1194	43.14
1973-74	1242	43.75	1974-75	1607	62.45
1975-76	1635	56.5	1976-77	1050.7	30.8
1977-78	1520.9	35.49	1978-79	1994	38.97
1979-80	2005.6	38.16	1980-81	2769	50.2
1981-82	2042.1	33.66			

The physical form of commercial fertilizers assumes great importance both agronomically and for satisfactory handling, transport, storage and application techniques. Most of the practical problems encountered; as caking, poor flowability,

segregation, hygroscopicity and dustiness can be attributed to undesirable properties. Good physical appearance contributes to some extent to the consumer satisfaction. Through visual observation an experienced farmer would look forward to a material which can be conveniently applied in the field with less expense.

Although the Indian Standard Institute and the Fertilizer Control Order of the Government of India lays down some standards for chemical composition of a fertilizer, very few physical properties are governed in commerce by laws or standard practice. As a result, the physical condition of a product is mostly the choice of the manufacturer.

1.3 Fertilizer Distribution and Handling

The deterioration of physical properties of fertilizers is further aggravated by unscientific techniques of handling and a long chain of distribution network (Fig. 1.1 and 1.2). Around 3000 blocks (each block covering around 120 villages) in the country have railheads while another 2000 blocks are served by road transport. Manual handling of fertilizer bags by using hooks, improper protection from atmospheric conditions during transit and storage, inadequate technical knowledge of the personnel involved in the above operations are few reasons for the deterioration in properties of the fertilizers. Coupled with these factors is the adverse

