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Band Spreading- A Sustainable Technology for Crop Fertilization and Irrigation

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Abstract: The application of liquid manure for agricultural farming is common knowledge in highly industrialized countries of Europe. The advantages of band spreading are well tested: unsurpassed precision in crosswise distribution, less dislocation to the ground water, better nitrogen utilisation and less odour to surroundings. If we assume further increasing prices of artificial fertilizers band spreading has a great potential to cut back the fertilizer costs. A regular distribution device is made up of a distributor head and the folding ramps. The distributor head cares for supply of liquid manure to the hoses with high accuracy. As a rule the coefficient of variation between hose flow rates of modern distributor heads is better than 10 %. The folding ramps fitted to the tankers care for spreading out the hoses up to 36 m working width. The band to band width differs according to crop type from 20 to 30 cm. New applications make use of band spreading devices as irrigation systems during plant grow on.
Key words: ammonia emission, band spreading, liquid manure, slurry distribution, irrigation

BACKGROUND

The company Vogelsang is located in the north-west of Lower Saxony, a highly agricultural structured area in Germany. In this region the animal concentration for meat production is extremely high. 30% of the German pork and 20% of German beef are produced here. The animal population creating liquid manure in Lower Saxony consists of 2.5 million cattle (30% are dairy cows) and 8.2 million pigs (45% are fattening pigs). 29 million tons of liquid manure has to be spread to land only in Lower Saxony *(NS Minister for Agriculture, Statistic 2005).*

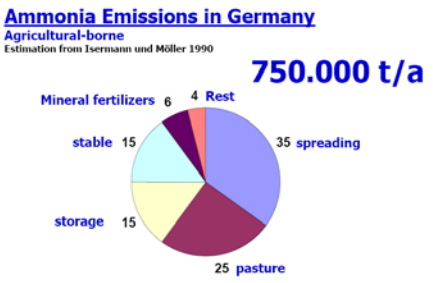

Figure 1. Ammonia Emissions in Germany

From years of experience the farmers know that animal borne waste is an excellent fertilizer for all kinds of plant which becomes more and more valuable. Just during the last two years the prices for mineral fertilizer are increased by 50% (N and K) up to 100% (P_2O). Unfortunately one important ingredient – N – is volatile as ammonia and can be dislocated to the groundwater as ammonium nitrate. It is estimated that in Germany 35 to 40 % from the total yearly ammonia emission of 750.000 tons is caused by spreading (**Fig.1)** *(Isermann, 1990).*

Nearly half of these emissions are caused by cattle breeding *(Döhler, 2003)*. And ammonia causes acid rain and is the reason for wood disease. This was the reason why in the early eighties the local authorities charged the agronomy to look for methods to reduce ammonia evaporation. Besides of tightening the storage tanks by a cover they concentrated on the development of better slurry distributors. The first idea was to improve the customary splash plates. On the bottom sketch of **Fig. 2** you can see five splash plates mounted on a boom each spreading array overlapping its neighbour array. That gives a better spreading precision.

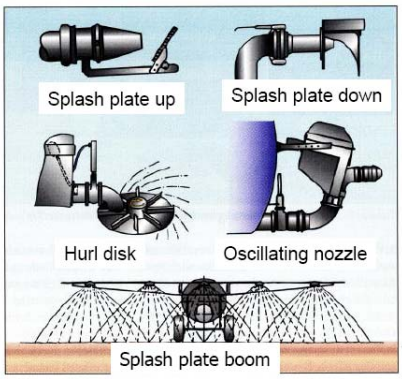

Figure 2. Splash plate versions (AID, 1996)

But applicators using nozzles have one big disadvantage: the plant leaves are sprinkled with manure. This can cause leave burnings on sensitive plants. Additionally the splash plate methods create large manure polluted surface which leads to increasing ammonia evaporation.

