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International Fertilizer Industry Association - Secretariat: 28 rue Marbeuf - 75008 Paris - France
Tel. +33 1 53 93 05 00 - Fax +33 1 53 93 05 45/47 - ifa@fertilizer.org - www.fertilizer.org

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SOME DEVELOPMENTS IN STORAGE, HANDLING AND DISTRIBUTION OF COMPOUND FERTILISERS

A M MacLEOD BSc and J W BAYNHAM BSc PhD DIC

Scottish Agricultural Industries Limited, Edinburgh, Scotland.

1. INTRODUCTION

1.1 General

SAI occupies a unique position as a major fertiliser manufacturer with direct sale to the customer. The situation is explained by SAI originating in 1928 from a merger of companies which included both fertiliser and feed stuff manufacturers and merchants who bought and sold a very full range of agricultural products. This tradition has continued, and the Company today is heavily involved not only in the manufacture of fertilisers and feeding stuffs, but also in the purchase and sale of large quantities of farm produce. It is therefore involved to a very considerable extent in direct retail selling to the farmer, and has developed a close association in the market which enables it to be more sensitive to more detailed market demands and needs than is possible generally with many other major producers.

In considering the developments in handling of fertiliser by the manufacturer, the merchant and the farmer, this paper is based primarily on the developments made within our own Company over the past 25 years. It is not intended as a detailed technical study, nor indeed is it a complete survey of the industry, but it is hoped it will stimulate discussion on an important service area of the fertiliser industry. While we endeavour to trace the developments and the economics of improved methods of handling and distribution

within SAI, we also recognise that the distribution system – the organisation, the planning, the people – must also be developed in parallel with improved methods of handling so that the overall result is optimised in both economic and general terms.

1.2 Product Storage Properties

The handling, packing, storing and distributing of fertilisers must be and is dictated by some of the basic properties of the products themselves and it is these physical properties which provide the framework, and in many cases the basis, for much of the development that has taken place. For that reason a summary of the progression in products and their storage properties serves both as a useful and as a necessary introduction to the main theme of packing, handling and distribution.

The past 30 years have seen the fertiliser industry change from essentially a simple, manual mixing operation to a relatively highly sophisticated branch of the heavy chemical industry. With major changes occurring over such a relatively short period, the rate of development has varied significantly from country to country and indeed from manufacturer to manufacturer. Nevertheless, in general terms, in the early 1940's most fertiliser mixtures were based on single superphosphate, were non-granular and largely prepared at the time of use. The industry therefore was predominantly seasonal in its operations and as it grew and developed in size, all the inherent disadvantages of seasonal operations became increasingly emphasised. There seems little doubt that this factor was the principal incentive to a more serious consideration of the storage properties of the final products.

Granulating the variety of chemicals in the fertiliser mixtures began to be actively studied in the 40's and continues to be studied today. Understanding of the granulating systems developed through this period, and ultimately the necessity was appreciated for achieving a chemically stable mixture as well as particles of a desired size range and handling strength.

Nevertheless, it was not until the early 50's that it seemed possible to have some confidence in the storage properties of compound fertilisers such that product bagged or stored in bulk would remain free flowing as discrete granules for an acceptable period. This was achieved by recognising the need for significant drying of the granular material and in the case of superphosphate based products containing ammonium sulphate, as a general guide this required moistures in the final product of less than 1.0%.

However, simultaneously with these developments, changes were occurring in the fertiliser formulations as the desirability was recognised of higher concentrations to minimise overall costs, including those incurred in storage and handling. More and more ammonium phosphate either as mono- or di- was used in place of superphosphate and the subsequent drying process assumed even more importance. The methods of moisture analysis began to be discussed in detail since there was a need to establish accurate relativities in defining acceptable specifications for a wide range of products. In general it may be said that at this stage granular products based on ammonium phosphate and containing ammonium sulphate, required to be dried to moisture levels of about 0.5% to ensure free flowing characteristics in storage.

