MODIFICATION OF A SOLID MANURE SPREADER

FOR USE AS A POST EMERGENCE SPREADER

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ABSTRACT

As the production costs increase and the profit margin decreases, today's farmers are more interested by the utilization of manure as a fertilizer. A way to lose less nutrients from the manure, would be to spread it as the crop is growing. A way to achieve this would be post emergence spreading and can be done as long as the plants can pass under the machinery. This time of year is also a period during which the farmer has more free time, compared with the fall and spring seasons. But post emergence spreading is easily feasible only on row crop.

Studies show that the nutrient concentration is varying a lot depending on the kind of manure. Since the actual manure spreaders are still designed to get rid of the manure as quick as possible, some modifications will have to be performed on an existing conventional solid manure spreader to make it compatible with the goal of post emergence spreading.

The major constraint in using an existing spreader for post emergence spreading, is that its wheels have to track between the crop rows. Some modifications should be performed to increase the manure shredding efficiency of the spreader and some other modifications are required specifically for this type of spreading. These modifications are the possibility to adjust the apron chain to a wide range of speed, protect the plants against the falling manure chunks by installing a plant shield, increase the ground clearance and decrease the soil compaction by installing big flotation tires on the spreader.

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1. INTRODUCTION

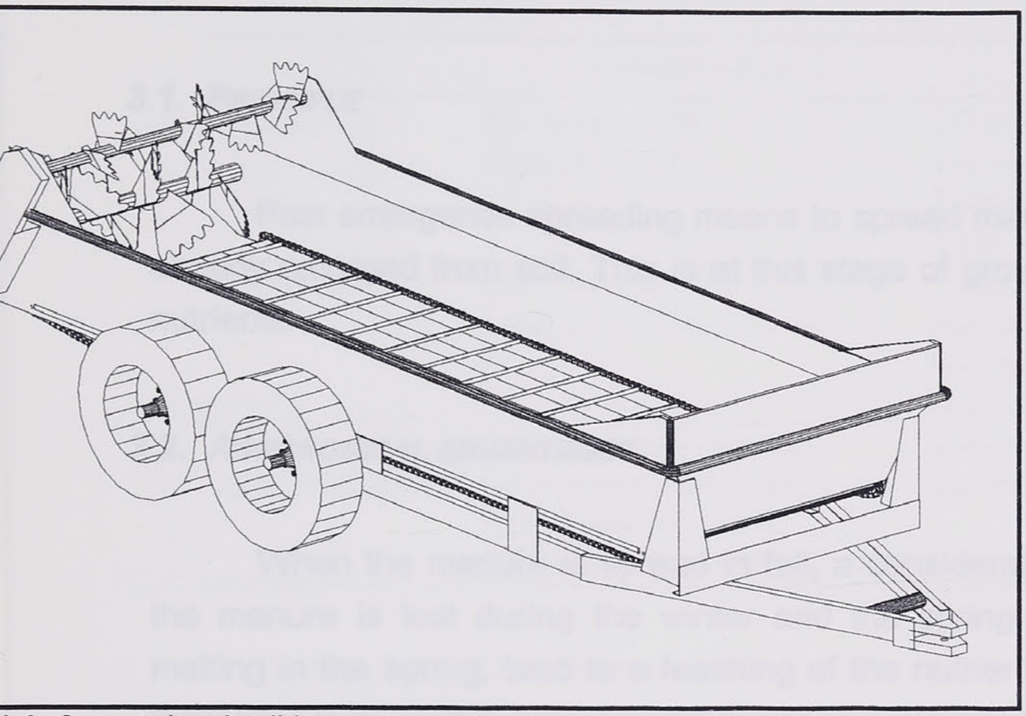
Since the beginning of agriculture in Canada and until recently, each farm was self sufficient and was reusing all of what was produced on the farm. Manure was not an exception, since it was the major source of fertilizer for the fields. In these days, mineral fertilizers were too expensive to be bought by the farmer or were simply unavailable. Also, the area of fields per farm was rather small compared to what it is today.

Then, with the coming of industrialized agriculture, farms grew bigger and bigger and the quantity of manure produced on the farm was not sufficient to fertilize the fields. Also, mineral fertilizers started to be more available and at a cost that farmers could afford. In this period of time, the status of manure dropped from a respectable "essential resource" to a poor "undesirable waste". Mineral fertilizers were more concentrated, easier and faster to spread, did not smell and were clean. In summary, they had all the advantages on their side. The manure now considered like a waste, was spread thereafter just to get rid of it, at unreasonable dosages.

Today, with the increasing production costs, the decreasing profit margin and the degradation of soil, manure is again put in "fashion". Everybody started to be interested in manure and its favorable effects on soil fertility and structure. Research projects and studies were started to determine what is the fertilizing value of manure and what is the rate at which these nutrients are released in soil.

But even today, some improvements are still to be found in the way and the time manure is spread. Traditionally for example, manure was spread during the fall season. Because of nutrient losses during winter, spring spreading is now very popular. But the ideal spreading time would be at the moment the plant needs the nutrients from the manure. Also, the actual conventional solid manure spreaders are still designed to apply manure in a way to get rid of it as quickly as possible.

A conventional solid manure spreader is used to shred and spread solid manure in the field. It is constructed of a box in which the manure is loaded. On the floor of this box, an apron chain brings the manure to the rear part of the box where 1, 2 or 3 beater(s) depending on the model, shred the manure and spread it on the ground surface. A picture of a spreader of this type is shown on figure 1.1, here it is a Sperry New Holland, model 679. Data concerning this spreader are included in Appendix 2. On certain model, the apron chain is replaced by a metal plate that is pushing the manure through the beaters.



1.1: Conventional solid manure spreader

This project is divided in three parts. In the first part, the agronomical efficiency of post emergence spreading will be demonstrated. In the second part, a literature review will be made on the fertilizing and monetary value of solid manure from different animals spread in post emergence. In the third part, a conventional solid manure spreader will be modified to improve its spreading uniformity and to make it compatible with post emergence spreading.

2. OBJECTIVES

- Use an existing conventional solid manure spreader.
- Be able to spread on already emerged row crop.
- Increase manure shredding efficiency of the spreader.
- Be able to handle solid manure at various moisture content.
- All this at a reasonable cost.

3. POST EMERGENCE SPREADING

3.1. PRINCIPLE

Post emergence spreading means to spread manure when the plants are already emerged from soil. This is at this stage of growing that the plant needs nutrients.

3.2. AGRONOMICAL ADVANTAGES

When the manure is spread in fall, a considerable part of nutrients from the manure is lost during the winter and the spring. Heavy rains and snow melting in the spring, lead to a leaching of the nutrients to the water table and thereafter through the underground drainage system to the ditch.

Spreading the manure in spring before the seeding period solve this problem. But during this period of year, the soil is rather moist and the circulation of heavy loads of manure can result in the compaction of the soil, and a loss in crop yield.

When manure is spread after the emergence of plants from soil, less nutrients from the manure will be lost and therefore available to the plants. Also the soil is relatively dry during this period, which reduces the risk of soil compaction. A summary of advantages and disadvantages is listed in table 3.1.

3.3. TIME MANAGEMENT ADVANTAGES

Concerning the time management on a farm, everyone knows that the spring and fall seasons are periods when the farmers are very busy. Therefore, the spreading of manure during these periods adds one more thing to be done during the seeding or the harvesting period.

Table 3.1: Time of year to spread manure

	Advantages	Disadvantages
FALL	No manure storage during winter	30 to 45% nitrogen losses Potassium losses by leaching Harvesting period = busy time Late Fall = wet soil conditions
SPRING	Low nitrogen losses Low potassium losses	Seeding period = busy time Humid soil = soil compaction Danger of seed burn by manure
POST EMERGENCE	Low nitrogen losses Low potassium losses Relatively free time Dry soil = less compaction	Easily feasible on row crop No manure spreader adapted

During the period of year when the plants have emerged from soil, the farmer has more free time. Depending of the plants grown, he has during this period to spray pesticides in the fields. But he also has enough free time to spread manure on the fields.

