Australian Government

Australian Centre for International Agricultural Research

Final report

Project full title	**Protection of stored grains against insect pests**
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date published	24/01/2022
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Contents

1 Acknowledgments

Davren Global (Davren) would like to acknowledge the following people and agencies that have contributed to and supported the work conducted under SRA CIM/2017/031.

First and foremost, Davren acknowledges ACIAR for the funding but also its confidence in Davren to progress this important work. Given also the challenges which COVID19 has created in conducting and administering the program, Davren also appreciates the flexibility and pragmatism the agency has demonstrated allowing the project to continue and achieve the results reported here.

The company would also like to extend its thanks to and acknowledgements of our in-country colleagues, at the Tropical Pesticides Research Institute (TPRI) in Arusha, Tanzania, in particular Dr Maneno Chidege. Likewise, the Company would like to express its gratitude to Dr Simon Lugandu who conducted extensive in-country interviews and research to support the development of the business cases for the use of Davren's technology for grain protection in Tanzania.

Davren is also very fortunate to be supported by a number of long-term consultants without whom it could not have developed the SAS technologies. These include Dr David Eagling (*Highfield Consulting*) who led our entomology and SAS-materials characterisation, Mr Robin Reid (*R2 Consulting*) who was pivotal in Davren's understanding of grain handling and processes and who oversaw our insect-trials, and lastly Mr Michael Hopkins (*Convenant Solutions*) who was central to the design and overcoming the engineering challenges for the construction of the Company's Tanzanian prototype SAS-applicator.

2 Executive summary

The development of a technology using synthetic amorphous silica (SAS) for the control of insect pests in stored grain, for use in Tanzania has been assessed.

Scheduled in-country activities in Tanzania were disrupted by COVID however the project adapted in order to demonstrate the control of a range of insect pests relevant to commodity grains produced in Tanzania.

A prototype SAS application device has been constructed with design functions informed by prior in-country staff input, such as the ability of the device to be self-reliant for power and to be applicable to the treatment of grain at volumes likely to be produced by individual landholders, as well as bulk quantities stored at centralised facilities.

The device has completed initial field-testing in Australia and transport arrangements were finalised to have the SAS applicator and other scientific equipment collected by the Tropical Pesticide Research Institute (TPRI) in Tanzania in early March 2022.

As in-country visits were not possible a local, ACIAR-endorsed consultant was subcontracted to carry out the in-country interviews and incorporating the information Davren provided, separate business cases for the two identified commercialisation models were prepared.

It is intended that the application device will form the basis of a further demonstration-based activities including in-country testing and consultation to develop preliminary costings and explore service delivery models for the exploitation of the technology in Tanzania.

3 Background

Tanzania is the largest country in East Africa, with an area of almost 1 million km^2 and a population of 51.8 million (https://data.worldbank.org/country/tanzania).

Agriculture is key to Tanzania's overall economic growth and development, accounting for 24.1% of GDP and representing the livelihoods of about three-quarters of the population (https://data.worldbank.org/country/tanzania).

Key challenges facing the agriculture sector include weak market linkages and post-harvest losses with on-farm storage critical to providing small landholders with a food supply beyond the harvest period.

One of the critical risks to on-farm storage is commodity damage by insect pests. Although yield losses of up to 100% have been observed, the economic significance of most pests under farmers' production conditions is not adequately understood (Abate TI, 2000).

Pesticide use in Africa is low by global standards due to economic and social constraints, such as lack of infrastructure, equipment, and awareness. The bulk of pesticides that are used are applied mostly against pests of commercial crops such as cotton, vegetables, coffee, and cocoa, and to some extent for combating outbreaks of migratory pests such as the locusts (Abate TI, 2000).

Indigenous pest management approaches are still used in Africa (Abate TI, 2000). These include strategies such as crop rotation and the use of silica containing materials or inert dusts.

Inert dusts have been the subject of several reviews (Cook & Armitage, 1999) (Ebeling, 1971); (Fields & Muir, 1995); (Korunic, 1998); (Subramanyam & Roesli, 2000) but in general, suffer from several limitations including relatively long insect kill times and high dosage rates required as compared to chemicals. Moreover, inert dusts are susceptible to reductions in efficacy due to factors such as relative humidity, temperature, and insect life stage.