Continuing examination of methods of increasing concentration and effecting cost reductions resulted in greater use of ammonium nitrate and also urea as a supplementary source of nitrogen in compound fertilisers. This use of much more soluble constituents meant an even greater need to reduce the moisture content of the final product to ensure stability in storage. With this progression towards lower and lower moisture levels in products, other methods were examined of achieving products which would remain as discrete granules and free flowing, and the use of inert surface coating agents in addition to some drying, assumed importance. The exact balance between the levels of inert surface coating agents and the need for drying varied, and does vary, both within product ranges and between the major manufacturers and indeed many producers continue to

use coating agents on some of the less demanding products in order to reduce the requirement for drying.

Thus, with continuing changes in formulations, in raw materials and in constituents, significant developments have taken place in manufacturing standards in an attempt to establish acceptable storage properties. In addition, the definition of acceptable storage properties has also continued to change during the years with parallel developments going on in packaging, handling and distribution. In this respect, market demands and, perhaps more importantly, price structures within the industry, have put heavy demands on storage properties with in many cases the fertilisers being produced in the Spring of one year for sale in the second half of that year, but not being required for use until at least the Spring of the following year.

2. HANDLING AND DISTRIBUTION

In the early 50's SAI were the first Company to guarantee free flowing granular compound fertilisers. At that time handling and distribution systems were installed which depended on this property. Large quantities were stored in bulk and product was offered to customer either in bulk or in bags to lorry via high speed packing lines.

In the late 50's, two thirds of the sales took place in March, April and May and some 95% was supplied in bags direct to lorry; of the bulk element, a proportion was offered in 2 ton bulk containers. These were designed to be readily handled on and off road vehicles, and in addition to provide portable silo facilities at the farm. (Fig. 1)

In the mid 60's increasing sophistication of products associated with the introduction of ammonium nitrate based compounds was paralleled by the development of a distribution organisation designed to maximise the tonnage delivered direct from Works to farm. Palletised storage was progressively introduced throughout the Company and by increasing warehouse capacity for bagged material, packaging of finished product

was better established at a steady rate throughout the year. This allowed the inherent advantage of the larger unit load to be fully utilised both in warehousing and distribution.

The greater use of palletised methods encouraged the development of a semi-automatic palletiser (U.K. Patent No. 1229809) by SAI. Initially the unit load size was 2.45 Imperial tons built in 7 layers each of 7 bags on a 1,525mm x 1,220mm 2-way entry reversible wooden pallet. Practical experience showed that this size of unit load tended to be unstable particularly when transported over distances of between 70 and 80 miles on twisting Scottish roads and the unit was reduced to 2.1 Imperial tons, i.e. 6 layers each of 7 bags.

Although the increase in use of bagged product was encouraged by the physical properties of the more sophisticated fertilisers, it was also influenced by a significant change in the price structure of fertilisers which took place in 1970. At that time the financial discount given for June delivery was substantially increased and this not only changed the selling pattern of fertilisers but also the whole framework of storage, handling and distribution. Hitherto about 65% of the Company's production had been sold between March and May, i.e. at the time of usage, but now only 15% of sales occur between January and May, and so 85% of production is sold between June and December - in other words in the year prior to usage. This is a fundamental change in the process from manufacture, through delivery to final usage on the farm.

In the first year of this new price structure, no doubt encouraged by the continuing increases in fertiliser prices - stemming primarily from high raw material costs - extra sales were generated in the June to December period. The farmer was now buying significantly ahead of his period of usage - perhaps even a full year - and stimulus was given to developing a package which would allow the product to be received and stored outdoors for some months without the product becoming unfit for use.

Along with these developments the farm labour force in Scottish agriculture was declining steadily - an average fall of 5.4% per annum from 1960 to 1970 - and the average age of those workers remaining was showing a marked increase. This trend has continued over the last 5 years although the average fall has lessened to 3.8% per annum and it is expected that figures to be issued later this year will show that the labour force in Scottish farms is now no more than 40,000. (Fig. 2) In this situation, the farmer, of necessity, actively sought labour saving innovations and fertiliser handling in particular was an area which presented opportunities for reduction of physical effort and inconvenience.