3.4. *Limitations*

Even if the manure is spread in a post emergence stage, it will have to be incorporated into the soil within 24 hours after spreading to ensure a minimum nitrogen loss through volatilization.

Post emergence spreading will probably be feasible only on row crops, such as corn, for 2 reasons:

1 - The small effective width of spreading requires that passes be close to other. This means running over the plants every three or four meters for a non-row crops, such as wheat. This is not a problem on a row crop since the wheels are circulating between the rows.

2 - The plants have to be protected against the possible drop of a big chunk of manure on them. This is easily achieved only on row crops.

There is no solid manure spreader adapted to the post emergence spreading. This kind of spreading requires several characteristics from the spreader, such as good manure shredding capacity, apron chain speed variation for different kinds of manure, which are not always present on every model.

4. MANURE CATEGORIZATION

4.1. FERTILIZING VALUE OF MANURES

The fertilizing value of manure is varying a lot with respect to the animal that produces it. The table 4.1 taken from Rapport synthèse sur l'utilisation des fumiers, 1982, shows average fertilizing values for three typical solid animal manures in kg/ton. It is interesting to realize that the concentration of nutrients is on average three times greater in chicken manure than in dairy cow manure.

Table 4.1: Fertilizing value of manure at the time of spreading

Animal species	% Dry matter	N total (kg/ton)	P_2O_5 (kg/ton)	K_2O (kg/ton)
Dairy cows	25	5	2	5
Beef cows	30	5	3	6
Chickens (with bedding)	70	17	18	13

It is also important to consider that these values are at the time of spreading, therefore the losses in the storage and the transport had been subtracted. But this is not the quantity of nutrients that will be readily available to the plant. A factor of nitrogen loss must be applied depending of the time of year when the manure is spread (e.g. fall) and in how much time the manure is incorporated into the soil after the spreading (e.g. 24 hours). Furthermore, an efficiency coefficient should be applied to all nutrients before knowing what will be available to the plants. These factors and coefficients taken from Dubé and Bernier, 1983, are listed in appendix 1.

The table 4.2 illustrates the total nutrients available to the plant for different manures. In this calculation example, it had been supposed that the manure was incorporated into soil less than twenty four hours after spreading and the coefficient of efficiency for each manure was taken in appendix 1.

Table 4.2: Nutrients available to the plants in manure

Animal species	N (kg/ton)	P_2O_5 (kg/ton)	K_2O (kg/ton)
Dairy cows	2.1	0.5	2.3
Beef cows	2.1	0.7	2.8
Chickens (with bedding)	12.4	11.7	11.7

4.2. *MONETARY VALUE OF MANURES*

In the table 4.3, fertilizers value of manure in dollars per ton was calculated with the values obtained in table 4.2. The prices taken for this calculation are:

N -> 0.75 $/kg

P_2O_5 -> 0.31 $/kg

K_2O -> 0.34 $/kg

Table 4.3: Fertilizer value in manure

Animal species	N ($)	P_2O_5 ($)	K_2O ($)	TOTAL ($)
Dairy cows	1.58	0.16	0.78	2.52
Beef cows	1.58	0.22	0.95	2.75
Chickens (with bedding)	9.30	3.63	3.98	16.91

4.3. Dosage calculations example for corn

The crop removal method is used to calculate the fertilizer needs for corn:

N -> 290 kg/ha

P_2O_5 -> 80 kg/ha - 20 kg/ha (starting dose, mineral) = 60 kg/ha

K_2O -> 162 kg/ha

The different manures will be dosed according to the nutrients content listed in table 4.2. The dose will be calculated to provide the totality of one of the three nutrients requirement, and the remaining quantity necessary to fulfill the requirements for the two other nutrients, will have to be provided by mineral fertilizers. The table 4.4 lists the calculated doses. Again, it can be seen that the doses are varying a lot according to the kind of manure.

Table 4.4: Manure dosage for corn

Animal species	Dosage (ton/ha)	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
Dairy cows	70.5	148.0	35.2	162.2
Beef cows	57.9	121.6	40.5	162.1
Chickens (with bedding)	5.2	64.5	60.8	60.8

5. MODIFICATION OF A SOLID MANURE SPREADER

5.1. Major constraint

The major constraint in using a conventional manure spreader as a post emergence spreader is that it must track between the rows of the crop. Not all spreader models can, for example, track on rows of corn spaced at 30 inches like on figure 5.1. This row spacing is varying for each crop and is even varied for the same crop. The wheel spacing of a spreader can be modified to track on row crop, but this modification becomes too expensive if the axles must be lengthened too much. In this eventuality, it is not worth it to modify the spreader and another one with the right wheel spacing had to be bought. Another factor is that the wheels of the tractor can be spaced large enough to track on rows.

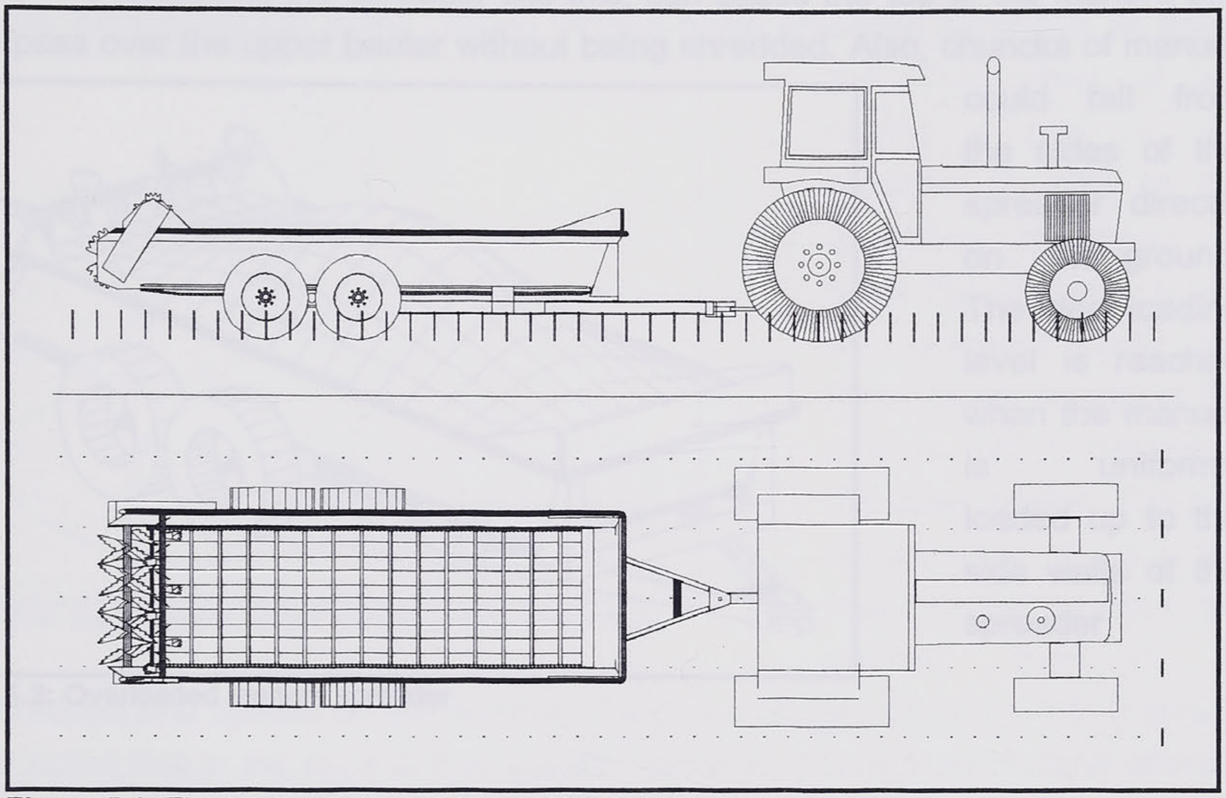


Figure 5.1: The tractor and spreader tracking between corn rows.