Dribble Bar Systems

It was a member of the local agricultural chamber - *Dr. Hoffmann* - who was convinced of the fertilizing power of liquid manure which the farmers around get plenty of. He always said: You have to apply the slurry into the plant's mouth. The fertilizer fluid should flow down to the ground close to the plant's roots without polluting their leaves. The only ways to perform this demand was leading the manure through hoses and apply it in band-shape: "Dribble bar distribution" was born.

It was in the early eighties when Vogelsang picked up this idea and started the development of dribble bar distributors.

The first test equipment was fitted with a cylindrical nozzle distributor with 24 outlets feeding the hoses simultaneously (**Fig. 3**).

To get good distribution accuracy with this method the nozzle diameter has to be rather small because otherwise you get not enough pressure difference for all nozzles. As a bad consequence the nozzles get blocked when using real manure instead of water.

Figure 3. First Dribble Bar Distributor

Rotating Nozzle Distributors

The next step was a distributor with rotating nozzles driven by a hydraulic motor. The principle is shown in **Fig.4**. The conveying into the hoses is no longer simultaneous but in quick succession. That gives a pulsing flow inside the hoses.

The pulse duration is very short. If 2 nozzles rotate with 300 rpm the pulse rate is 5 per second. If we postulate 40 outlets and assume that only 4 of the outlets are fed simultaneously a pulse period of 15ms is expected in each hose.

The single ration which is fed in 15ms every time into the hoses has a length of about 50 to 100 mm depending on the flow rate (e. g. 150 to 300 m^3/h) which is pumped into the distributor head.

The principle creates a suction pressure inside the hoses. So air is sucked in between the single slurry portions as the distributor housing is aerated to the atmosphere. This creates a steady flow inside the hoses and gives a vibration-free operating.
The fluid leaves the hoses on the ground as a continuously flowing stream.

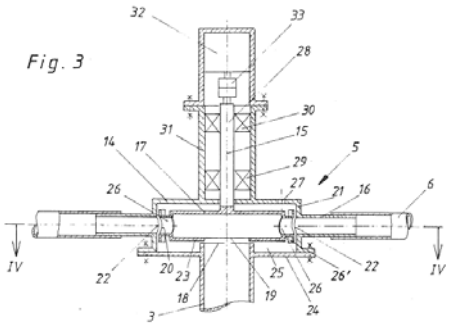

Figure 4. Principle of First Slurry Distributor with Rotating Nozzle

High Distribution Accuracy

The new principle has lots of advantages, for instance:

- High distribution accuracy
- Requires only low feeding pressure
- Can handle viscous fluids like liquid manure
- No blockage within the hoses because of the pulsating flow even at 40 to 50mm hose diameter

A European Patent was claimed for this principle in those days (*EP 0079018,* (1982)).

In the next years a lot of presentations were made with the new band spreading system. The users were pleased as long as the manure was not so much loaded with solids. Difficulties came up with cow slurry where fibres and feed leftovers caused blockages between rotor and housing.

So we modify the construction in order to get better cutting results and to get better access to the rotor in case of blockages. The result is shown in **Fig. 5** on a principle draw and two different worked-out versions.

The version on the right named *DosiCut* has a special cutter on top. It is made particular for applications where a vacuum compressor is used to fill and to empty the tank because this filling system has a poor mixing and stirring ability.
Both versions are equipped with a lid on top to get easy access to the spare parts.

Further benefits to the user are:

- Good cutting capability for fibrous (self sharpening chopper system)
- Smaller building space for hose connection
- Easy production, reduced price
- Easy access to wear parts

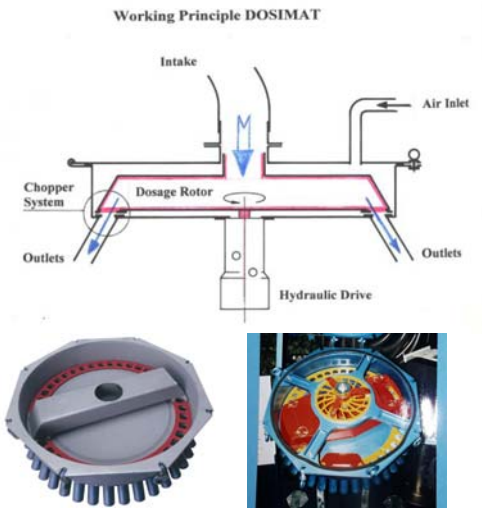

Figure 5. Principle of *Dosimat* Construction

In spite of simplifying the construction the accuracy of the system was still good. The measurements at university Hohenheim (*Grieser*, 1994) carried out with a distributor with 40 outlets show that even at high dry matter content up to 9% the variation coefficient VC is better than 5% (**Fig.6**).

