HANDLING OF FERTILIZER IN LARGE BAGS

By E. MEYER and F. B. WORLOCK

SA Sugar Association Experiment Station, Mount Edgecombe, 4300

Abstract

Fertilizer is now available to sugarcane farmers in bags that contain half a ton. The different systems for handling these large bags are described and evaluated while the labour requirements and costs, as well as tractor and implement productivity are considered. A reduction of labour due to increased mechanization and capital outlay does not necessarily result in lower application costs.

Introduction

Four methods of handling fertilizer were recently evaluated at the SASA Experiment Station's farm at La Mercy. Two commercial hoisting systems and one system built on the farm to handle half ton bags were tested and compared with the conventional method of handling 50 kg bags of fertilizer. The productivity of each of the systems used was determined by time and motion studies.

Methods of handling conventional 50 kg fertilizer bags are well known but it was necessary to study the labour savings, storage facilities and increased tractor productivity associated with the use of large bags. The advantages which cannot be costed, such as improved working conditions and convenience of using the large bags, were also weighed against the high capital outlay and maintenance costs of the equipment required.

Method and Equipment

The intermediate bulk container

Various shapes and sizes of containers are available but the half ton bag was considered to be most suitable for sugarcane farms in South Africa. The re-usable bag, which is 1 000 mm square and 620 mm high, is made of woven polypropylene and has 350 mm long loading loops attached to each of the four upper corners.

The bag is filled through a 500 mm diameter funnel. The funnel tube is 500 mm long which allows the bag to be tied by means of a cord. Fertilizer is dispensed through a 220 mm diameter funnel at the bottom of the bag. This bottom funnel is bound with a slip-knot which is easily untied when the bag is suspended and under pressure. The bottom funnel is attached to the inside of the bag and is protected by being folded into the bag opening while not in use.

Since most fertilizers are hygroscopic, an inner polyethylene liner is available and is essential if the fertilizer is to be stored for prolonged periods. The bags should be stored under cover as direct sunlight affects the material of which the bag is made. All the granulated topdressing fertilizers used in the industry can be handled in 500 kg bags.

The number of times that a bag can be used depends on the way it is handled. Since the life-span is limited, it is essential that each bag is marked so that the number of safe trips can be recorded. The life of the bag is prolonged by using a spreader bar on all handling equipment and bags should be lifted and not dragged, no matter how good the surface.

The lightweight, collapsible containers allow them to be stored easily when empty and their design makes it possible for the filled containers to be stacked for road and rail transport. Inventory control is simplified as each bag is filled with the correct weight at the filling point.

The bottom funnel of the bag can be closed after filling the hopper of the fertilizer spreader so fertilizing of fields can be done without having to empty the entire bag into the hopper. The inside of the bin of the spreader is calibrated in 50 kg divisions so that application rates can be determined accurately.

Gantry system

A removable gantry was constructed at La Mercy and was mounted on a flat deck trailer. Two pairs of support columns were bolted to each end of the trailer. An "I" beam section was suspended underneath the columns and extended over the rear of the trailer. A one ton chain block was attached to the "I" beam by a chain operated crawler which loaded and removed the bags by lifting them and moving them along the "I" beam. The height to which the bags were lifted was determined by the loading height of the fertilizer spreader and the number of bags which could be stacked on top of each other on the trailer. It was possible to stack three bags on top of each other with this gantry (see Figure 1).