5.2. *IMPROVEMENT OF MANURE SHREDDING*

Good manure shredding is important to improve the spreading uniformity. Several modifications are listed below and are followed by a percentage effect on manure shredding taken from Denis, 1993.

5.2.1. Overloaded spreader

The effect of overloading the spreader is -47% on the shredding efficiency. According to this number, one of the major modifications to make in order to improve the shredding efficiency is to change the farmer's habits. In attempting to spread as much manure as possible per load, they usually overload the spreader. Here, the word overload is not used for weight but for volume. A good example of overloading is shown on figure 5.2.

Overloading the spreader like this, can cause the top of the manure pile to pass over the upper beater without being shredded. Also, chuncks of manure could fall from the sides of the spreader directly on the ground. The ideal loading level is reached when the manure is uniformly loaded up to the side walls of the spreader.

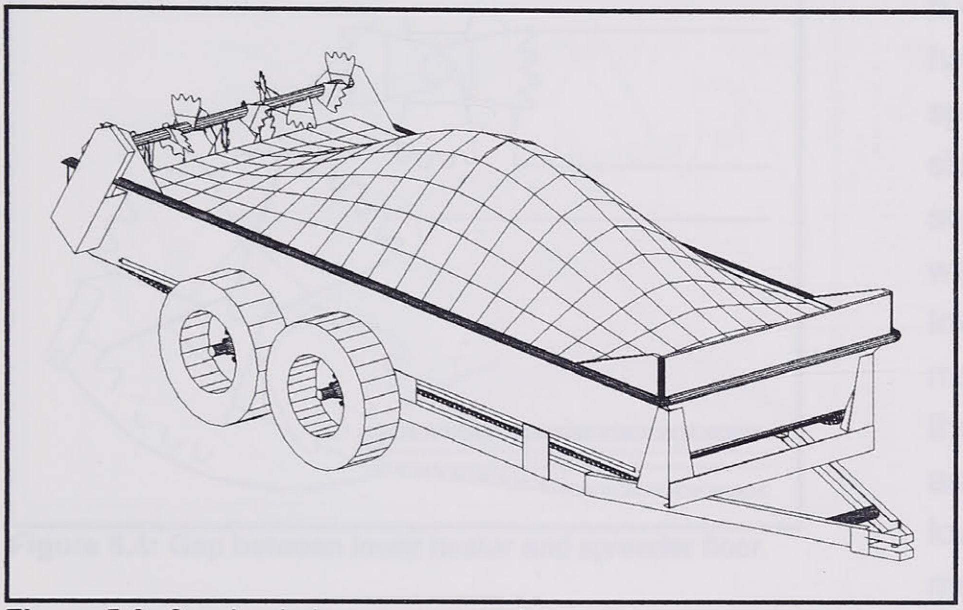


Figure 5.2: Overloaded manure spreader

On the other hand, the capacity of the spreader loaded in this manner is drastically reduced. Therefore to improve the capacity of the spreader, one two by twelve inche wood plank can be installed on each spreader side wall to deepen the spreader box. Then the spreader is loaded uniformly as shown in figure 5.3.

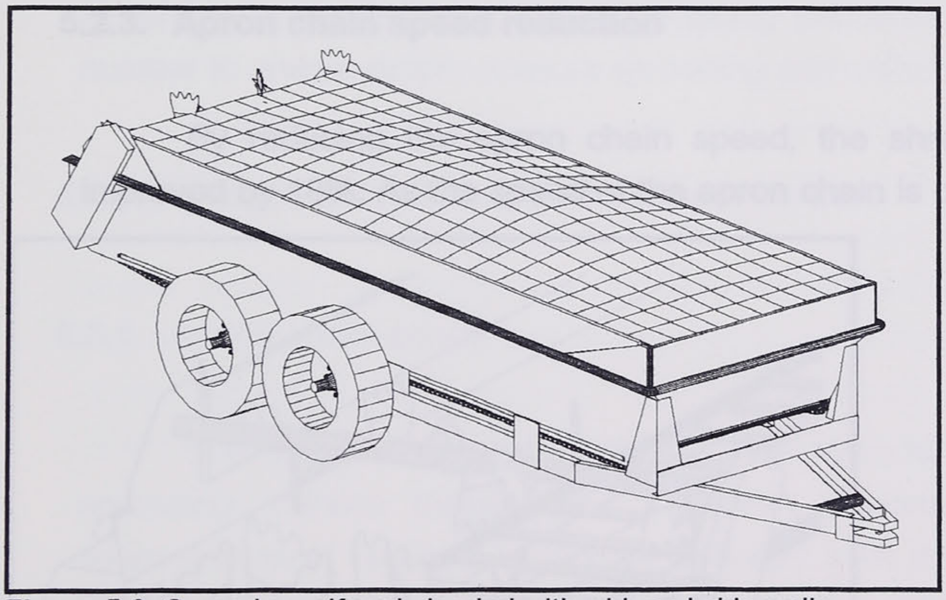


Figure 5.3: Spreader uniformly loaded with widened side walls.

5.2.2. Addition of a pan

When the manure is relatively dry and fine, some of it can pass under the lower beater and fall to the ground without being shredded as shown on figure 5.4. The effect of not having a pan on the spreader is -40% on the shredding efficiency. To solve this problem, a pan was installed under the lower beater to collect the manure that is bypassing the lower beater. The pan accumulates it until the lower beater touches the manure, then it is shredded and spread on the ground. The pan is shown on figure 5.5. It should be noted that in the case of this specific spreader, Sperry New Holland offers a pan that is fitting on the spreader for a price around 400.$

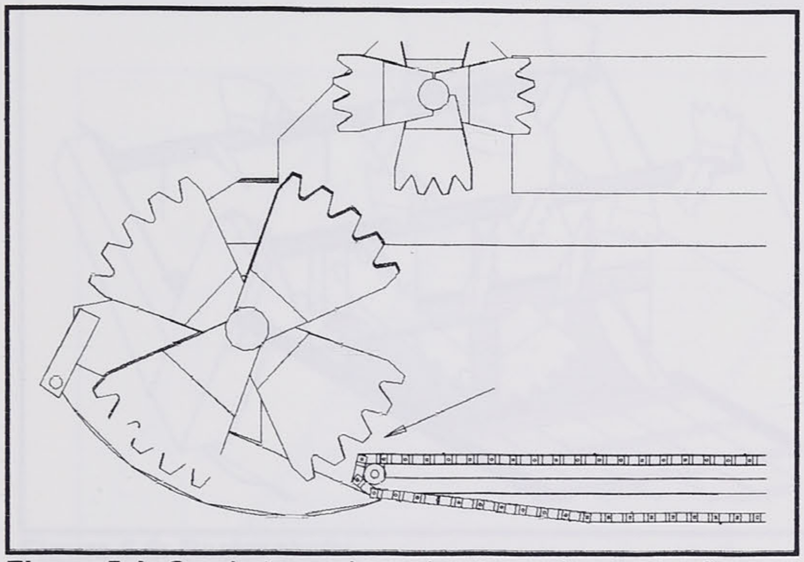


Figure 5.4: Gap between lower beater and spreader floor.

5.2.3. Apron chain speed reduction

By reducing the apron chain speed, the shredding efficiency can be improved by 18%. As the speed of the apron chain is decreased, less manure is passing through the beaters and it is more uniformly shredded. Of course, other considerations apply in this case, such as the desired dosage of manure. This will be discussed in detail in section 5.3.1.