These limitations may be resolved with the development of a breakthrough technology based on a form of silica known as synthetic amorphous silica (SAS).

The technology is being commercialised by an Australian company, Davren Global Pty Ltd, (Davren) and comprises of both high purity SAS and an application technology to optimise the control of insects.

ACIAR supported an initial assessment of the technology (CIM-2015-009) in which SAS was applied by hand to insect pests in laboratory / enclosed field shed settings in Timor Leste and Tanzania.

SAS successfully protected stored agricultural commodities from common pests such as: the cowpea bruchid (*Callosobruchus maculatus*); the maize weevil (*Sitophilus zeamais*); the larger grain borer (*Prostephanus truncatus*) and the bean weevil (*Acanthoscelides obtectus)*.

In Tanzania, laboratory experiments showed complete control (100% mortality) of several key insect pests of stored grains within 5 – 10 days of exposure at rates of 200 g SAS / tonne commodity.

The project included a successful grain post-harvest technology training workshop in Tanzania which included an engaging discussion on the most appropriate technologies that could be applied in the Tanzanian grain production and handling systems.

Using the information gathered and the in-country support developed during the initial phase in Tanzania, Davren Global proposed a second phase assessment combining a mix of targeted laboratory research experiments, community consultation and first phase machine development to inform distribution / extension pathways for the new technology to both small landholders and larger volume grain aggregation systems in Tanzania.

4 Objectives

Objective 1: To determine the target range of storage insect pests for which SAS may provide control

Objective 2: To explore and demonstrate how the principles, present in the current SAS prototype application machines developed by Davren Global, may be re-engineered to be relevant in Tanzania

Objective 3: To undertake a community consultation process through small landholder focus groups to inform both the development and in-country testing an application device for small landholders and explore issues around distribution / service delivery models for the new technology.

Objective 4: To bring together the new knowledge and potential commercial opportunities in the form of draft business plans to inform future exploitation, support, and financing of the technology.

5 Methodology

Davren Global Pty Ltd, an Australian company, is commercialising a new technology for insect control in stored bulk foods based on synthetic amorphous silica (SAS).

This project when initially contracted, anticipated considerable in-country work, interacting directly with staff in Tanzania along with not-for-profit social enterprise structures to build and expand on the initial findings of an earlier ACIAR-supported assessment of the SAS technology for control of pests in stored grains in Tanzania.

The advent of COVID has prevented the in-country activity, however Davren has used innovative approaches to achieve valuable outcomes.

For example, the first stage of the project, was to examine the SAS-based control of a range of insect pests relevant to commodity storage in Tanzania. This has been completed using insects (determined by in-country staff) as relevant to Tanzania, but using Davren's laboratory facilities and expertise in Australia.

The second activity focused on the Australian-based development of a prototype SAS application device deigned to be suitable for treating grains held by both small landholders also well as companies and government structures which store larger grain volumes.

This work has been completed with the design and development of an application device. However, the planned in-country consultation process using landholder focus groups to inform the design phase was not able to proceed. Instead, key design functions were informed by incorporating in-country staff input. For example, the ability of the device to be self-reliant in respect to power, with the device having now completed initial field-testing (to demonstrate the on-board generator), in Australia prior to shipment to Tanzania.

The final task was to be in-country consultation to understand local market factors and examine preliminary costings and explore potential distribution and service delivery models for the new technology. This has proceeded in an amended form using contracted, in-country expertise to provide an assessment of the technology including potential commercialisation models.

Exchange of technology details has been completed and contracted in-country consultants have prepared two separate business cases for the two commercialisation models, namely, Franchisee Service Business (FSB) to treat small volumes of grain on-farm, as well as the second, and Franchisee Lease Business (FLB) to allow larger grain storage companies to self-operate the technology.

6 Achievements against activities and outputs/milestones

Objective 1: To determine the target range of storage insect pests for which SAS may provide control

No.	Activity	Outputs/ milestones	Completion date	Comments
1.1	PC = advice on target insects: A = testing of SAS control potential	Control potential of SAS determined for target insects on identified commodities	June 2021	Completed; full control of rust-red flour beetle (*Tribolium castaneum*); lesser grain borer (*Rhyzopertha dominica*); saw toothed grain beetle (*Oryzaephilus surinamensis*); rusty grain beetle (*Cryptolestes ferrugineus*) and rice weevil (*Sitophilus oryzae*) on sorghum and wheat.