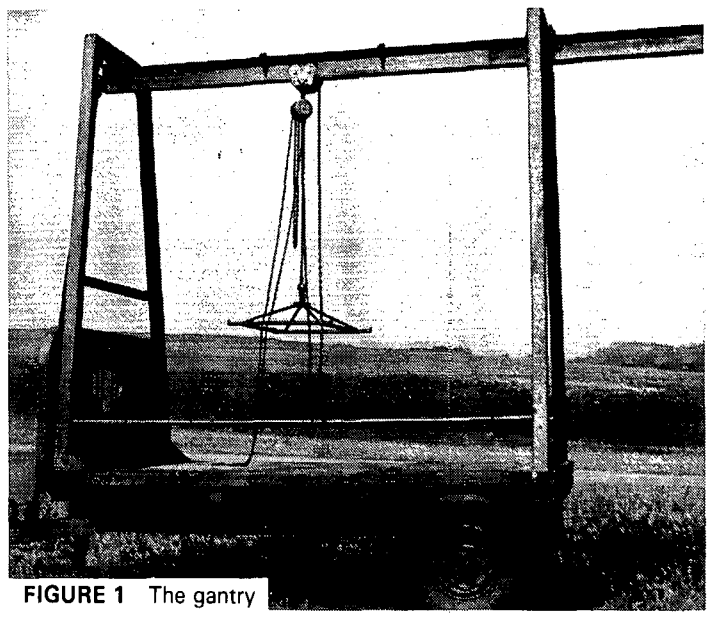

FIGURE 1 The gantry

The complete handling system required the fertilizer bags to be loaded onto the trailer by the gantry or by other equipment such as front-end loaders, fork-lifts or three-point mounted tractor cranes. A trailed, fertilizer spreader driven by the pto and having a capacity of 900 kg, was coupled to the loaded trailer and taken to the field where it was hitched to the tractor so that the field could be fertilized. The trailer had to be positioned on level ground to prevent the crawler gear from slipping.

The bags were raised individually and swung out over the rear of the trailer while the tractor and spreader were being used to apply fertilizer. To re-fill the spreader, the bottom funnel of the bag was simply untied and the contents poured into the spreader hopper.

This system required equipment to be moved and interchanged, which could cause reduced productivity if not managed properly. A tractor driver and one helper were required to operate this system which involved more manual work than the other systems described, where a tractor- or trailer-mounted crane was used.

Hydraulic trailer-mounted crane system

This system consisted of a removable swivelling crane mounted centrally at the rear of a 5 ton trailer. For other tasks it might be preferable to position the crane at the front of the trailer so that it does not interfere with the work to be done. Simple, inexpensive out-riggers at the front of the trailer deck prevent the trailer from tilting sideways. The telescopic crane was operated by the external hydraulic system of the tractor but a small power pack could be used as an alternative. Slewing of the crane was effected by a manual crank and gear system (see Figure 2).

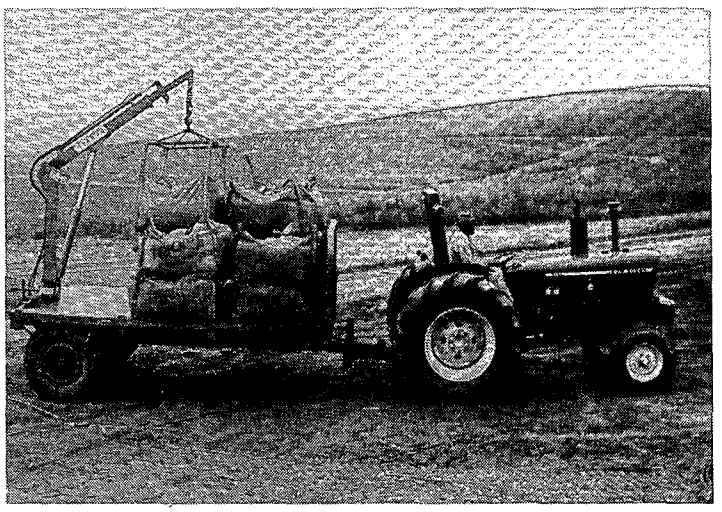

FIGURE 2 The hydraulic trailer-mounted crane

The bags were loaded by the crane with the tractor parked next to the trailer. The tractor was then hitched to the trailer and taken together with the spreader to the field. Here the tractor was coupled to the spreader and parked next to the trailer where the hydraulic quick-release lines were attached. The crane was then ready to lift a bag and to dispense fertilizer into the hopper. Every time the hopper was filled, the tractor had to be connected to the hydraulic lines from the crane before the bags could be lifted. The trailer had to be level so that it was not subjected to undue stresses while it was being offloaded, and to minimize the manual effort required to slew the bag over the spreader.

Immediately next to the crane there was an area where it could not operate but it was still possible to load 5 tons (or 10 bags). The system required coupling and uncoupling of hydraulics and equipment but only one tractor and two men were needed. The only disadvantage of this system compared with the others was the time taken to re-fill the fertilizer spreader.

Tractor-mounted crane/spreader system

An hydraulically operated, non-slewing, crane was mounted on the three-point hitch of the tractor. A small, fertilizer spreader, driven off the pto and with a capacity of 350 kg, was mounted immediately behind the crane which was equipped with skids to facilitate hitching and to prevent the tractor from overturning on uneven terrain.