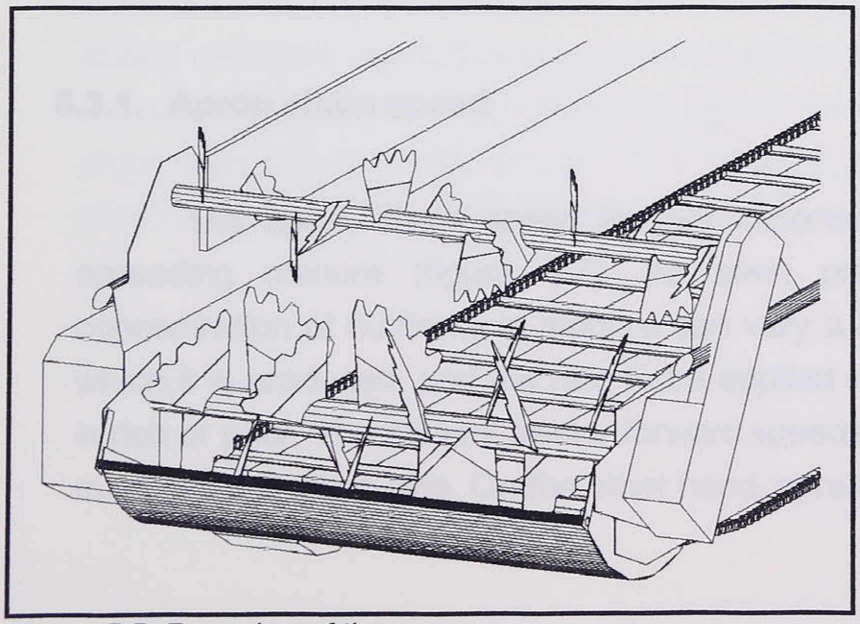


Figure 5.5: Rear view of the pan.

5.2.4. Beater shafts

Three characteristics of the beaters affect the shredding efficiency. The first is how many beaters the spreader is equipped with. On the studied model, adding a third beater improved the shredding efficiency by 7%. As in the case of the pan, a third beater is available for the studied model through the Sperry New Holland company for approximately 500.$. The three beaters assembly is shown on figure 5.6.

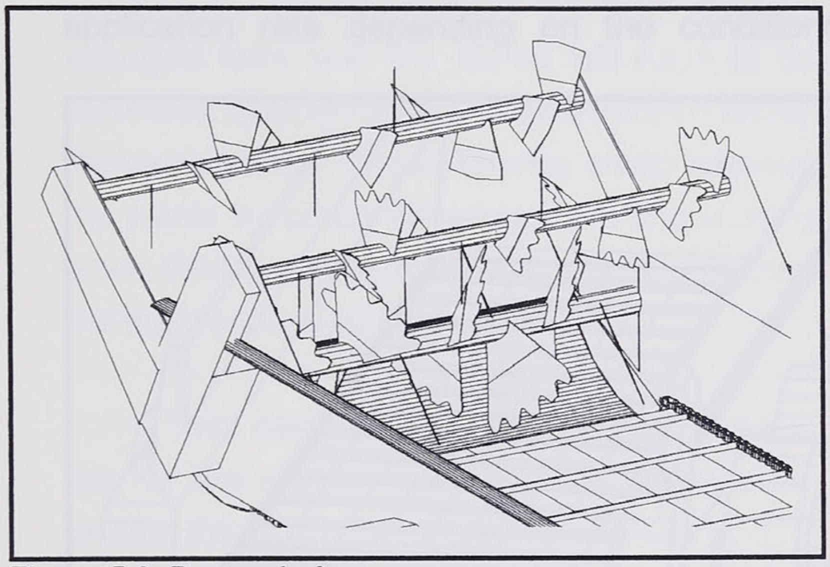


Figure 5.6: Beater shafts.

The second characteristic is the beaters speed of rotation. In general, a speed over 200 RPM should ensure a good shredding.

The third characteristic is the number of paddles on each beater shaft. According to the literature, sixteen to twenty paddles per beater shaft is a good number to ensure proper manure shredding and uniform spreading.

5.3. Modifications for post emergence spreading

5.3.1. Apron chain speed

The apron chain speed is very important for a proper dosage when spreading manure (figure 5.7). As seen previously in section 4.3, the concentration of nutrients in manure can vary a lot depending of the animal by which it is produced, and the rate to be applied is different depending if the soil is rich or poor. The several tractor forward speeds can provide a certain range of manure application rate. On the other hand, spreading manure at a speed higher than eight kilometers an hour could be dangerous or impossible in some fields and at very low speed is rather unproductive.

Thus, the apron chain speed variation must provide the proper manure application rate depending on the conditions. Also, in the case of post emergence spreading, the application rate may be very small as seen in table 4.4. Calculations made with respect to the studied spreader and different manures for the dosage calculation example of section 4.3 for corn, show required apron chain speeds of 21 to 151 cm/min. depending on the manure and considering a constant tractor speed of 7 km/h. This is quite a wide variation in speed.

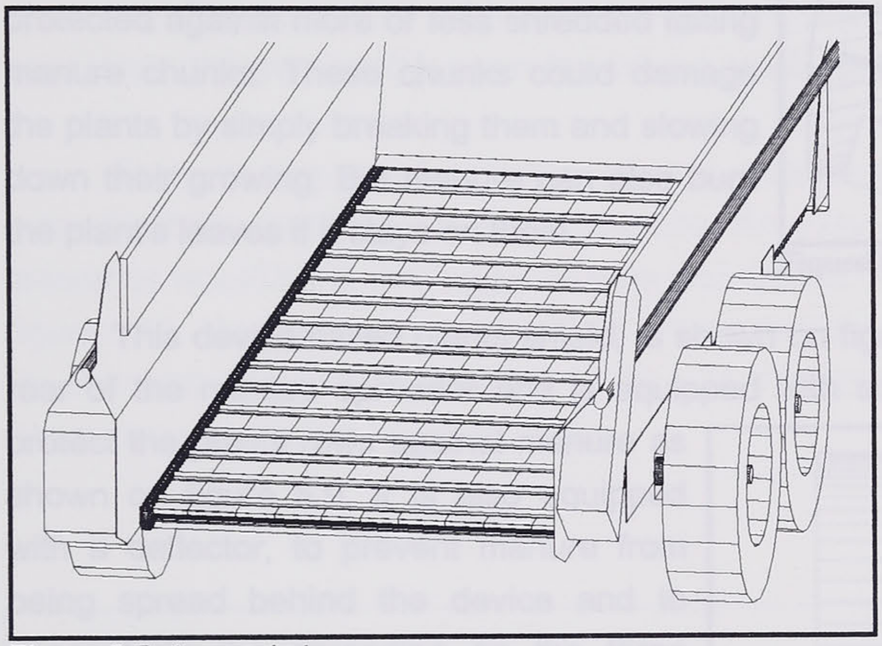


Figure 5.7: Apron chain.

Therefore, it is recommended that spreader used for post emergence spreading be equipped with at least 3 apron chain speeds. The ideal is a spreader with an hydraulic motor driven apron chain, this will provide unlimited speed variation. Again this is a standard option available through the dealer for the studied spreader. An interesting option here would be to drive the apron chain with the spreader wheels, this would provide always the proper apron chain speed with respect to the tractor speed.

5.3.2. Plants shield

Since post emergence spreading requires to spread manure on crop already emerged form soil, the plants will have to be protected against more or less shredded falling manure chunks. These chunks could damage the plants by simply breaking them and slowing down their growing. But manure can also burn the plant's leaves if it stays on them.