Obviously there are a number of alternatives to handling and storage of fertiliser in bags, e.g. supply of solids in true bulk, the provision of contract application services, the supply of fertiliser in liquid form. The experience which SAI had gained in handling and distribution of product in palletised unit loads within its own operations suggested a development which was introduced to the farmer in 1970 under the name of STAKPAK. With this scheme 1-ton unit loads of fertiliser, shrink wrapped on to fibreboard flats, are delivered and stacked on farm. The unloading costs and material cost of this service is borne by the customer, and it gives him the opportunity of having fertiliser delivered and stored outside ahead of the period of usage without having to provide either labour for unloading or covered space for storage.

Using the semi-automatic palletiser operating on an air bed principle, 1-ton unit loads are palletised by locating bags in pin-wheel fashion on fibreboard flats 1,168mm square. These unit loads are handled side by side, 2 at a time, and moved to storage by the forks of a fork lift truck in the centre portion of the pallet. In this way, 2 unit loads can be readily handled through store and on to the delivery vehicle. (Fig. 3)

When the service was initiated in 1970 it was believed that the most appropriate method of delivery and unloading would be to use an articulated vehicle with the prime mover fitted with "fold forks" to give a dual purpose unit. Having transported the load in the normal way directly from packing point to farm, the prime mover became a fork truck to unload and stack the unit loads at the farm. It can be seen (Fig. 4) that during this operation the fork fingers are inserted into the outermost spaces of the "take it or leave it" pallet thus enabling the shrink wrapped unit load, complete with fibreboard, to be picked up from the trailer leaving behind the wooden pallet.

The unit load was stored on suitable ground, either on pallets provided by the farmer, or stacked up to 3 high without the need for the farmer to provide pallets. (Fig. 5)
The choice of a 1-ton unit load rather than 1.5 tons or more was determined by the view that a 1-ton unit load on a base about 1.2m square was likely to be most suitable to manufacturer, haulier and farmer. Moreover if farmers elected to have STAKPAK set down on their own pallets it was more likely that they would fit attachments to their tractors which could handle this weight, whereas to handle 1.5 unit loads safely required a specialised rough-terrain fork truck which only the largest farmers would be likely to buy.

It will be appreciated that this development offers significant benefits both to customer and to SAI -

1. Offloading at farm is effected by mechanical means with no intervention of farm labour, customarily provided in the 60's for unloading of vehicles. Increasingly the shortage and sometimes the total absence of labour had prevented this and, on occasions, extra labour had to be supplied along with a driver to help unloading, incurring additional costs which could not be recouped from the customer.

2. Offloading by mechanical means reduces turn-round time of vehicles at farms compared with traditional methods of discharging, yielding a direct saving to the Company. By this means, a lorry load of STAKPAK can be unloaded and stacked unassisted by farm labour with a saving of about 45 minutes.

3. The shrink wrapped unit can be stacked outside with the contents safely protected from the weather.

4. The seasonal nature of fertiliser use inevitably creates significant storage problems which are costly in terms of storage accommodation, and of double handling from factory to store, and from store to farm. Ideally, fertiliser should be stored on the farm of ultimate use to which it should be delivered directly from point of production. The ability to increase deliveries in the out of season period created by STAKPAK produces a more even pattern of monthly offtake presenting opportunities for the reduction both of storage and distribution costs.

The articulated vehicle prime-mover fold fork system with which we began the STAKPAK project, required a clear area of some 16.5 metres square within which to function. A survey which we had carried out of more than 400 farms in Central and South Scotland suggested that 70% of farms taking 30 tons or more of compound fertiliser in the year could provide a suitable unloading area. Unfortunately in practice, when we came to deliver we discovered that many of our farmers neither had the area cleared and ready for manoeuvering, nor did they wish their fertiliser stacked where our survey had shown it could be most suitably placed. Indeed, as the system developed, we began to be asked to supply STAKPAK to dropping points to which it was quite impossible to gain access without using a tractor-type vehicle. Thus we now employ rough-terrain fork trucks for unloading and stacking at the farm and plan our STAKPAK deliveries in such a way as to minimise movement of the fork

trucks between farms. Tonnages offloaded per day can vary widely but the average performance we expect from a truck and driver is about 80 tons per day. The approach to the stow is as normal for a fork truck but the method of withdrawal is novel. A wedge is inserted which is withdrawn at the same time as the forks, thus enabling a neat and tidy stow to be built and the forks to be withdrawn without dislodging the lower unit loads.