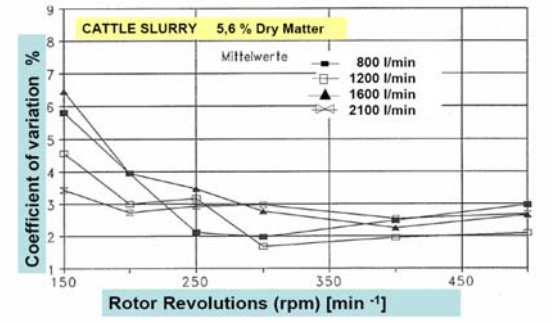

Figure 6. *Dosimat* Accuracy Curves

Because of the maximum working width of 12 m the band spreaders at that time were fitted usually with one central distributor head. **Fig. 7** shows a typical band spreader unit fitted with a *Dosimat*.

Figure 7. Band Spreader Unit with a Central Distributor

Further challenge was increasing working width. The farmers and more and more contractors too asked for tanker lorries with high capacity, fitted with band spreader with working width beyond 12m. If the boom is fitted only with one central distributor you get a negative effect on the spreading accuracy because of difference in flow resistance between short and long hoses, particularly at high viscous slurries (*Türk, 1994*). So the idea comes up to install separate distributors which are able to be set up into the slewing boom construction in duplicate. Therefore smaller units are needed. In addition they should be able to handle both thick and thin media and should contain a stone catcher too.

ExaCut - the Distributor for all Kind of Slurries

Fortunately Vogelsang has experience with handling such heavily polluted animal waste from the stables in East Germany. A chopper principle called *RotaCut*® was developed in the early nineties. The idea was to combine the chopper principle with the *Dosimat* principle. The result was the *ExaCut* distributor. The principle is shown in **Fig. 8**.

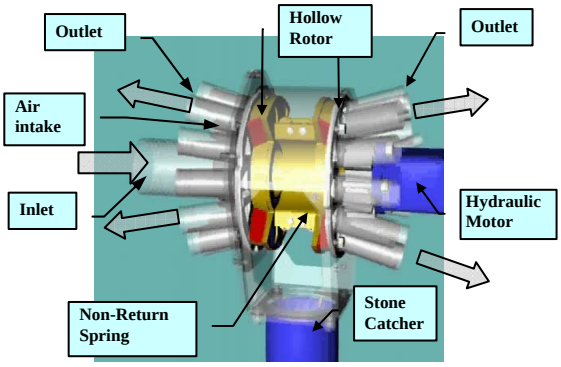

Figure 8. Principle ExaCut distributor

The *ExaCut* principle is the reverse of the *Dosimat* principle: slurry gets into the housing; the rotating hollow rotor is aerated. The *ExaCut* distributor in its optimum version contains these features:

- excellent chopping capability for all kinds of solid slurry content, self-sharpening knifes
- good distribution accuracy
- integrated stone catcher
- small building space, fits in the slewing booms on both sides of tanker lorries

Other Distribution Principles for Band Spreaders

- ***Stade*-Distributor**

Assessment: flow rate according to rotating angle should balance different hose length, no chopping device, no casing aeration, no stone catcher. (*Stade, K.,* 1986)

- **Time controlled nozzles, "Taktomat"**

Assessment: integrated flow control, high mechanical and abrasive stress on the switching

elements, sensitive against solids, gains no acceptance with customers. (*Schnelle,W.* 1984)

