

Development of Animal Liquid Manure Field Spreader Suited to Small Scale Crop Production Farms

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소규모영농에 적합한 가축분뇨액비살포기 개발

최광재 · 오권영 · 유병기 · 이성현

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Summary

For even distribution of liquid manure in the field, a boom nozzle type spreader was designed and studied to determine its suitability for small scale crop production farms. Boom nozzle type spreader was compared in the impact triple nozzle and impact single nozzle type spreader. Spreading uniformity of the boom nozzle type liquid manure spreader showed 5.2% (C.V.) and impact single nozzle type spreader showed 6.9% (C.V.). The spreading uniformity of the impact triple nozzle type spreader was quite uneven, therefore, the spreader could be modified as twin nozzle for spreading in orchard farm. The wheel axle height adjustable type liquid manure spreader has higher the stability and it considered much useful on the hilly agricultural land.

(Key words : Animal liquid manure spreader, Liquid manure tank spreader, Uniformity of manure spreading, Liquid manure application)

INTRODUCTION

The current animal manure tank spreader do not adapted well for its animal liquid manure spreading operation in paddy field and small scale hilly upland in the country. The organic recycle farming liquid manure storage tank and spreader have been introduced more than three thousand location up to the 2005, and the govern-

ment has been recommended the positive use of animal liquid manure for crop farming. In fact, the application of animal liquid manure to agricultural land will probably be one of the most effective way to enrich the fertilizer source for soil in arable land.

In this circumstance, the currently using manure spreaders have problems of its uneven spreading of liquid manure on field, and

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spreaders emitted offensive odor during spreading liquid manure on fields. Furthermore, the tractor cannot draw liquid manure spreader with the tank filling liquid manure within fields because the weight of spreader including animal liquid manure is too heavy for soft paddy soil condition.

The study was aimed to improve the animal liquid manure spreader towards the uniform spreading of liquid manure, ease the utilization of spreader in sloped field and lower height of spreader for orchard farms. In the experiment process, designed and tested a boom nozzle type manure spreader, a impact triple nozzle type and a impact single nozzle type spreader. In addition, wheel axle height adjustable type frame of liquid manure spreader was also tested for its availability.

equiped with volumetric liquid pump that can intake liquid manure from storage tank to transportation tank, and field spreading of animal liquid manure from transportation tank without air pressure in the tank. The animal liquid manure spreader was consisted of liquid pump, liquid manure transportation tank, manure distributor and surface spreading devices.

The power train of the boom type liquid manure spreader designed as in the order of tractor PTO → universal joint → speed reduction chain gear → lobe pump driven system. The liquid manure spreading quantity can be controlled by the revolution speed of the pump.

The animal manure spreading device was designed and assembled with liquid manure transportation tank, liquid pump, rotary distributor, twelve spreading hoses and pipes. The tip of the spreading pipes attached liquid impact plates that can make small droplet of liquid manure near ground.

MATERIALS AND METHODS

1. Design of prototype

Boom nozzle type liquid manure spreader

Wheel driven liquid manure spreader was

Triple impact nozzle type liquid manure spreader

The power train of the triple nozzle type

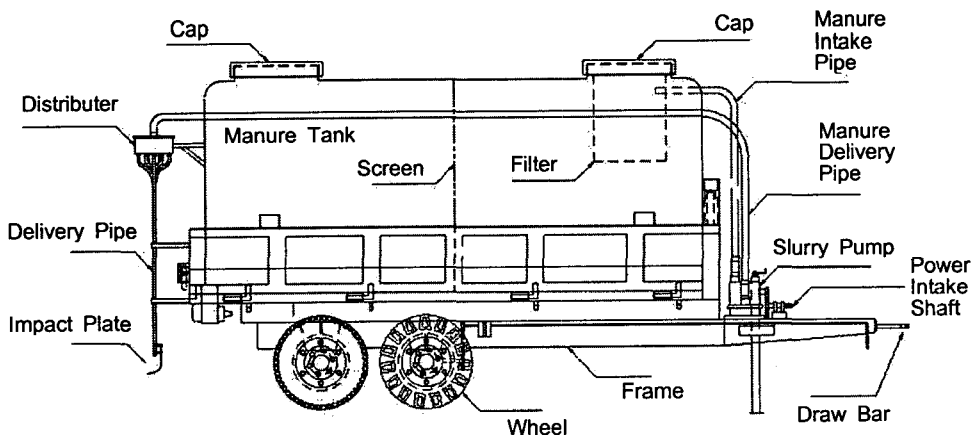


Fig. 1. Boom nozzle type liquid manure spreader.