PC = partner country, A = Australia

Objective 2: To explore and demonstrate how the principles, present in the current SAS prototype application machines developed by Davren Global, may be re-engineered to be relevant in Tanzania.

no.	activity	outputs/ milestones	completion date	comments
2.1				
2.2				
2.3				

PC = partner country, A = Australia

Objective 3: To undertake a community consultation process through small landholder focus groups to inform both the development and in-country testing an application device for small landholders and explore issues around distribution / service delivery models for the new technology.

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	PC = focus groups and application testing; A = support activities	Prototype design and testing in-country	June 2021	Performance affected by COVID, Objective incomplete as of June 2021; Objective redescribed as Variation (see Variation section)

PC = partner country, A = Australia

Objective 4: To bring together the new knowledge and learnings in the form of a draft business plan to inform future distribution, support, and financing of the technology.

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	PC = drafting of business case; A = support activities	Draft business case	June 2021	Performance affected by COVID; Objective incomplete; new completion date contracted as part of Variation (see Variation section)

PC = partner country, A = Australia

7 Key results and discussion

Insect control

An earlier ACIAR investment showed that SAS can protect commodities from the common pests of stored grains in Tanzania of maize weevil (*Sitophilus zeamais*) and the larger grain borer (*Prostephanus truncatus).*

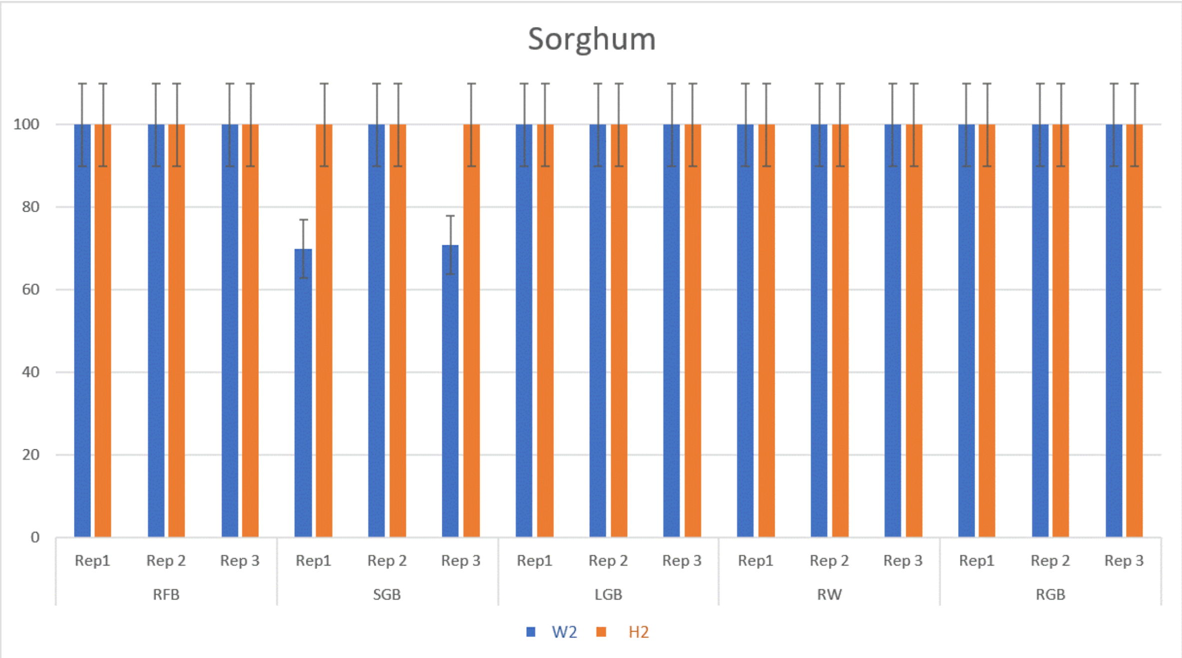
To complement this work, in-country communication identified rust-red flour beetle (*Tribolium castaneum*); lesser grain borer (*Rhyzopertha dominica*); saw toothed grain beetle (*Oryzaephilus surinamensis*); rusty grain beetle (*Cryptolestes ferrugineus*) and rice weevil (*Sitophilus oryzae*) as other economically targets.