- **Pipe distributor**

Assessment: Slurry inside a horizontal Pipe, slurry gets out simultaneously through small nozzles into vertical hoses; nozzle blockage is prevented by a rotating screw, screw conveys foreign bodies to its end (stone catcher); limited distribution width, limited spreading accuracy. (*Fliegl, J.* 1996)

- **Eccentric Disk distributor**

Assessment: Principle similar *ExaCut*: two eccentric moving disks connect and disconnect the outlets with/from supplied manure, aeration of the outlets when disconnected; sinus shaped flow rate, frequency half of *ExcaCut* pulse rate; excellent chopping ability, stone catcher integrated, low wear sensibility; limited number of outlets because only single row distributors are feasible. (*Sörensen, H.* 1993)

Application Methods

Besides of the climate condition during spreading the application method has significant effect on the ammonia losses (**Fig.9**). In comparison to splash plate application ground injection is the optimal way to avoid ammonia losses.

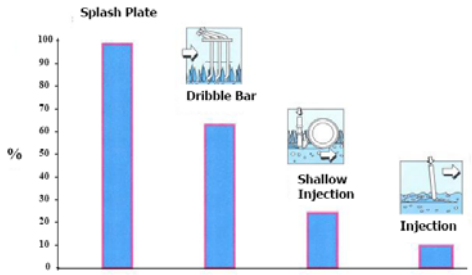

Figure 9. Ammonia losses of different Application methods

But injection is only feasible on arable land, allows only small working width and needs high pulling forces. To find out what is the best application method for crops or grassland in the early nineties a pilot project was carried out in our region. The best compromise seems to be a method called ***Sliding Feet***. 40% reduction of ammonia loss was measured. Samples are shown in **Fig. 10**.

Figure 10. Sliding feet applicators

Dribble Bar Spreading Gets its Way

In 1996 the Bavarian Ministry of agriculture started a programme to increase the number of band spreaders in Bavaria. Beside investment subsidies up to 22.5% additionally 1 €/m³ was granted to the farmers who use band spreaders. An accuracy of VC < 15 % was the condition for the subsidy. This German programme has of course achieved positive effects on further development.

Governmental funds are supporting the use of environmental friendly slurry application also in other countries. So Vogelsang put a lot of effort in developing high efficient spreading technology.

Although there are a couple of competitors Vogelsang still is the market leader on the market segment "Active Distributors". We have produced 20.000 distributors until now. If we assume a market share of 50% nearly 40.000 distributors with rotating elements have been produced until now. We guess that roughly 30.000 band spreading systems are on duty world wide.

Slewing Booms for Increasing Working Width

At first our emphasis was to sell distributor heads only and let our hands off the booms. But after a short period of time we learned from complains this: A dribble bar systems means nothing if there is no efficient and robust handling the fold-up and fold-in method of the trailing hoses.

So we are forced to turn our attention also on developing better slewing boom constructions.

Fitting only one distribution head and using single hinged booms the maximum working width is limited to 15m because otherwise the slewing booms would obstruct the tractor's manoeuvrability. Additionally the long hoses to the outside parts have a negative effect on the distribution accuracy.

Two distribution heads therefore are recommended from 15m on. That gives optimum spreading accuracy even when the hoses are arranged in a way that all have nearly the same length. Furthermore it prevents a V-shaped fertilizing print on the ground at spreading start which occurs when different hose lengths are installed.

Figure 11. Dribble bar Spreader in Transport Position (*SwingUp* Hose Ends)

The optimum distributor head for such application is the *ExaCut* -Version because of its small building space (**Fig 11**).

A special construction of Vogelsang is fixing the hoses first on the boom hinging on a vertical axis and secondly fixing the hose ends on a different boom which is able to move up and down. So all hose outlets point up when the frame is folded into transport position (*SwingUp* feature).

Fig. 11 shows further features of modern folding ramps. At first you see that the booms with *SwingUp* feature don't widen up the transport width of the tanker trailer. The fold-in hose unit fill up the space above the mudguard. Secondly you can see that the hose-to-hose distances at both ends of the *SwingUp* boom are minimized. The boom ends can be extended telescopically when fold out (*TeleShift*). With this technique one can achieve up to 24m of working width. **Fig. 12** shows a tanker unit fertilizing a maize field.