The tonnage supplied in STAKPAK form rapidly increased until in 1974 some 28% of our deliveries were in this form and this was accompanied by a rapid drop in the tonnage of fertiliser supplied in bulk which, within 2 years, had dropped to almost negligible proportions.

But STAKPAK was not enough. An increasing number of customers were buying their own fork truck attachments which could be fitted to the rear of their tractor and which readily enabled them to handle safely the 1-ton unit load around which we had designed the STAKPAK system. The system was therefore developed to include a 1-ton unit load shrink wrapped on to a 1,168mm square 2-way wooden pallet for customers who were able to receive and handle fertiliser in this way and who agreed to participate in a pallet pool. This arrangement requires farmer to buy the pallet at market price at the same time as he buys the fertiliser on it. When the pallet is returned in good condition he receives credit at the figure which is being charged for new pallets at the time of return.

STAKPAK and delivery of 1-ton unit loads shrink wrapped on pool pallets are essentially complementary to each other, and now 40% of our deliveries are made in one or other of these ways, each of which is in its own way contributing to the simplification of the storage and handling process from point of packaging to point of use.

Whilst ultimately delivery to farm has to be made by road vehicle, it should not necessarily be assumed that the total

movement must be by road. Although British Rail carry 17% of total freight traffic in the UK, one third of which is on short (bulk) hauls (25 miles or less), it is generally accepted that, unless private sidings are available at both origin and destination, rail will continue to be more expensive than road especially for wagon load traffic. Our experience suggests that only where journey distances exceed something like 140 miles can an element of movement by rail be considered on economic grounds and then only if the traffic is carried in palletised unit loads. Thus although we had, in 1970, moved some 5% of our bagged compounds by rail in traditional wagons the high labour content associated with the process of loading and unloading raised the total cost of movement over the succeeding years to a level which compared unfavourably with the cost of movement by road. By 1975 our rail traffic was negligible.

However, British Rail have recently introduced to their Scottish services covered common user air-braked wagons of the COV-AB or COV-VDA type. Our 1,170mm square palletised 1-ton unit loads, shrink wrapped in STAKPAK or pool pallet form are fully compatible with these wagons and enable their total carrying capacity to be exploited. Therefore we are again able to move product satisfactorily and economically over distances in excess of 150 miles by rail. Although the scope for such movement is limited in Scotland, it is possible to envisage perhaps up to 10% of our deliveries having a rail element as part of the total movement process to customer.

A most interesting development recently has been the use of Norwegian designed and built side-loading pallet boats specially constructed to enable palletised cargoes to be loaded and unloaded expeditiously. Our Scandinavian friends have longer experience and use these vessels much more extensively than we do but their use on coastwise movement between our plants at Leith and Aberdeen and the islands to the North and West of Scotland - and even indeed to the far North of the Scottish mainland - has enabled product to be moved virtually damage-free and significantly more economically than by any other

method. Although the principle can clearly be applied to larger vessels we find it appropriate to our scale of operation to use ships of 600/650 tonnes capacity which can quite readily be loaded or unloaded in four hours.

What we have been describing have all been elements within an integrated storage, handling and distribution system which we expect this year will embrace about half our total sales of bagged compound fertiliser. We hope we have illustrated effectively the advantages of operating with such a system.

As has been indicated earlier in this paper, these arrangements developed from the initial application of palletised handling methods to fertilisers based upon a 2.1 ton unit load located in 6 layers of 7 bags on a 1,525mm x 1,220 2-way entry pallet. Within the Company, these pallets are still used extensively for storage and handling of substantial tonnages of our bagged compounds although we now use a 5 bag layer building this 6 or 7 layers high depending on the product concerned. While some of this fertiliser is depalletised at a Company unit before loading on to vehicles for farm delivery, much of it is transported on pallets by road to customer from Works or intermediate store. This requires the empty pallets to be returned to the Company by the haulier. Whilst this process undoubtedly speeds turn-round at works or store, where only a limited number of bags are depalletised nowadays, the laborious task of manual unloading bag by bag at the farm has still to be carried out. If the customer elects to receive his order in this way we must provide this service. In order to maintain control of the pallets we have a contractor pool system. Each time a contractor receives a load of fertiliser on pallets, these are logged against him. He is required to return these pallets to any of our Company units and when he does so he is credited appropriately. Each contractor has a pallet float relevant to the scale of his business with us and the period of the year concerned. Our experience with this arrangement which has been operating for about a year and costs relatively little to administer, is encouraging.