Table 1. Specification of boom nozzle type liquid manure spreader

Item		Contents
Body	type	trailer combination use
	size(L×W×H, mm)	4200×2000×2100
	travelling	tractor drawn wheel
Manure spreading unit	type of pump	volumetric pump (lobe pump)
	pumping capacity(ℓ /min)	100~800
	size of tank(ℓ)	4,600
	distribution unit	rotary distributor
	No. of nozzles(ea.)	12
	spreading method	nozzle & impact plate
	total width, nozzle distance (mm)	4,000, 364

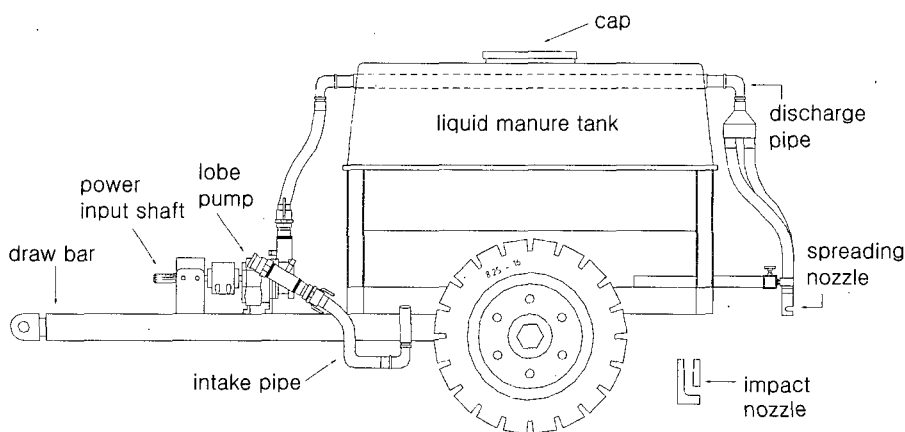


Fig. 2. Triple impact nozzle attached liquid manure spreader.

Table 2. Specification of triple impact nozzle type liquid manure spreader

Item		Specification
Main body	size(L×W×H, mm)	4,200×2,330×1,600
	travelling	tractor drawn
	height(mm)	600
Manure spreading unit	type of pump	volumetric pump(lobe pump)
	pumping capacity(ℓ /min)	80~400
	source of power	tractor PTO
	size of tank(ℓ)	2,000
	material of tank	FRP
	No. spreading nozzle(ea.)	3
	type of spreading	impact surface spreading
spreading width(cm)	400	

liquid manure spreader was designed the same as the boom nozzle type liquid manure spreader. The animal manure spreading device was designed and assembled with liquid manure transportation tank, liquid pump, three pipes and spreading hoses. The tip of the spreading pipes attached liquid impact plates that can make small droplet of liquid manure near ground.

Wheel axle height adjustable type liquid manure spreader

The wheel axle height adjustable type liquid

manure surface spreader was designed and assembled with the hydraulic cylinder operating wheel axles up and down move. If the height of axle shaft become lower, the height of the draw bar moves upward because the hydraulic cylinder attached to the wheel axle and the draw bar moved to different direction. The liquid manure tank was designed as the oval shape so that it can be useful in hilly and orchard farms.

The power source of the prototype adopted to tractor PTO power use slurry pump operation system, and tractor's hydraulic power use operation of hydraulic cylinder for the

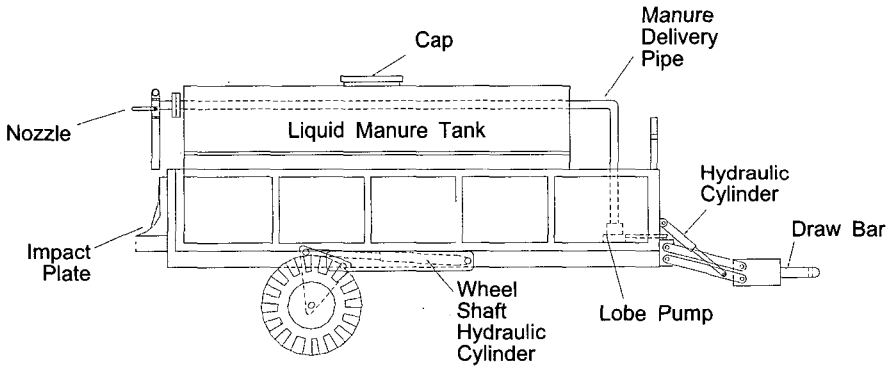


Fig. 3. Wheel axle height adjustable type liquid manure spreader.

