

APPENDIX 2

DIFFERENT PRACTICAL METHODS FOR AMMONIA TREATMENT

A - Batch treatment under plastic sheeting

This is the most simple and flexible treatment method to put into practice.

It consists of the following procedure:

a/ Construct a stack of straw on top of a plastic sheet laid out on the ground, choosing a flat surface which has been cleared of clods, stones or any other rough or sharp materials. Build it up in layers until it is as high as possible (with various layers of cubic bales or rows of round bales).

- cover the whole stack with a second and much wider plastic sheet, making sure that coverage is the best possible,
- wrap up the whole stack so that it is entirely covered, tucking in together the cover and the sheet on the ground so that a hermetic seal is achieved. For this, it is best to have an overlap of at least 70 cm between the two sheets.

A metal or PVC pipe (about 20 mm in diameter) with 5 mm holes pierced every 50 cm, is now placed into the middle of the stack along its length. This can be done whilst the stack is being built if the pipe is flexible, alternatively a rigid pipe can be forced in after the stack has been completed. This pipe is then connected to the ammonia tank, ready for injection (Photo 2).

b/ Inject the ammonia at a rate of 3 kg NH_3 per 100 kg bulk weight of straw (see below),

- either inject it as a liquid which is quicker, by branching the pipe through the lower valve (liquid phase) of the tank. The ammonia evaporates immediately at ambient pressure and drops the temperature of the stack (down to -33°C , the boiling point of ammonia, where it exits through the small holes in the pipe). Because the chemical reaction between the ammonia and the straw is exothermic, the temperature of the stack will then quickly rise again;
- or inject it as a gas which is slower and can last several hours or even days, depending on the amount of ammonia to be injected. This is done by branching the pipe through the upper valve (gaseous phase) of the tank.

Because injecting ammonia as a gas is slower, it certainly improves treatment efficiency (giving more regular adsorption of the alkali by the cell

matter) but it means that the ammonia tank has to be left in place, so immobilising it for use elsewhere. To give an order of magnitude of times, about 9 minutes are needed to treat 1 ton of straw with liquid ammonia whereas it takes about 6 hours if ammonia gas is injected.

In cases where supplies to farms of the ammonia are irregular, it is possible to resort to using gas bottles similar to those for 30 kg of propane gas (Photo 3) which also allow one to carry out emergency treatment operations for about 1 ton of straw. This type of treatment however, is much more onerous for the farmer.

The ammonia tanks must comply with a whole series of standards: resistance to pressure, good operational condition of the valves (for filling, emptying, safety, ...) and the gauges and meters for measuring the quantities delivered. These must be regularly checked for accuracy. The other equipment must also be regularly checked and maintained, such as the flexible pipes for filling and delivery, the connections for the pipe in the stack and the transport equipment (the trucks and their platforms, the tractors and their trailers). These standards form the subject of User Manuals prepared by the different companies involved in the distribution of ammonia (Ammoniac Agricole, Norks Hydro,...).

The personnel handling the ammonia must be well trained and must respect all the safety regulations, in particular wearing gloves and face masks (Photo 4), specially when transferring ammonia from one tank to another.

The plastic sheeting used should conform to certain standards of quality (quality labels, non-porous) and of thickness (150 microns). Egypt uses transparent sheeting (Photo 5) which does not pose any problem due to the high ambient temperatures.

The size and shape of the stack depend on the size of the bales and the width of the plastic sheeting. This is generally sold in 50 kg rolls and in widths of 8, 10, 12 or 14 m.

The size will also depend on the capacity of the small tanks (500 kg or 1 ton) which have to return to the storage centres for filling up (from the "mother" tanks of 2 or 4 tons) and on the distance to the farms (normally a maximum of 50 km) and on the number of treatments which they have to undertake during each outing.

B - Treatment by direct injection into round bales ("Armako")

This is a technique which has been perfected by the Danish for round bales. These are mainly used in Western countries, in the French Antilles and in the Ile de la Réunion. Round bales hardly exist at all in the Southern zones, the Eastern Mediterranean region nor in the tropics.

The ammonia is injected directly into the bale with a tractor front-end mounted fork equipped with 5 hollow prongs. The prongs are connected through to a tank of anhydrous ammonia mounted at the rear of the tractor. Injection is rapid and is carried out during routine handling of the bales (Photo 6) which are individually sealed up from end to end in a large black plastic sheet of appropriate size with assistance from a special device that unrolls the sheath around the bales. A single operator can treat about 40 bales of 300 kg per hour. This figure should be halved however, if one also counts the time to wrap the plastic and for filling up with ammonia. The diffusion of the ammonia in the bale is rapid and better than when treating a complete stack. Recommended amounts of ammonia in Europe which are 3 to 5 kg for treating a stack, have been reduced to 2.5 to 3.0 kg per 100 kg of straw by the "Armako" treatment method. This technique requires significant amounts of high quality plastic sheeting (strong and non-porous).

C - Treatment in an insulated container

This treatment method is only mentioned for completeness as it is aimed at countries which are cold. It involves very high investment and operational costs and has now been abandoned in Europe in favour of treatment in stacks and in "sausages".

Treatment is undertaken in a calorific enclosure either made on the farm or industrially. The enclosure, which is well insulated, can be heated by electricity (to 85-90°C) or left unheated. In this latter case (the "Cordesse" method), it is the heat from the chemical reaction of the ammonia on the straw (which is exothermic) which raises the temperature within the enclosure. Treatment time then takes between 4 and 5 days. For cases when the enclosure is heated to 85-90°C during a period of 15 hours, this is followed by 4 hours of pickling and it is then ventilated for 4 hours with fresh air to drive away any ammonia which has not been fixed.

Several containers may be placed together in series. Each one has a capacity which varies from 400 kg to 2 tons of straw.

This technique was particularly interesting for the flexibility which it offered in organising the treatments (small volumes, short cycles). Apart from the inconvenience of its high cost, there was also a risk at these high temperatures, of the formation of highly toxic imidazole through combination of the ammonia with the soluble carbohydrates which might eventually be present in the forage to be treated (the case of hay from grasses harvested prematurely).

It is convenient to note here that in all cases, ammonia treatment implies:

- significant infrastructure which represents a high capital investment cost;
- efficient organisation (by the cooperative or entrepreneur) with a careful plan for turn around time and preparation;
- dependence of the livestock farmer on an organisation which is external to the farm.