While summarising some of the recent developments in distribution methods relating to bagged compound fertilisers of SAI manufacture, it is appropriate to indicate that we are keeping in close touch with the possibilities of using Intermediate Bulk Containers for compounds. It is of interest to mention that we have for the past year been successfully using these with phosphate/potash mixtures and unground phosphate which we supply for aerial application by helicopter to forest land in Scotland. For this duty, we have used a returnable Intermediate Bulk Container formed of woven polypropylene and incorporating a polythene liner. The container holds 750 Kg and is filled at Works and transported by lorry to a point suitable for helicopter operation. It is unloaded by crane and the helicopter hopper, which can hold 750 Kg, is filled in something like 25 seconds. The system was introduced to eliminate handling of 25 Kg bags to minimise helicopter loading time and enable it to spend as much time as possible in the air. Following the spreading of several thousand tonnes, product loss has been virtually eliminated and the returnable bag arrangement has worked well recognising that only one haulier and one aerial spreading contractor has been involved. During the first year of operation an average of 9 trips was secured from each Intermediate Bulk Container, although several had completed 15 journeys. After the six month period of use in 1975 lifting tests indicated that the Intermediate Bulk Containers had suffered minimal deterioration due to Ultra-Violet degradation etc.

3. DISTRIBUTION MANAGEMENT

It has been acknowledged for a number of years that in many industries the extent to which distribution costs can be controlled is of vital importance to the profitability of a Company. This is so in the fertiliser industry. Indeed it has been quoted elsewhere that transportation costs amount to some 40% of the logistical costs, and indeed some 10% of the total product cost to the customer. It is of the greatest importance that adequate management strength and expertise are allocated

to the distribution function if the rewards of the technological developments during the past 2 decades are to be fully reflected in the presentation of plant food at the point of ultimate use. Those of us who work in this area are, moreover, constantly reminding our colleagues, particularly those in the marketing function, to consider carefully what the effect on distribution costs might be of a fresh marketing approach before it is presented as a "fait accompli" and perhaps unnecessarily incurring additional distribution costs.

Over the past 20 years SAI has progressed from local manufacture at 7 plants dispersed throughout Scotland, each in association with a number of satellite stores, to the current situation where 2 plants located at Leith and Aberdeen supply an unduplicated range of products throughout Scotland. Leith manufactures only ammonium nitrate based compounds whilst Aberdeen produces ammonium phosphate based and a small tonnage of superphosphate based compounds. With just 2 manufacturing points it is not practicable, even with a country as relatively close-knit in agronomic terms as is Scotland, to deliver all compounds directly from plant to farm. Thus it is necessary for us to use a small number of storage sites strategically located throughout Scotland to enable us to distribute fertiliser effectively. The best possible balance has to be struck between the storage of just enough of each type of fertiliser to enable our customers' requirements to be expeditiously serviced and the tonnage which it is necessary to move to these peripheral stores to permit production and packaging at our plants to continue at a steady rate throughout the year.

Virtually all our compound fertiliser tonnage in bags is shrink wrapped and thus it is not necessary to provide covered storage. We wrap with 60 – 100 micron Ultra-Violet inhibited shrink wrap film and find the combination adequate to withstand the rigours of the Scottish climate.