Table 3. Specification of wheel axle height adjustable spreader

	Item	Contents
Body	size(L×W×H, mm)	4,200×2,330×1,600
	travelling height from earth(mm)	tractor drawn 0~400
Manure spreading unit	type of pump	volumetric pump(Lobe pump)
	pumping capacity(ℓ/min)	80~400
	size of tank(ℓ)	3,000 (FRP)
	spreading mechanism	single nozzle, plate impact
	spreading method	semi-circle plate impact
	spreading width(mm)	4,000

prototype. The travel system of liquid manure spreader was agricultural wide tread tire, and the lower the height of the main body, the higher the safety in travelling on sloped agricultural land. Animal liquid manure spreading device of the machine was consisted of liquid manure tank, liquid pump, delivery pipes & hoses and liquid impact plate.

2. Test method for spreading uniformity of liquid manure

The spreading nozzles of the animal liquid manure for the test were 12 nozzles holding wide boom spreading nozzle, single impact nozzle and three impact nozzles. For the measurement, liquid spreading operation during forward and return running were done by tractors, and the collected liquid in 300 ml size glass container were measured by mass cylinder, and the each test repeated 3 times.

The quantity of spreaded manure during test for the liquid manure spreader were measured for the revolution of the pump between 300~900 rpm. The work performance of the

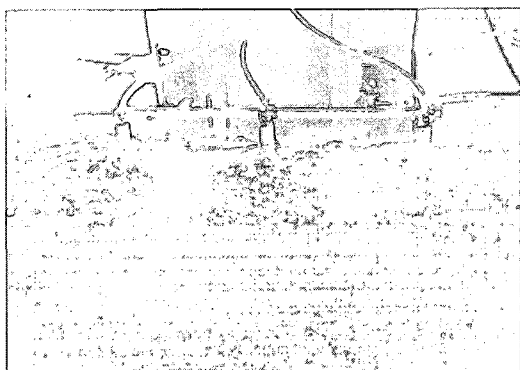


Fig. 4. Nozzle test for liquid manure droplet uniformity.

machine was analysed by the working hours per hectare.

RESULTS AND DISCUSSION

1. Boom nozzle type liquid manure spreader

The boom nozzle type liquid manure spreader with liquid pump has non-rotational volumetric pump, and the slurry pump's pumping hydraulic pressure was 8.0 kgf/cm^2 . If the revolution speed of pump was increased, the manure spreading volume was also increased as shown in Fig. 6.

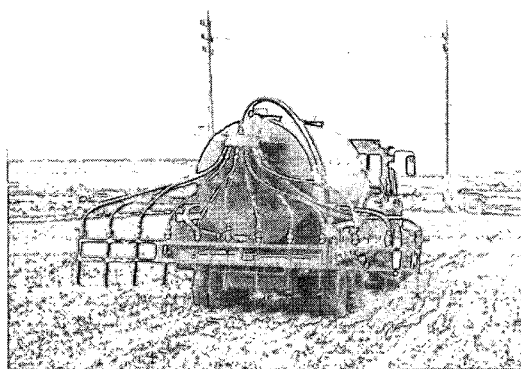


Fig. 5. Boom nozzle type liquid manure spreader in operation.

The power requirement for the driving of $\phi 80$ mm pump was in the range of 2~6 kW, and the spreaded manure volume was range of 250~330 ℓ for the pump revolution speed of 500~800 rpm. Therefore, the pump capacity was $20 \text{ m}^3/\text{h}$, which can finish the manure spreading operation for one hectare of field within one hour.

The length of the spreading boom attaching 12 distribution pipes for the boom nozzle

spreader was 4 m, and it can be folded to the length of 1.8 m for the driving on traffic roads. The machine equipped with rotative knives attached distributor for the prevention of clogging foreign materials in those pipes and it showed more even deliberation of liquid manure to 12 spreading pipes.