Wheat, of which about 90,000 ha are grown in the south of Tanzania and sorghum, which is grown in almost all the semi-arid areas by subsistence farmers in Tanzania for food, feed, and beer were identified as commodity targets to complement the prior work on maize.

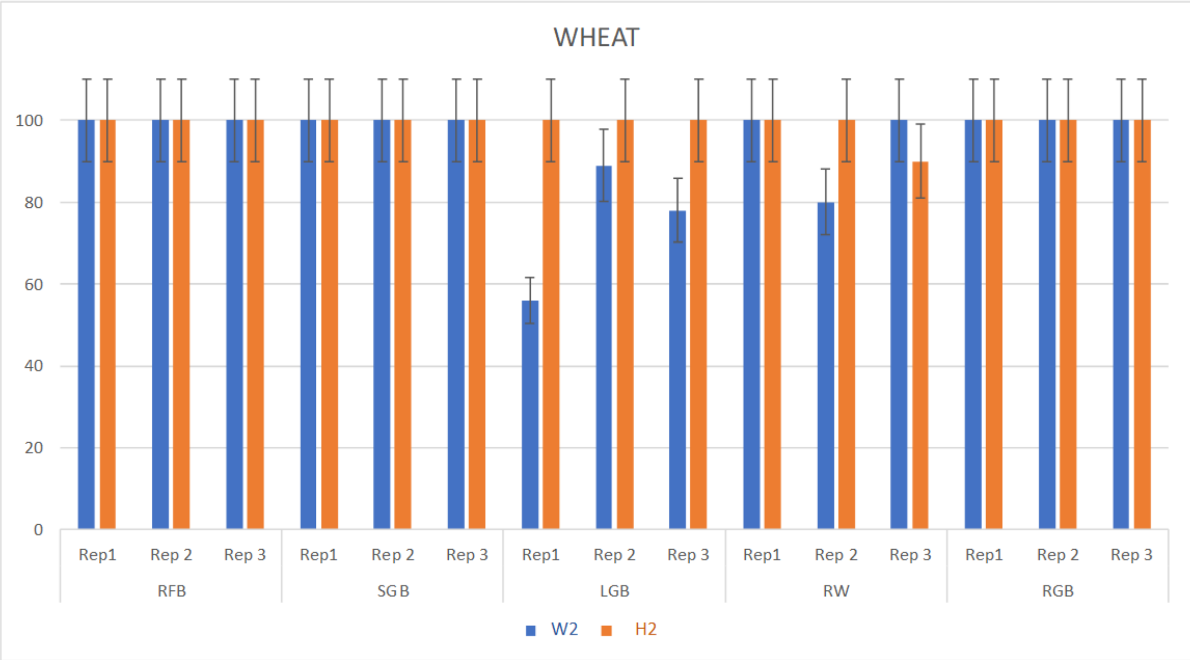
Several SAS products were sourced commercially and tested for the ability to control the target pests.

A commercial SAS product (H2) was identified that provided full control (100% mortality) of all five target pest species on both sorghum and wheat four days after initial exposure (H2; Graphs 1 and 2).

Graph 1: Means and 95% confidence limits for insect mortality (y axis = 0 – 100% mortality) after 4 days exposure to sorghum treated with SAS (product W2 and H2) at 100 g/t incorporated by hand rolling. RFB = red flour beetle; SGB = saw toothed grain beetle; LGB = lesser grain borer; RW = rice weevil; RGB = rusty grain beetle.



Graph 2: Means and 95% confidence limits for insect mortality (y axis = 0 – 100% mortality) after 4 days exposure to wheat treated with SAS (product W2 and H2) at 100 g/t incorporated by hand rolling. RFB = red flour beetle; SGB = saw toothed grain beetle; LGB = lesser grain borer; RW = rice weevil; RGB = rusty grain beetle.



Application Technology.

In Tanzania, as in several other developing economies, maize (*Zea mays* L.) is a staple crop, but yields are low and are further eroded in storage by losses due to infestations by insect pests such as the larger grain borer.

In-country advice is that the traditional practice of storing maize on the cob does not offer protection and does not suit newer hybrid varieties as they have shorter and looser husks.

Accordingly, in Tanzania storage of cobs for seed is not a common practice, with farmers preferring the storage of shelled grain.