It will be appreciated that distribution problems increase in complexity as local manufacture and associated storage is replaced by a central plant manufacturing for the whole country with which is associated much less significant peripheral storage. Planning has to be more exact, customer needs have to be sensitively anticipated and all costs associated with distribution closely monitored so that the benefits associated with the larger scale manufacture possible at one or two central points are not dissipated. Notably, targets have to be set such that the higher tonne-kilometres which inevitably have to be covered with central rather than local manufacture are travelled at a lesser cost. Given developments in distribution technology and management expertise which might be expected at least to parallel those of fertiliser technology, the distribution cost per tonne should be contained to a level which compares favourably with the appropriate national or industrial cost indices. The accompanying graph illustrates this approach as it applies to SAI. The changes in the total transportation costs per tonne of compound fertiliser that SAI has incurred over the past 10 years are compared with 3 indices which we consider have some relevance in this connection - the UK retail price index, the wholesale price index for chemical/allied products and the index covering materials/fuel purchase for chemical and allied industries.

These comparisons confirm that with certain exceptions, the reasons for which we believe we understand, our transportation costs have kept broadly in line with the indices concerned. One may deduce that the cost per tonne-kilometre has been reduced over the same period for the reasons stated earlier and thus that at least the transportation element of the operation is being carried out with greater efficiency than 10 years ago - and indeed when we examine our costs per tonne-kilometre we find supporting evidence for this conclusion.

There are 2 further indices which are, we believe, of importance in monitoring distribution management performance. The first of these relates the total transportation cost to the sales realisation for the product group concerned and the second the total distribution cost including packaging and storage as well as transportation to the same sales realisation figure. Monitoring of these indices can be a most useful pointer to the effectiveness of performance - measured in economic terms - of a distribution department provided it is recognised that these are means and not ends in themselves.

ACKNOWLEDGEMENTS

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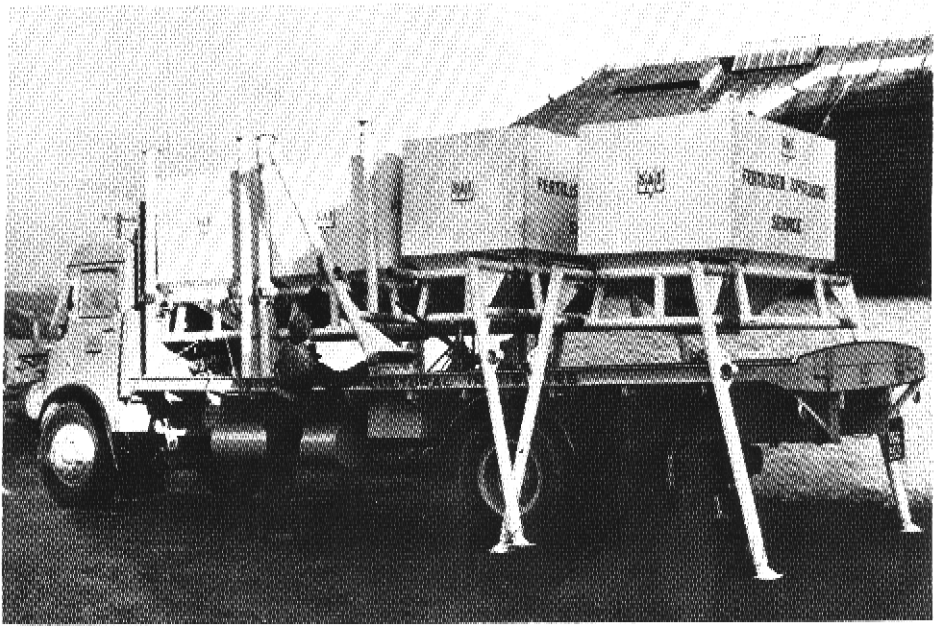