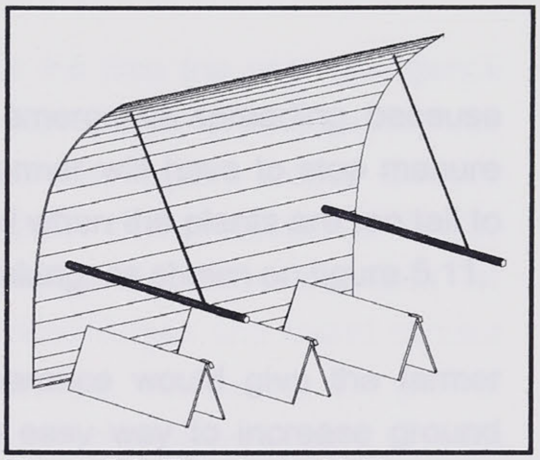


Figure 5.8: The plants shield.

This device called plants shield, is shown on figure 5.8. It mounts on the rear of the manure spreader and is equipped with some kind of channels to protect the plants rows against manure as shown on figure 5.9. It is also equipped with a deflector, to prevent manure from being spread behind the device and to concentrate the spreading on the three protected rows, as seen in figure 5.10. When spreading sticky manure, this device will have to be coated with an anti-sticking material, such as Teflon.

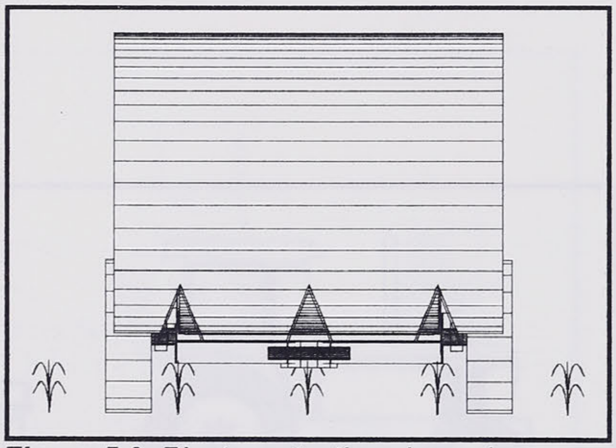


Figure 5.9: Plants protection channels.

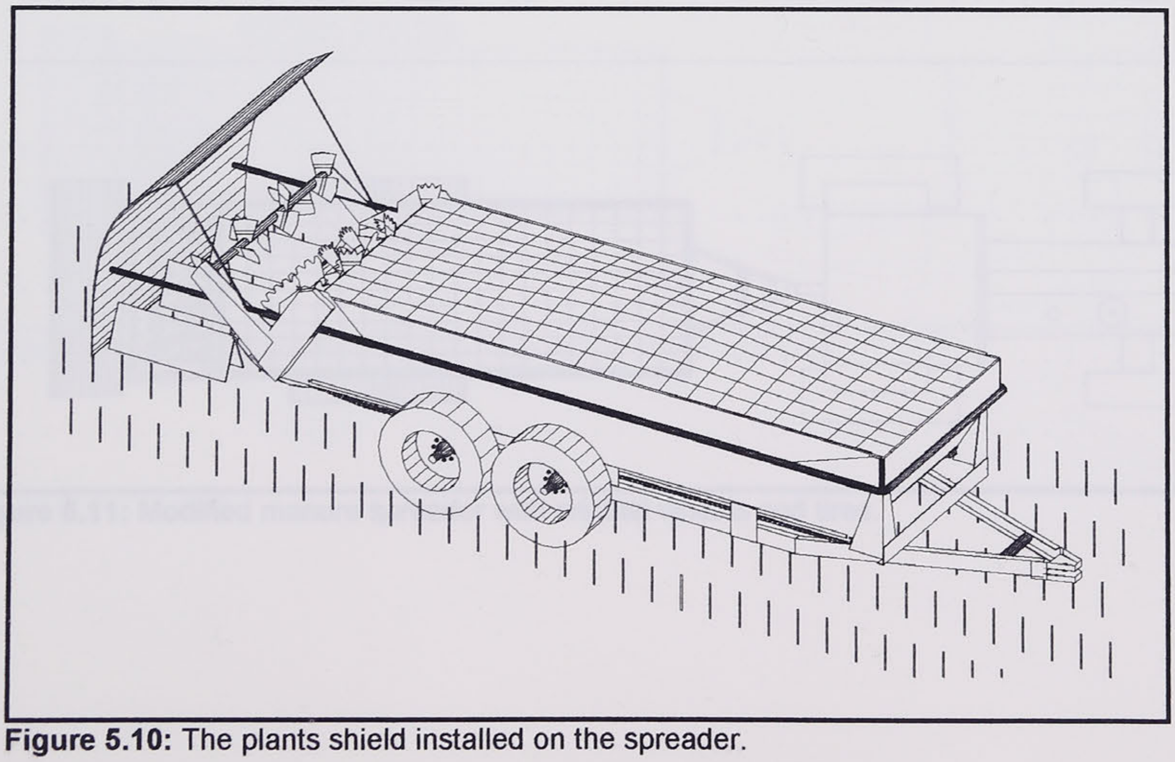


Figure 5.10: The plants shield installed on the spreader.

5.3.3. Spreader ground clearance

The ground clearance is important in post emergence spreading, because this is the factor that will determine when the farmer will have to stop manure spreading. The spreading will have to be stopped when the plants are too tall to pass under the frame of the spreader without breaking, as shown on figure 5.11.

Then an increased spreader ground clearance would give the farmer more flexibility and time to spread manure. An easy way to increase ground clearance would be to put bigger wheels and tires on the spreader, as seen on figure 5.12. Usually, manure spreaders are equipped with 10.00 - 20 truck tires. By changing the rims and putting 14.00 - 24 truck tires, the ground clearance can be increased from 30 cm to 45 cm.