One of the attractive advantages if the application device has the facility to treat relatively large volumes of shelled grain (~50 t/hr) but can also be fitted with a hand-held application device that makes treating small on-farm volumes quick and convenient. As the applicator is mobile it can be easily transported from farm to farm.

The device uses a generator to create air pressures which both present selected SAS materials in the preferred aerosolised small particle size and aids in the transfer of the SAS onto the target grain.

An image of the unit connected to a grain auger as part of a field demonstration is provide (Image 1) is that of the device now being transported (see Appendix 1) to Tropical Pesticides Research Institute (TPRI) in Tanzania.

Image 1: SAS field application device that feeds an aerosolised stream of SAS into a moving grain flow being fed by a hopper fitter with an auger

8 Impacts

8.1 Scientific impacts – now and in 5 years

Insect control

An earlier ACIAR investment showed that SAS can protect commodities from the common pests of stored grains in Tanzania such as maize weevil (*Sitophilus zeamais*) and the larger grain borer (*Prostephanus truncatus).*

To complement this work, in-country communication identified rust-red flour beetle (*Tribolium castaneum*); lesser grain borer (*Rhyzopertha dominica*); saw toothed grain beetle (*Oryzaephilus surinamensis*); rusty grain beetle (*Cryptolestes ferrugineus*) and rice weevil (*Sitophilus oryzae*) as other targets.

Wheat, of which about 90,000 ha are grown in the south of Tanzania and sorghum, which is grown in almost all the semi-arid areas by subsistence farmers in Tanzania for food, feed, and beer were identified as commodity targets to complement the prior work on maize.

Several SAS products were sourced commercially and tested for the ability to control the target pests.

A commercial SAS product was identified that provided full control (100% mortality) of all five target pest species on both sorghum and wheat four days after initial exposure.

Through Davren's on-going relation with TPRI that institute will continue to examine the utility of SAS under different conditions, including for example variable humidity. This has been facilitated by the ACIAR funding as included in the shipment to the TPRI is a Davren-purchased humidity chamber.

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The device uses a generator to create air pressures which both present selected SAS materials in the preferred aerosolised small particle size and aids in the transfer of the SAS onto the target grain.

8.2 Capacity impacts – now and in 5 years

Certain SAS materials have been reported to loss of functionality and performance in high moisture environments. To investigate the effect of moisture the project has purchased a small temperature / humidity-controlled cabinet suitable for detailed laboratory experiments. The cabinet will be transported to our in-country partners (the Tropical Pesticides Research Institute (TPRI), Tanzania) where research to explore the impact of humidity of the SAS materials to be used in Tanzania will be undertaken.

The application unit and humidity chamber will remain in-country at the conclusion of the project where it will add to the scientific capacity at the TPRI, including an increased ability for the establishment and maintenance of insect colonies required for ongoing research activities.

8.3 Community impacts – now and in 5 years

No community impacts were achieved during the reporting period due to COVID-related inabilities for in-country activities.

8.3.1 Economic impacts

As noted, two business cases have been prepared by an in-country consultant. Under the terms of the licence provided to TPRI, in consultation with Davren the SAS application can be used for pre-commercialisation trials to demonstrate *in situ* the commercial potential of the equipment. The results from this will provide confidence concerning the commercial attractiveness of the either or both the business models. Based on that, bespoke commercial licences and additional machines could be made available for/to local franchisees / licensees.

8.3.2 Social impacts

Subject to the findings / outcomes referred to in section 8.3.1 in future years, new businesses based on the SAS applicator technology might be anticipated and drive the prosperity of those involved. However, importantly it is Davren’s expectation that if a SAS insecticide can be registered for use in Tanzania then via the commercialisation activities that follow, there will be a substantial increase in the level of affordable grain protection technology that will see a marked reduction in grain losses. Accordingly, this allows for a commensurate increase in the net availability of grain for subsistence and small-landholding farmers, which will engender an increase in the quality of life and prosperity in the regions that take up the opportunity,

8.3.3 Environmental impacts

In the longer term if SAS technology is taken up it will see a proportional reduction in the use of conventional (toxic) grain protectants. The removal of these conventional toxins and carcinogens from the environment will bring a wide range set of health and other environmental benefits to the region.

8.4 Communication and dissemination activities

The in-country consultant conducted a detailed study to generate the data and asses the market-opportunity.