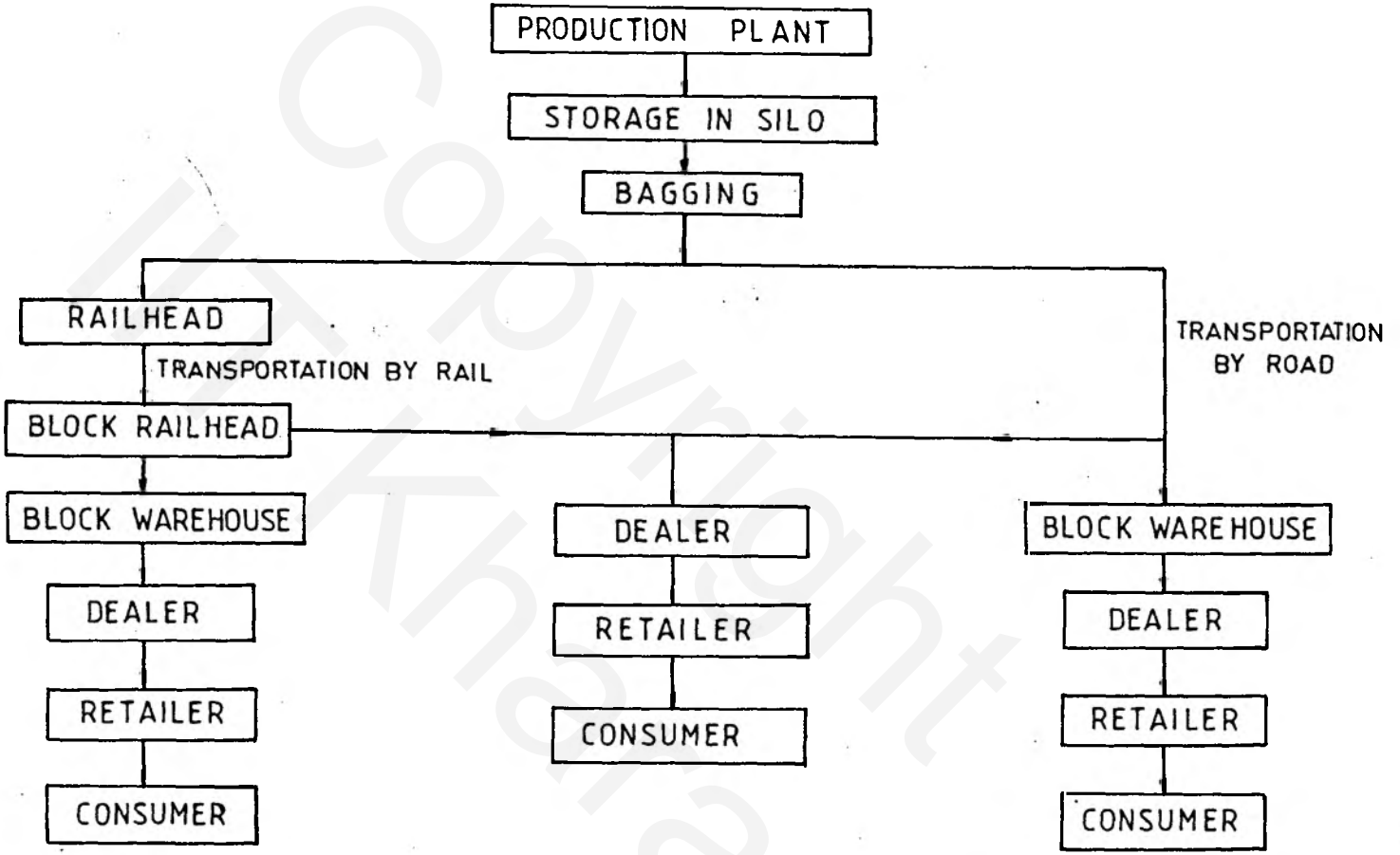

Fig.1.1. Flow diagram of distribution system of indegeniously manufactured fertilizers

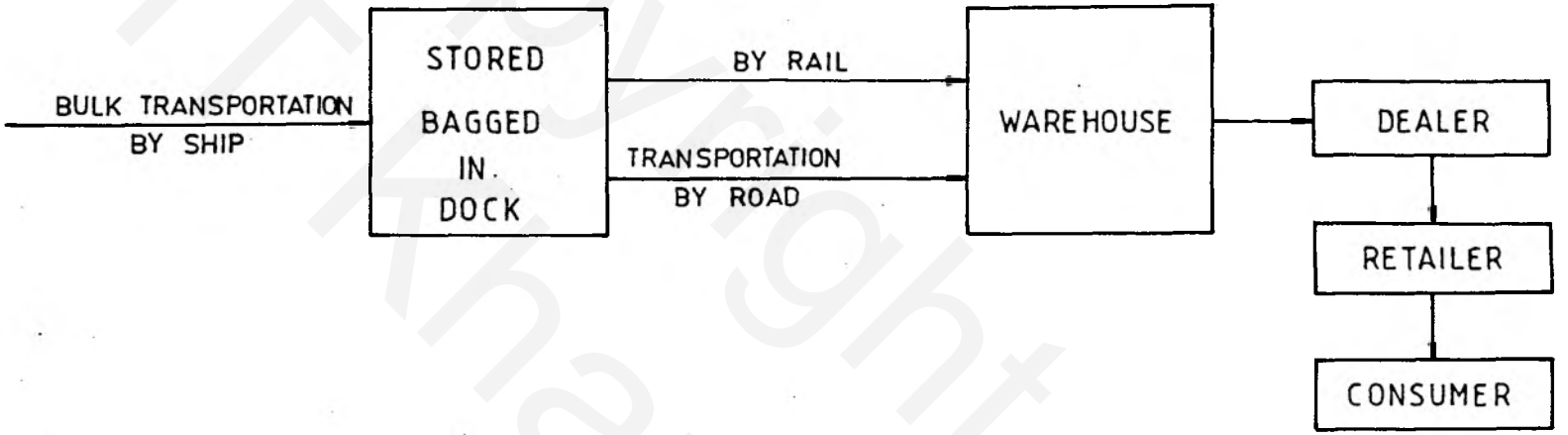

Fig.1.2. Flow diagram of distribution system of imported fertilizer

storage facilities available with the farmers who are compelled to maintain a minimum of buffer stock for ready availability of the material at the time of use. Thus it can be seen that although the manufacturers might take sufficient care to produce fertilizers of reasonably good quality, the actual benefit accrued by the consumer may turn out to be minimal.

1.4 Field Application of Fertilizer

Application of chemical fertilizers to the plants is achieved by various techniques. The most common methods of solid fertilizer application are either broadcasting over the surface or drilling under the soil surface. Application through irrigation water and foliar application is practised in the country in a very limited scale. The broadcasting of fertilizers is done either manually or by use of fertilizer spreader, the former being more commonly used. Drilling the material under the soil is normally accomplished by using fertilizer drills or by suitable attachment made to the country plough.

For mechanical solid fertilizer distributors, uniformity and easiness of discharge of predetermined quantity of fertilizer is of primary importance. Deviation from the above poses the problem of "concentrated fertilized areas" or "blank zones" leading to inefficient use of material and loss in its beneficial effect as both higher or lower concentration leads

to lower crop yield. The financial loss of the farmer assumes a higher dimension due to high cost of the fertilizer. Indirectly the impact on the national exchequer is also significant as the loss in crop yield is coupled with the loss in foreign exchange.