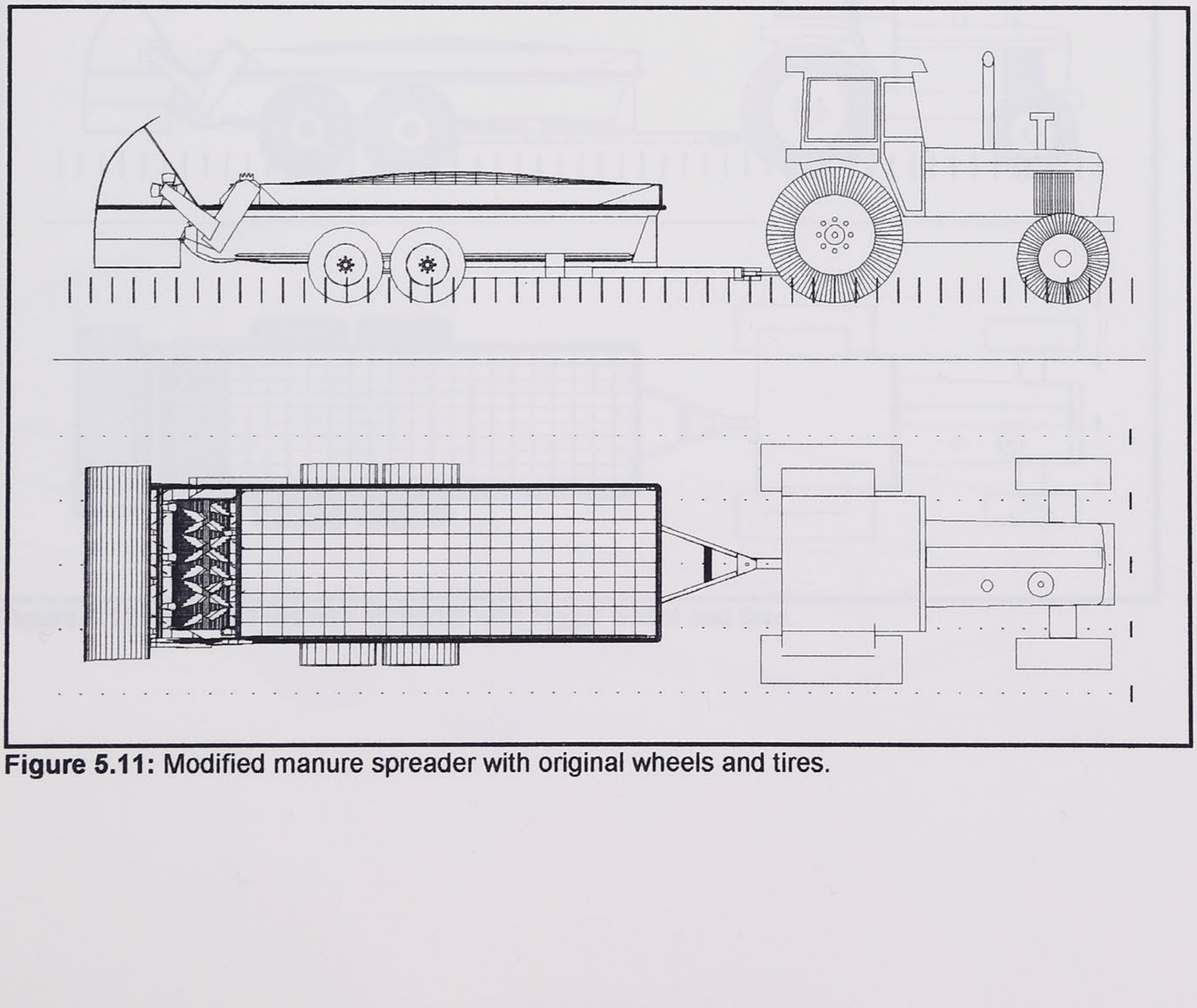


Figure 5.11: Modified manure spreader with original wheels and tires.

5.3.4. Soil compaction

Since soil compaction is a critical issue at the time the post emergence spreading is done, attention had been given to that subject. The spreader was equipped with 10.00 - 20 truck tires which have very square edges and flat surface of contact, that tends to cut ground under heavy loads. As in the previous problem, the solution would be to change the rims and tires for installing 14.00 - 24 truck tires, which have rounded edges and round contact surface. These have also a greater surface of contact, decreasing the ground pressure from 149 kPa (21.5 psi) to 89 kPa (13 psi), which is very good. Ground pressure calculations are included in Appendix 3.

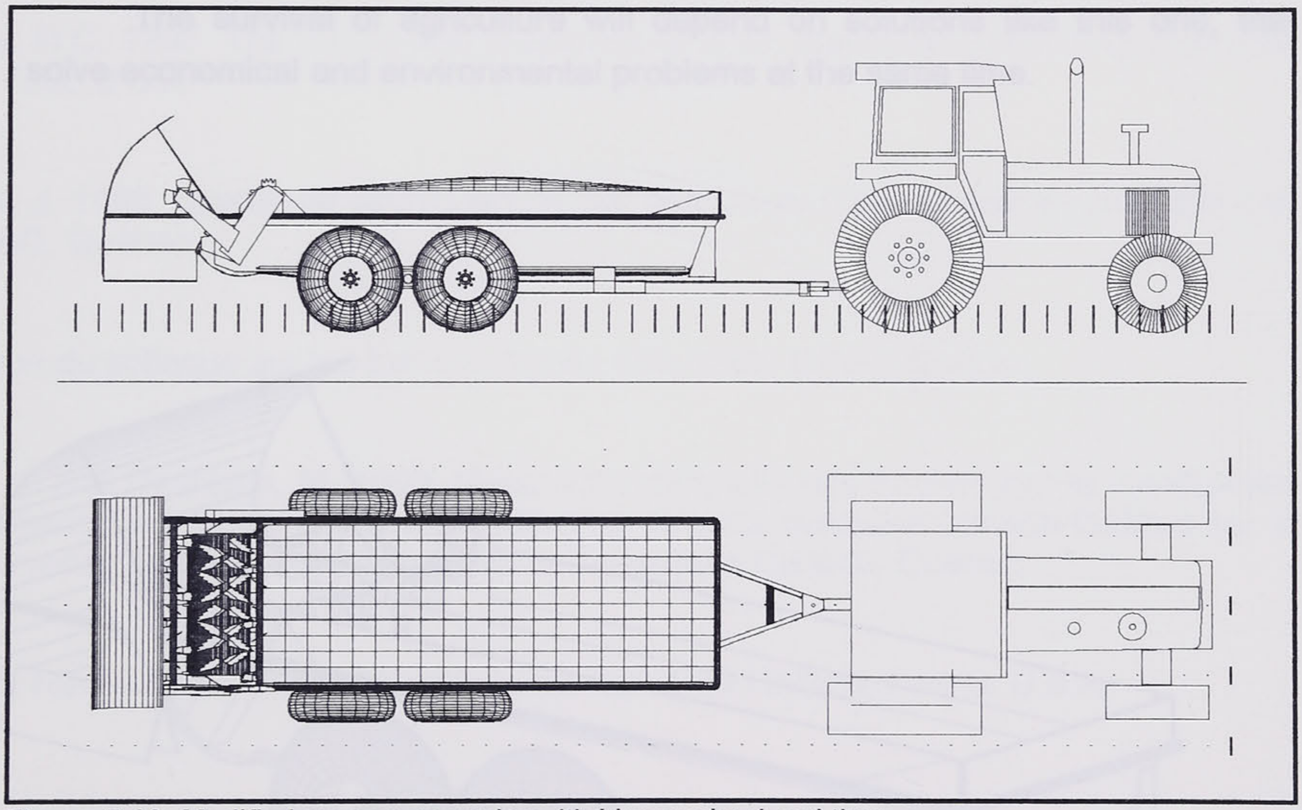


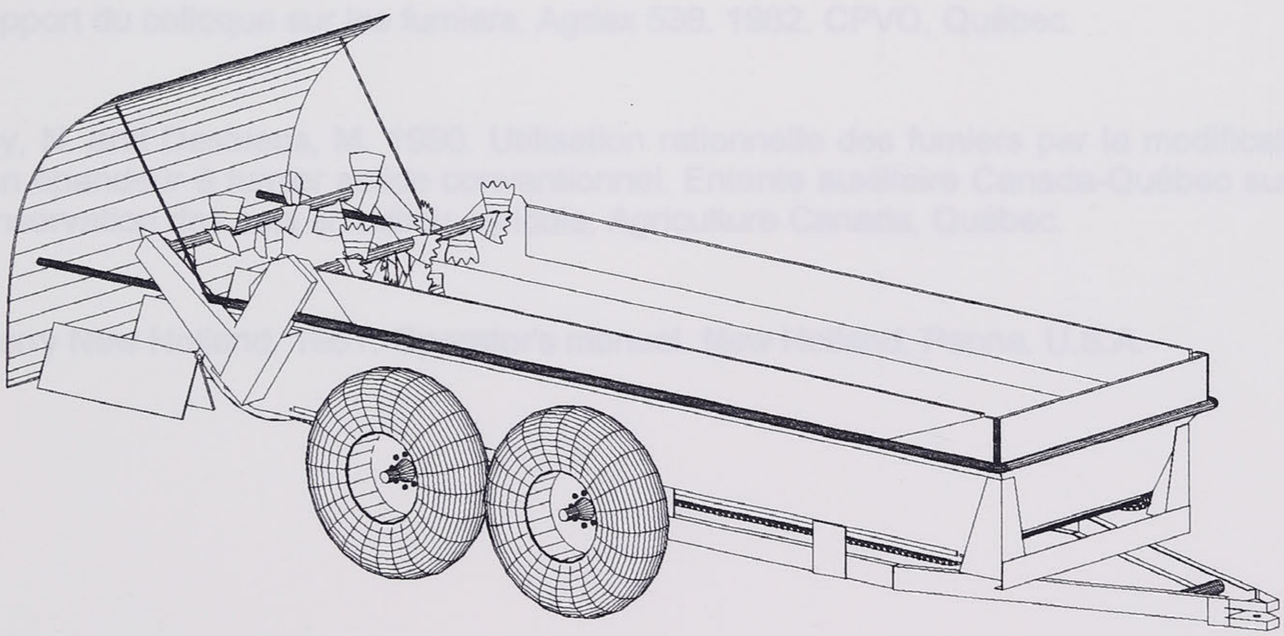
Figure 5.12: Modified manure spreader with bigger wheel and tires.