Ten bags were easily loaded onto a trailer by the tractor-mounted crane. The fertilizer spreader had to be unhitched to avoid it being damaged during this operation. A second tractor was needed to haul the fertilizer trailer to the field. After being coupled to the spreader, the tractor with the crane proceeded to the field where the spreader was uncoupled so that the tractor crane could be used to offload the bags and place them strategically along the edge of the field. The spreader was then recoupled to the tractor.

The bags were lifted off the ground by the telescopic crane and suspended over the spreader hopper so that the bottom funnel of the bag was well inside the bin. The discharge of fertilizer stopped as soon as the level of the fertilizer in the spreader bin reached the outlet of the funnel. As the level of the fertilizer inside the bin dropped, more fertilizer was released from the suspended bag and only when the bag was empty was another full bag lifted into position (see Figure 3).

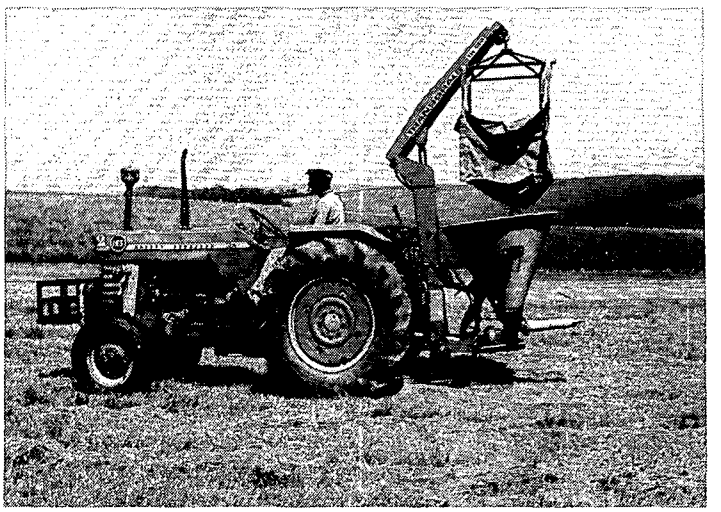

FIGURE 3 The tractor-mounted crane/spreader

Although a certain amount of rearrangement of equipment was involved in this system, it was less than that required for the gantry or trailer-mounted crane systems. However, for stability, the tractor had to be heavy because of the large rear overhang and the fact that the fertilizer bag was suspended well behind the tractor while operating in the field. This system was therefore not suited to steep slopes. An additional problem was that the suspended bag hung vertically downwards, and this caused the funnel sometimes to move clear of the spreader bin when on a steep slope.

This system could be operated by the tractor driver and one other man but for costing purposes, the second tractor and operator had to be included.

Conventional 50 kg bag system

The standard 50 kg fertilizer pockets were loaded manually onto the trailer and taken out to the field where they were either placed at a central point or along the edge of the field. One tractor was used to transport the fertilizer while a second tractor was used with the spreader to apply the topdressing.

Four, five or six men were needed to load the bags and to place them in the field, a task which took 2,4 hours per 5 ton load. Two men were required to re-fill the fertilizer spreader, no interchanging of equipment was necessary and small tractors could be used.

Results and Discussion

Time studies were conducted for each of the four systems and the time taken to complete each stage of the fertilizing operation is shown in Table 1. If 100 hectares were to be top-dressed during the season at a rate of 500 kg per hectare, then 50 tons of fertilizer would be required. The trailer had a capacity of 5 tons which meant that 10 trips to the field would be required in a year. Since downtime is a variable factor it was not included.

The bin capacity of the mounted spreader used with the tractor-mounted crane was relatively small, so it was more efficient to place the bags at each end of the field, rather than to leave them on the trailer. Generally, the smaller the hopper the more important the correct placing of the bags becomes. Ideally, the capacity of the hopper should be slightly greater than half a ton so that even if it is not empty, it can be re-filled thus reducing the time spent travelling while empty.