The various farm machinery used in the country for distribution of solid fertilizer in the field have still not attained high level of performance due to a number of interacting reasons. A major universal factor is the complex nature of behaviour of different fertilizers due to the variation in their physical/chemical properties in the range of operating conditions (temperature and humidity). The physical degeneration or amalgamation of the particles during transportation, distribution and storage of the materials (as discussed before) further aggravates the problem. Improper design of the application machinery, in some cases, also lead to severe operational difficulties. The above factors highlight the need of proper investigation of the flow characteristics of commercial fertilizers through the various components of the application machinery.

1.5 Scope of the Work and Objectives

In most of the fertilizer distributing systems, the material is stored in a hopper from which a steady discharge of metered quantity is desired to be extruded either through a controlled

outlet or a suitable metering mechanism. The fertilizer is then either broadcasted or discharged in the soil through a discharge pipe and furrow opener. Thus the material stored in the hopper has to travel through a long path before the same is put in the soil. Disturbance anywhere in the path would finally result in unsteady flow behaviour. Obviously, therefore, a steady rate of discharge of material is to be ensured from the hopper. Only then the suitable metering mechanism, following the hopper can offer uniform discharge at a predetermined rate. The hopper thus, is much more than a simple means of holding the material during field operation. Systematic studies of the flow behaviour of fertilizer under various environmental conditions are unfortunately not available to the extent that one can go ahead with the design of suitable hoppers and flow-aiders.

Storage of fertilizers, in bulk or in small quantities, in suitable hoppers are widely done by the manufacturing industries and different agencies involved in handling the finished product. On many occasions, though stringent requirement of accurate flow rate may not be required, steady gravity flow of the material from the hopper is a common service requirement. Sufficient information about the flow behaviour pattern of the fertilizers from hoppers is thus of prime importance for suitable designs to be accomplished.

In any flow control system, one may think of using an open-loop system by having a controller between the input and

output unit. Clearly such systems are not feedback control systems. An advantage of the closed-loop system is that the use of feedback makes the system response relatively insensitive to external disturbances. A closed-loop system, in general, requires a suitable and reliable measuring element which helps to determine the corrections to be applied in order to achieve the desired output. A complete feedback control system is expected to be much more complicated and not essentially reliable all the time. Keeping this in mind, it was decided to limit the scope of present studies to an open-loop system where hopper with fertilizer is treated as a plant.

The present studies were therefore, undertaken to determine the flow properties of selected fertilizer varieties and investigate theoretically and experimentally their relationship with the flow behavioural pattern of the materials under various boundary conditions.

The specific objectives of the studies reported may be listed as follows:

1. Selection of fertilizer varieties for the present studies,
2. evaluation of physical properties of the selected fertilizers in order to determine flow/no-flow criteria under gravity,
3. comparative evaluation of equations proposed by different authors with various conceptual approaches,

4. development of a suitable equation governing the flow of granular materials through hoppers under gravity,
5. determination of effectiveness of a flow-aider for otherwise non-flowing materials under gravity,
6. development of a generalized equation and determination of its bounds to help predict flow rate of granular materials through hoppers with and without flow-aider,
7. determination of power requirement of the flow-aider.

1.6 Summary

Consumption of chemical fertilizers in India has increased significantly in the period 1970 to 1983. In the present decade, the consumption rate per hectare of arable land has also been quite reasonable when compared with other continents in the world. As the production of fertilizer remained below the consumption rate, the Government of India had to import around 42.78 per cent of the material in order to meet the requirement.

The control on physical properties of fertilizers is not strictly governed by laws, as consequence of which the physical condition of a product is mostly the choice of the manufacturer. The various hazards during transit and storage deteriorates the physical form of fertilizers.

The performance of various farm machinery used in the country for distribution of solid fertilizer in field have not attained

high level of performance due to a number of interacting factors. One major factor is the complex behaviour of chemical fertilizers due to change in physical/chemical properties in varying atmospheric conditions.

During flow of fertilizer through a fertilizer distributor, a steady and uniform discharge rate is a must from the hopper for proper functioning of other systems of the machine. Similar flow behaviour under gravity through bulk storage system without serious obstruction is also of great importance to the concerned industries.

In view of the above assessment, studies were undertaken to determine the flow behaviour of selected fertilizer varieties and investigate theoretically and experimentally their relationship with the flow parameters of the materials under varying boundary conditions.