FIGURE 1 PORTABLE FERTILISER BULK CONTAINER

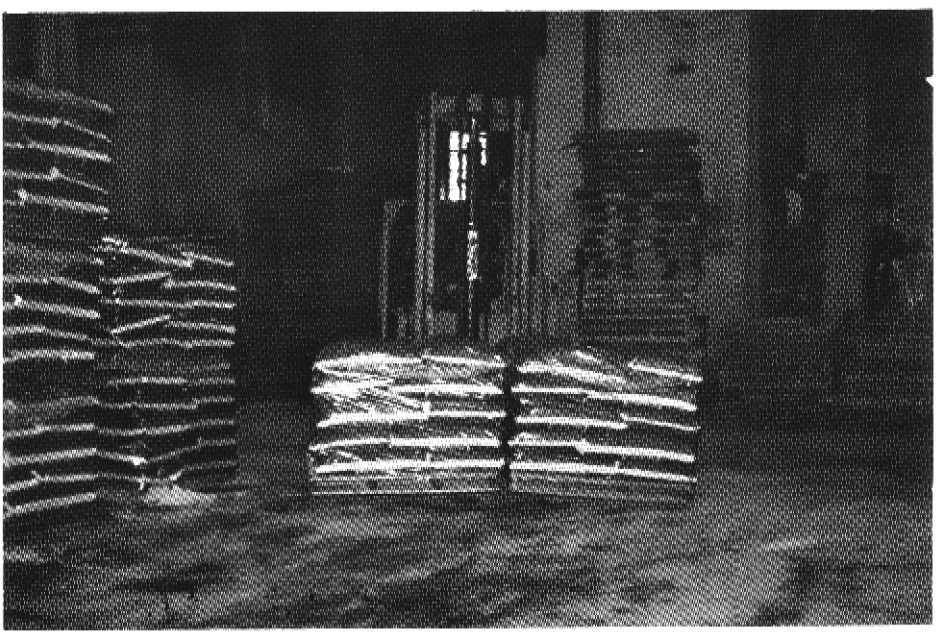
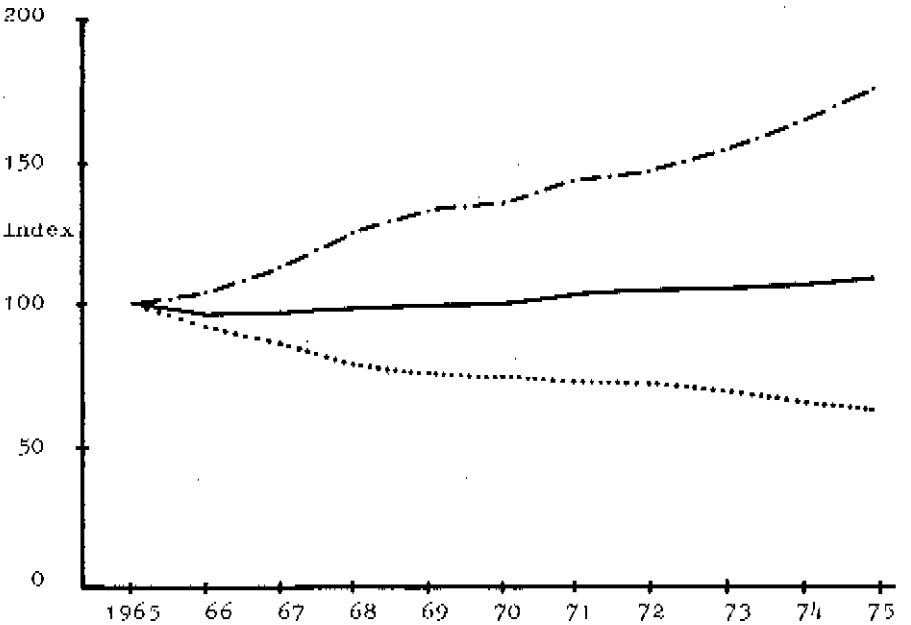


FIGURE 3 FORK TRUCK HANDLING 2 x 1 TONNE UNIT LOADS

RATIO OF COMPOUND FERTILISER USAGE TO FULL TIME FARM LABOUR IN SCOTLAND

FIGURE 2



.-.-.-.- ESTIMATED USAGE PER FULL-TIME WORKER

———— ESTIMATED COMPOUND FERTILISER USAGE (SCOTLAND)

..... FULL-TIME FARM WORKERS (SCOTLAND)

FIGURE 4 STAKPAK PALLET HANDLING

FIGURE 5 STAKPAK STOW ON FARM

RELATIONSHIP OF FERTILISER DISTRIBUTION COSTS
TO PUBLISHED UK COST INDICES

FIGURE 6