6. CONCLUSION

In this report, the feasibility and advantages of post emergence spreading had been demonstrated. A conventional manure spreader was also modified to be adapted to the requirements of this kind of spreading.

A prototype of this manure spreader should be built to see if all solutions achieve their goal. Also, agronomic research is needed on the effect of post emergence spreading on yield, since the manure is incorporated into soil at or a few days before the time the plants need the nutrients the most.

The survival of agriculture will depend on solutions like this one, that solve economical and environmental problems at the same time.



REFERENCES

Association des fabricants d'engrais du Québec, 1990. Guide de fertilisation, 3e édition. Montréal, Québec.

Belzile, M. 1982. Rapport synthèse sur "L'utilisation agricole des fumiers. MAPAQ, Québec.

Brady, N.C. 1990. The nature and properties of soils. Macmillan publishing company, New York, U.S.A.

Denis, J. 1993. Qualité de déchiquetage des épandeurs à fumier solide conventionnel. MAPAQ, Québec.

Rapport du colloque sur les fumiers, Agdex 538. 1982. CPVQ, Québec.

Roy, N. and Desbiens, M. 1990. Utilisation rationnelle des fumiers par la modification d'un épandeur à fumier solide conventionnel. Entente auxiliaire Canada-Québec sur la conservation des sols en milieu agricole, Agriculture Canada, Québec.

Sperry New Holland. 1981. Operator's manual. New Holland, Penna. U.S.A.

APPENDICES

APPENDIX 1

COEFFICIENTS AND FACTORS OF MANURE FERTILIZING EFFICIENCY

Les fumiers

Les fumiers employés correctement ont une place importante comme amendement organique du sol. En plus d'apporter de l'humus, ils contribuent à augmenter le taux d'infiltration et la capacité de rétention en eau du sol qui devient en quelque sorte une éponge. Les échanges gazeux, l'activité microbiologique, les échanges cationiques sont facilités alors que le ruissellement et l'érosion sont diminués.

Les fumiers constituent une valeur fertilisante intéressante si on en connaît leur composition chimique. Aussi, l'analyse de laboratoire devient-elle indispensable puisque les fumiers diffèrent quant à leur âge, leur type de litière et leur mode de conservation.

Le résultat obtenu par l'analyse de laboratoire n'est cependant qu'une valeur relative à laquelle il faut soustraire différentes pertes d'azote. Les principales sources de volatilisation de l'azote viennent de l'entreposage, de la date d'apport, du type de sol, du mode d'épandage. (Tableaux 1, 2, 3)

Il s'agit de diviser la composition initiale du fumier par les indices de correction mis en cause dans les tableaux suivants pour en trouver la valeur.

Tableau 1

Indices des pertes d'azote liées à la manutention avant et pendant l'entreposage

Système	Indice
Fosse étanche et plate-forme couverte	1,0
Fosse étanche et plate-forme non couverte	1,1
Tas de fumier sur le sol	**1,4**
Étang ou lagune	1,5
Fumier décomposé, compost	1,8

Réf.: Dubé, A., Bernier, P.J., 1983, Manuel de gestion agricole des fumiers

Tableau 2

Indices des pertes d'azote liées à la date d'épandage et au type de sol

	Prairie		Culture sarclée	
Date d'apport	Loam à sable loameux	Sable	Loam à sable loameux	Sable
Printemps	1,0	1,1	1,0	1,1
Automne	**1,4**	1,8	**1,4**	1,6
Fractionnement: automne-printemps	1,2	1,4	1,2	1,3

Réf.: Dubé, A., Bernier, P.J., 1983, Manuel de gestion agricole des fumiers

Tableau 3

Indices des pertes d'azote liées au mode d'épandage

Mode d'épandage	Indice de perte
Injection	1,0
Aéroaspersion	
– incorporé en moins de 24 heures	1,1
– incorporé en moins de 48 heures	1,4
– incorporé en moins de 1 semaine	1,6
– laissé en surface	1,8
Irrigation	
– incorporé en moins de 24 heures	1,3
– incorporé en moins de 48 heures	1,4
– incorporé en moins de 1 semaine	1,6
– laissé en surface	1,8
Épandeur	
– incorporé en moins de 24 heures	1,1
– incorporé en moins de 48 heures	1,3
– incorporé en moins de 1 semaine	1,5
– laissé en surface	**1,8**

Réf.: Dubé, A., Bernier, P.J., 1983, Manuel de gestion agricole des fumiers

Exemple: Un fumier analysé, dosant 10 kg/t de N, est entreposé en tas au sol. De plus, il est épandu au sol (loam à sable loameux) à l'automne et laissé en surface. En se référant aux tableaux on utilise les chiffres en caractères gras, sa valeur passe de 10 kg/t à 2,8 kg/t (10 ÷ 1,4 ÷ 1,4 ÷ 1,8) = 2,8 kg.

Finalement, il faut connaître l'efficacité des éléments fertilisants du fumier au sol. (Tableau 4)

Tableau 4
Coefficient moyen d'efficacité des éléments fertilisants des fumiers (%)

Espèce animale	N	P_2O_5	K_2O
Bovins (fumier)	**46**	24	46
Porcs (lisier)	70	80	100
Volailles	70-90	50-80	90

Réf.: Dubé, A., Bernier, P.J., 1983, Manuel de gestion agricole des fumiers

Dans l'exemple précédent, un fumier de bovin apporterait une valeur fertilisante de 1,28 kg/t de N: (2,8 x 46%). Le degré de disponibilité des éléments fertilisants étant plus grand pour le fumier de volailles, cette valeur passerait entre 1,9 et 2,5 kg/t de N (de 70% à 90%) soit 2,8 x 70% = 1,9 kg ou 2,8 x 90% = 2,5 kg.

Tableau 5
Quantité d'éléments fertilisants contenus dans une tonne de fumier frais

	% du total		N	P_2O_5	K_2O
			kg	kg	kg
Bovins	liquide	25%	2,26	traces	3,62
	solide	75%	2,26	1,81	0,9
	total		4,53	1,81	4,53
Porcs	liquide	40%	1,81	0,45	1,81
	solide	60%	4,08	2,72	2,72
	total		5,89	3,17	4,53
Volailles	total		13,6	6,79	3,17

Réf.: «Les Fumiers» – Y. Martel – Dossier TCN, 21-5-75

Tableau 6
Teneur approximative des lisiers de porcs en éléments majeurs assimilables au cours de l'année d'application selon leur teneur en matière sèche déterminée par l'hydromètre de Tunney (en kg/m³)

% M.S. du lisier	NH_4	P_2O_5	K_2O
1	0,7	0,2	0,8
2	1,3	0,6	1,4
3	1,7	1,0	1,8
4	2,1	1,4	2,0
5	2,5	1,8	2,2
6	2,8	2,2	2,4