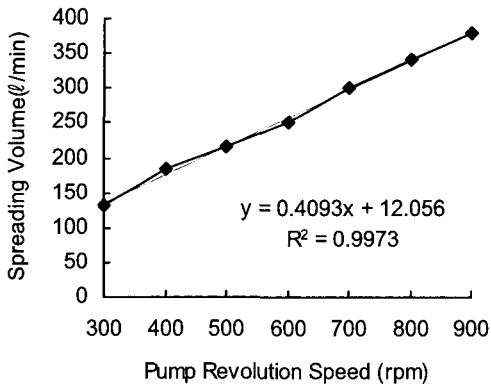


Fig. 6. Pumping volume of liquid manure and its revolving speed.

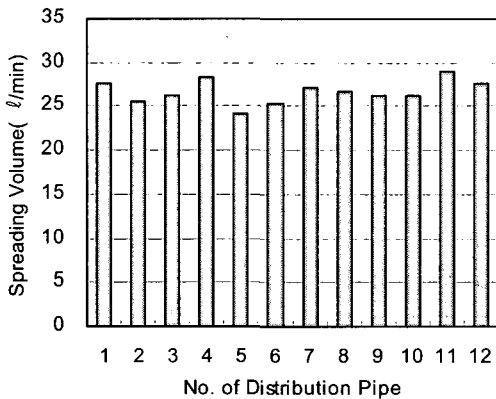


Fig. 7. Spreading uniformity of boom nozzle type liquid manure spreader.

The discharge volume of twelve liquid manure distribution pipes was measured on the point for its uniformity and denoted by the coefficient of variation value. And the discharged volume of liquid manure showed even distribu-

tion and the coefficient of variation revealed as 5.2%. The utilization of proper liquid manure distributor regarded as much important in the wide boom nozzle using liquid manure spreader.

The work performance of prototype liquid manure spreader was 2.1 h/ha, while the manual gravity spreader showed the work performance of 8.0 h/ha

2. Impact plate type liquid manure tank spreader

The discharge volume of impact plate attached single hole liquid manure tank spreader was measured as the uniformity as shown in fig. 9. The discharge volume of the



Fig. 8. The operation of impact plate type liquid manure tank spreader.

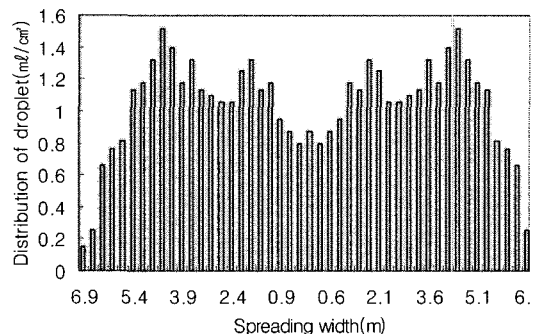


Fig. 9. Spreading uniformity of impact plate type liquid manure tank spreader.

liquid manure showed much uneven distribution and the machine cannot be used in crop production farm except grass land.

3. Triple impact nozzle type liquid manure spreader

One hose attaching tripartite nozzle was designed and evaluated for the uniformity of liquid manure distribution. The liquid distribution was shown as fig. 11, and the liquid manure distribution was not uniform. The quantity of the central area was too much because the accumulation of liquid manure droplets, so the triple impact nozzle type

spreader can not be used for crop cultivation farms.

4. Twin impact nozzle type liquid manure spreader

The triple nozzle system was modified to twin nozzle for orchard farm use liquid manure spreader as shown in fig. 12. The fertilizer for orchards such as pear, apple, peach, etc. are mostly being spreaded near the tree's root area. Therefore, it is expected that the twin impact nozzle type liquid manure spreader can be used as the orchards' proper liquid manure spreader.

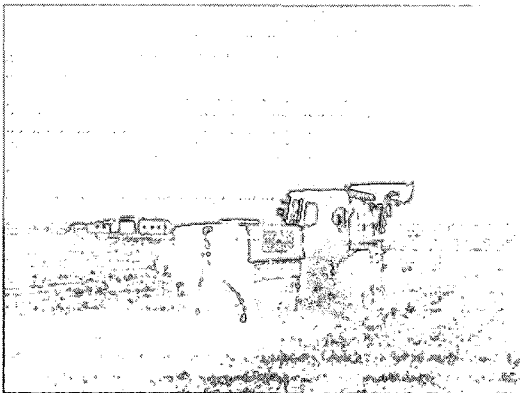


Fig. 10. The operation of triple impact nozzle type liquid manure spreader.