The study was conducted in five districts of Monduli, Same, Kiteto, Mvomero and Babati. The districts were selected on the basis of presence of maize smallholder farmers, mechanisation hire service providers, variation in agroclimatic zones and proximity for timely data collection.

Business case analysis was used as an analytical framework to obtain information from key sources on the feasibility and profitability of two business models, namely Franchisee Service Business (FSB) and Franchisee Lease Business (FLB).

Business case analysis framework was used to assess the costs, risks, and benefits of a decision which then allows the business stakeholders to review and determine whether they should proceed.

Both primary and secondary data were collected. Primary data comprised structured interviews using 150 randomly selected smallholder farmers households from five districts of Monduli, Same, Kiteto, Mvomero and Babati.

Key social economic information was collected in order to understand the factors affecting the adoption of crop protection technologies; the awareness and willingness to adopt pest control options such as SAS-based applicator; the types of pesticides used; the typical costs inherent in pest control management including production (tonnage of produce per year; the length of pesticide efficacy of their current pesticides last; duration before reapplication of the pesticide; and associated but disaggregated pest control cost such as the cost of the pesticide, cost for application of the pesticide, packing/bagging material and warehouse storage costs.

9 Conclusions and recommendations

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9.1 Conclusions

The ACIAR funded program has facilitated the design and construction of a prototype SAS-grain applicator that exploits Davren's discoveries that SAS offers an exciting new, safe class of grain protectant.

The work has demonstrated (in trials in Australia) the significant capacity SAS has to protect stored grain in Tanzania. The ACIAR funding has been critical in allowing the equipment to be transported to our collaborators in Tanzania (TPRI) who now can continue to research the scope and effectiveness of SAS and continue to fine-tune the technology for application in their region.

The business cases that were supported under the grant also articulated locally-informed business models that can be further elaborated to increase confidence in the commercialisation potential.

9.2 Recommendations

Under the terms of the licence between Davren and TPRI, the latter has made a commitment to share with Davren the findings of its subsequent studies. That on-going communication will potentially identify follow-on designs to improve effectiveness of the technology and/or support future commercial opportunities in-country.

Subject to the merit of those opportunities it is recommended that ACIAR remain connected to the progress made and consider future funding proposals to accelerate the uptake and scaling of a commercial program in Tanzania and indeed as it may apply to other African nations within ACIAR's remit.

10 References

10.1 References cited in report

References as integrated as hyperlinks in this report

10.2 List of publications produced by project

NA

11 Appendixes

11.1 Appendix 1: Confirmation of Shipment details for transfer of SAS applicator and Humidity chamber to TPRI - Tanzania

International Trade Management
Delivering Success™

Export Sea Booking Confirmation

DATE: 16/12/21 08:22:01

TO	: DAVREN GLOBAL PTY LTD	**SHIPMENT REFERENCE**	: BRSE62224
ATTENTION	:	**CONSOL REFERENCE**	:
		BOOKING REFERENCE	: EBKG02312149
FROM	: Karen Packham	**ORDER**	:
EMAIL	: karen.packham@itm.com.au		
PHONE	: +61 7 33489899		

SHIPMENT DETAILS

CONSIGNOR:
DAVREN GLOBAL PTY LTD
LEVEL 1, 8 PHIPPS CLOSE
DEAKIN ACT 2600
AUSTRALIA

CONSIGNEE:
TROPICAL PESTICIDE RESEARCH INSTITUTE
NAIROBI ROAD
NGARAMTONI AREA
TANZANIA
TANZANIA

HBL/HAWB	: 62224	**ORIGIN**	: SYDNEY AUSTRALIA, AU	**ETD**	: 22/01/22
OBL/MAWB	: MEDUGR399486	**DISCHARGE**	: DAR ES SALAAM, TZ		
VESSEL/VOY	: APL MIAMI / MA202R	**DESTINATION**	: DAR ES SALAAM, TZ	**ETA**	: 07/03/22
CARRIER	: MEDITERRANEAN SHIPPING CO.				

GOODS DESCRIPTION : 1X 40'FT HIGH CUBE

TOTAL PIECES : 3

GROSS WEIGHT(KG) : 3130.0
VOLUME(CBM) : 0.000

CONTAINER	SEAL	MODE	TYPE	MARKS AND NUMBERS
TBA		FCL	40HC	N/M

COMMENTS:
CUT OFF: 18/01/2022

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