TABLE 1

Operational details of the four systems: time spent to apply 5 tons of fertilizer to 10 ha

System	Hitching equipment h	Travel h	Loading h	Filling hopper h	Spreading h	Turn h	Total time h
Tractor-mounted crane*	0,07	0,60	0,70**	0,32	3,43	0,32	5,44
Gantry trailer	0,21	0,60	0,39	0,37	2,36	0,22	4,15
Crane trailer	0,20	0,60	0,22	0,86	2,36	0,22	4.46
Conventional manual	-	0,60	1,80**	1,22	2,36	0,22	6,20

* with tractor-mounted fertilizer spreader; all others with trailed spreader
** includes loading and offloading

TABLE 2

System costings: tractor-mounted crane/spreader

Equipment required	Capital outlay R	Annual usage hrs	Cost per hour R	Cost per hectare R
Crane and spreader bar	1 739	54,46	8,14	4,43
Trailer	-	13,72	2,20	0,30
Tractor No. 1	-	54,46	12,60	6,86
Tractor No. 2	-	13,72	10,00	1,37
Fertilizer spreader	795	54,46	4,01	2,18
Field assistant	-	10 man-days	4/m-d	0,40
Total	2 534			15,40

TABLE 3

System costings: gantry mounted on trailer

Equipment required	Capital outlay R	Annual usage hrs	Cost per hour R	Cost per hectare R
Structure chain block spreader bar	1 000	41,52	5,42	2,25
Trailer	-	41,52	2,20	0,91
Tractor	-	41,52	10,00	4,15
Fertilizer spreader	3 508	41,52	17,33	7,20
Field assistant	-	10 man-days	4/m-d 0,40	0,40
Total	4 508			14,91

TABLE 4

System costings: trailer-mounted crane

Equipment required	Capital outlay R	Annual usage hrs	Cost per hour R	Cost per hectare R
Crane and spreader bar	3 760	44,64	17,28	7,71
Trailer	-	44,64	2,20	0,98
Tractor	-	44,64	10,00	4,46
Fertilizer spreader	3 508	44,64	16,12	7,20
Field assistant	-	10 man-days	4/m-d	0,40
Total	7 268			20,75

TABLE 5

System costings: conventional/manual

Equipment required	Capital outlay R	Annual usage hrs	Cost per hour R	Cost per hectare R
Trailer	-	24	2,20	0,53
Tractor No. 1	-	24	10,00	2,40
Tractor No. 2	-	38	10,00	3,80
Fertilizer spreader	3 508	38	18,73	7,12
Field assistant	-	40 man-days	4/m-d	1,60
Total	3 508			15,45

The total time required to apply 5 tons of fertilizer was similar for the gantry and the trailer-mounted crane systems. The tractor-mounted crane system was considerably slower and took 5,44 hours. This was because of the 7,5 m swath compared with 10 m for the other systems at the same speed and application rate. The same task for the conventional system using 50 kg bags, required 6,2 hours because of longer loading and filling times.

The cost of applying fertilizer for each system was calculated by assuming that 100 ha per year was topdressed at a rate of 500 kg/ha. Fertilizer handling and spreading equipment was depreciated over a maximum period of 10 years and the hourly costs of all tractors and machines were debited against fertilizer spreading for the period that they were used, whether they were operating or not. Results are shown in Tables 2, 3, 4 and 5. Total costs per hectare for the tractor-mounted crane (R15,40) the trailer gantry (R14,91) and the conventional system (R15,45) were very similar. The trailer-mounted crane system was more expensive (R20,75/ha), primarily because of the high capital cost of the crane. The labour cost per hectare was low, even for the conventional system.

If these bags are used, the fertilizer company offers a discount of R10,00 per ton. The cost of the bag without a liner is R11,50, which means that each bag must be used at least 2,3 times to justify its cost. If a bag can be used five times before it is discarded, this would leave the advantage from 2,7 trips to offset the cost of the handling equipment. Twenty bags would probably be purchased for a farm using 50 tons of fertilizer annually, allowing R270 (20 bags x 0,5 t/bag x 2,7 trips per bag x R10/ton discount) for this purpose. The number of bags required by a particular grower will depend on the annual tonnage of fertilizer, the type and method of transport, and whether a further discount for early orders could be obtained.

Conclusion

Tests involving various systems of handling fertilizer in large bags have shown that they are economically competitive with the conventional method using 50 kg pockets. Careful consideration must however be given to a change from the standard bag. The equipment required must be robust but not too expensive in relation to the annual tonnage of fertilizer used. The larger bags must be offloaded from either rail or road transport, therefore the choice of handling equipment is particularly important. Although mechanical offloading of the bags is possible with all the methods described, some will require more time than others.

The cost of fertilization should not be the main incentive for changing to mechanized handling systems. Increased tractor and machinery productivity and utilization, as well as a reduction in the number of labourers required on the farm could be the main advantages of such a change.

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