Figure 12. Dribble Bar spreader in a maize field

But the contractors want more. The manufacturers of pesticides spraying equipments demonstrate that a working width beyond 24 m is feasible. And the reason why the contractors asked us to follow was: they don't want knock down crops by using an additional track in between the given tramlines.

Figure 13. Band Spreader 27 m working width

Top-Fold Booms for 27m Width

So our engineers have to meet the next challenge. After trying out different methods they found the best in a boom extension with a horizontal hinge, which means that the boom extension swivel 180° to the top. When moving a boom in a vertical plane (*Top-Fold*) there is no addition torque created on the base frame and additional weight consuming bridging is not necessary (**Fig. 13**).

During the season contractors who are specialized on slurry spreading use to bring out more than 1000 m³/day; in three shifts up to 2000 m³/day is possible. The transport of the slurry to the fields is managed by separate tankers and operates with a docking station to refill the spreading unit.

DoubleSwing Booms for Extreme Working Width

If working width (**w**) beyond 27m are requested we slowly come up to limits because the distance (**d**) which is able to be fertilized with one tank content (**V**) with a certain dosage (**D**) becomes too small {**d=V/(D·w)**}. In this case we propose to our *DoubleSwing* principle and operate in two steps.

As shown in **Fig. 14**. A working with up to 36m is now possible. The actual 18m-boom is devided in two 9m-booms which are fold out into a position as shown. The first-step areas become fertilized and the 18m second-step area is left over.

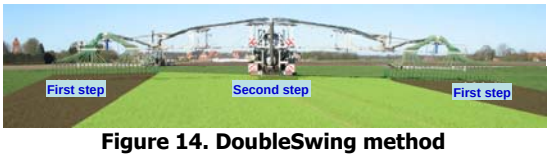

Figure 14. DoubleSwing method

After emptying the tank the next step is done with the single slewed boom and the inner area is finished. So the spreading unit is using only one tramline which is dry.

Manure Hosing for Continuous Operation

Some contractors substitute tankers by irrigation systems using hose reels and umbilical hoses. The slurry is pumped from the storage tank straight to the band spreader which is fitted on a tractor (**Fig.15).**

In this case the tractor is pulling a lay-flat hose. Because of its crosswise movement in bends this method is only suitable in arable land, grass land or on other low crops. 400m lay-flat hose of 90mm diameter is possible to pull.

The system has a capacity of 120m³/h. Particularly on sloped fields where tankers couldn't drive this method is the only practicable one.

There is a Danish invention (*Eriksen, G.* et al. (1991) WO 92/10082) which avoids the crosswise hose movement completely and therefore is able to operate in high crops too.

Figure 15: Slurry "hosing"

This system works with a hose reel which is mounted on a trailer together with the band spreader. On the way there the hose unwinds and on the way back the hose winds up. On the ground the hose doesn't move.

Special Applications of Band Spreaders

The potentialities for band spreaders are not exhaust. One example application is cultivation of lettuce. The producer found out that watering of plants immediately after planting saves up to 15% dry-up loss. Common systems with irrigation jets can't bring water quick enough to the roots and waste too much water. The system shown in **Fig.16** was the solution. The farmer can drive the tanker with a velocity of 5 to 6 km/h. Steering is simplified because of the front fit of the hose boom. Applying water rates between 20 and 25 m³/ha the farmer is able of continuous irrigation of 900 to 1125 m field length. The system has a capacity of about 2 ha/h.

Figure 16: Band irrigation of vegetables

We are told that in spite of the high cost of more than 100.000 Euro the investment pays off within two years. It's only because this method makes 100% of the young plants grow on. The customer's fields are positioned near Hamburg. And to make the most of his investment he transported the whole equipment to Spain and raise up lettuce again.

CONCLUSION

We are convinced that band spreading gets its way and will displace splash plate distribution of liquid manure in future completely.

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