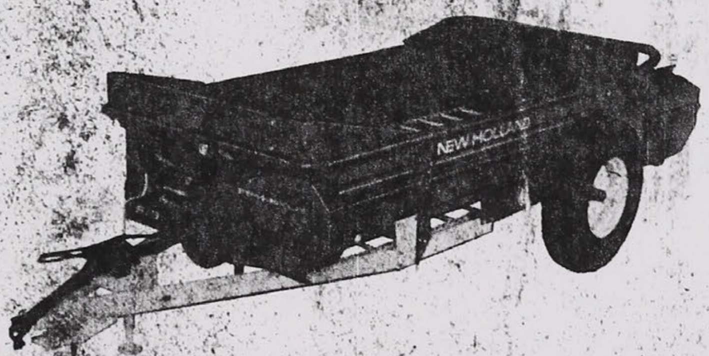
APPENDIX 2

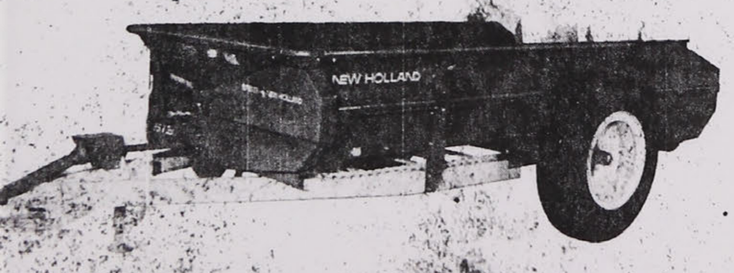
SPREADER SPECIFICATIONS

OPERATOR'S MANUAL

MANURE SPREADER
513-519-679

SPERRY NEW HOLLAND





SPECIFICATIONS

	679
Overall Length	268½" (682 cm)
Overall Width w/10.00 x 20 Tires	96" (244 cm)
Overall Height w/10.00 x 20 tires (without upper beater)	46¾" (119 cm)
Wheel Tread (center to center)	84" (213 cm)
Axle Bearings	Tapered Roller
Jack	Screw Type
Inside Length of box	192" (488 cm)
Inside Width of box	60⅞" (154 cm)
Inside Depth of box	22⅝" (58 cm)
Apron Speeds	2 plus 1 option
ASAE Capacity — w/Single Beater heaped	280 cu. ft. (7.90 m³)
ASAE Capacity — w/Upper beater heaped	340 cu. ft. (9.60 m³)
ASAE Struck Level	162 cu. ft. (4.60 m³)
Gear Box Bearings and Jack Shaft	Tapered Roller
Overload Protection	Belt drive and shear bolt
Powered required	80-85 HP (59-63 kw)
PTO Speed	540 or 1000
Maximum Net Load	6½ tons (5897 kg)

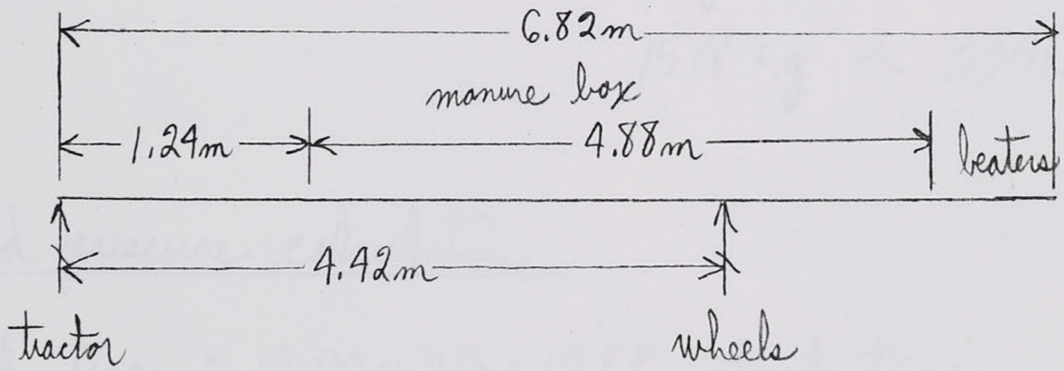
APPENDIX 3

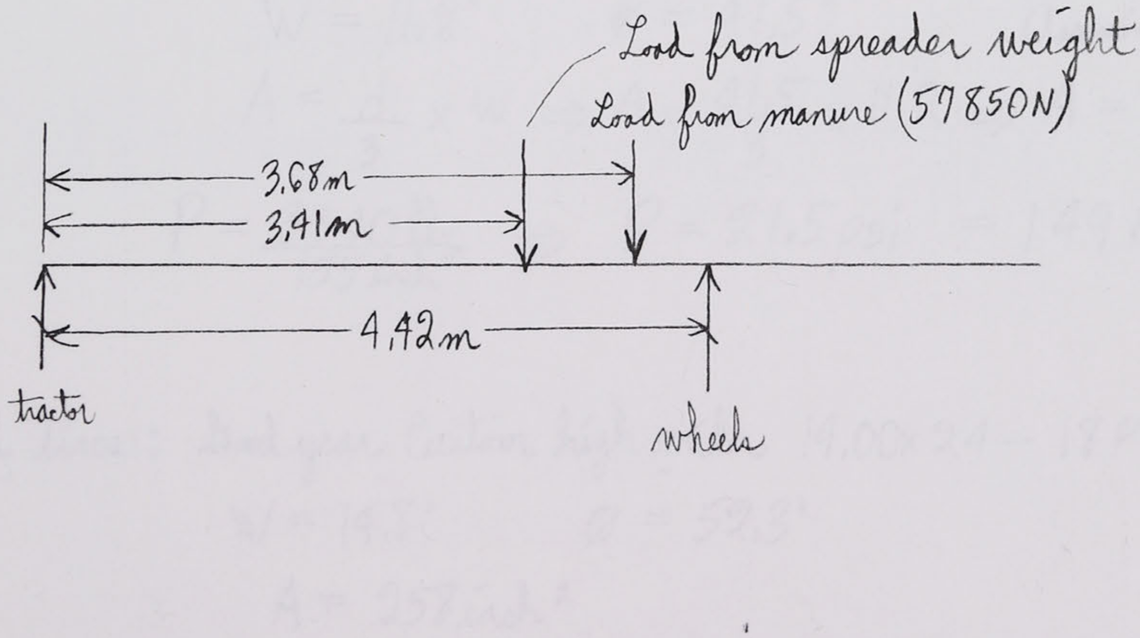
SAMPLE CALCULATIONS

Weight on wheels of the spreader

Spreader overall length ⇒ 6,82m
Inside length of box ⇒ 4,88m
Max. net load ⇒ 5897 Kg = 57850N
Spreader weight ⇒ 1500 Kg = 14715 N
Distance between attachement and wheels pivot ⇒ 4.42m

Assumptions: - The spreader weight is uniformly distributed along the complete spreader length.
- The load weight is uniformly distributed along the box length.





$$\Sigma M_{R_1} = 0 = -14\,715\,(3.41m) - 57\,850\,(3.68m) + R_2\,(4.42m)$$

$$R_2 = 59\,517\ N$$

$$\Sigma F_y = 0 = +R_1 - 14\,715 - 57\,850 + 59\,517$$

$$R_1 = 13\,048\,N$$

∴ → 18% on tractor drawbar
→ 82% on spreader wheels

Weight on each wheel ⇒ $\frac{59\,517 N}{4}$

$= 14\,880\ N/\text{wheel}$

⇓

1518 Kg or 3340 lb

Ground pressure calculation

Actual tires: 10.00 x 20 - 12PR truck tires

$W = 11.2''$ $\quad \varnothing = 41.5''$ $\quad$ Assuming $L = \frac{d}{3}$

$$A = \frac{d}{3} \times W \Rightarrow A = \frac{41.5}{3} \times 11.2 \Rightarrow A = 155\,\text{inch}^2$$

$$P = \frac{3340\,lb}{155\,\text{inch}^2} \Rightarrow P = 21.5\,psi = 149\,KPa$$

Projected tires: Good year Custom high miler 14.00x 24 - 18PR truck tire

$W = 14.8''$ $\quad \varnothing = 52.3''$

$A = 258\,\text{inch}^2$

$P = 13\,psi = 89\,KPa$

Compétition québécoise d'ingénierie
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Programme Officiel

Official Program

McGill
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