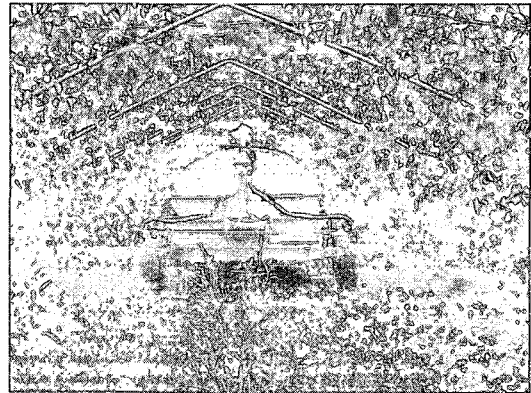


Fig. 12. The operation of twin impact nozzle type liquid manure spreader.

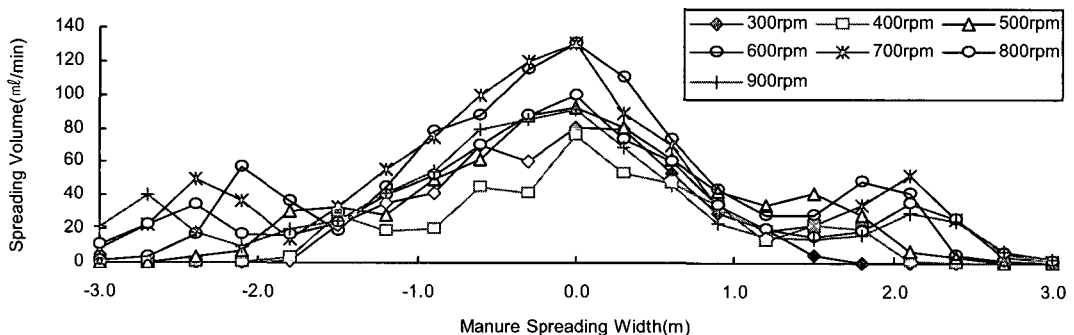


Fig. 11. Liquid manure distribution of triple impact nozzle.

5. Single impact nozzle type liquid manure spreader

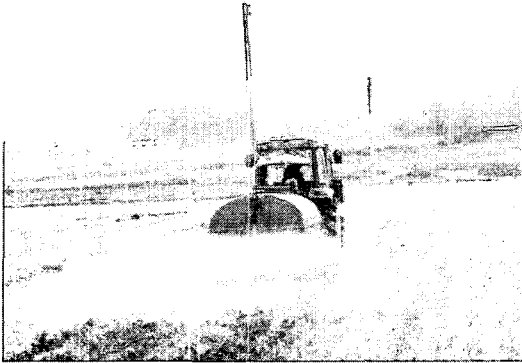


Fig. 13. Single impact nozzle type liquid manure spreader operating in the field.

Single impact nozzle has comparatively large size liquid manure delivery hose and a large spreading nozzle. And also, the liquid manure supply hose was direct connected to a large size nozzle, which system can prevention of clogging foreign materials in the spreading nozzle. As the spreading uniformity, the data gained for the pump speed over than 600 rpm. The lobe pump spreading single impact nozzle type spreader in the central part of 3.0 m in width showed 6.9 % of C.V. value. So, if the

liquid manure spreaded to overlap on the two way spreading, the spreading uniformity will be improved much higher than vacuum tank spreader.

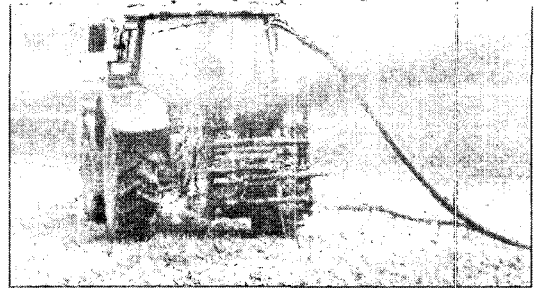


Fig. 15. Delivery hose use single impact nozzle type spreader in function.

The operation speed of wheel axle height adjustable liquid manure spreader was around 0.8 m/s, which takes 2.16 hours for spreading one hectare of agricultural land except liquid manure supplying time. In principle, the proper amount of liquid manure to be spreaded is decided by crop's fertilizer requirement, the nitrogen contents of soil and the source of liquid manure.

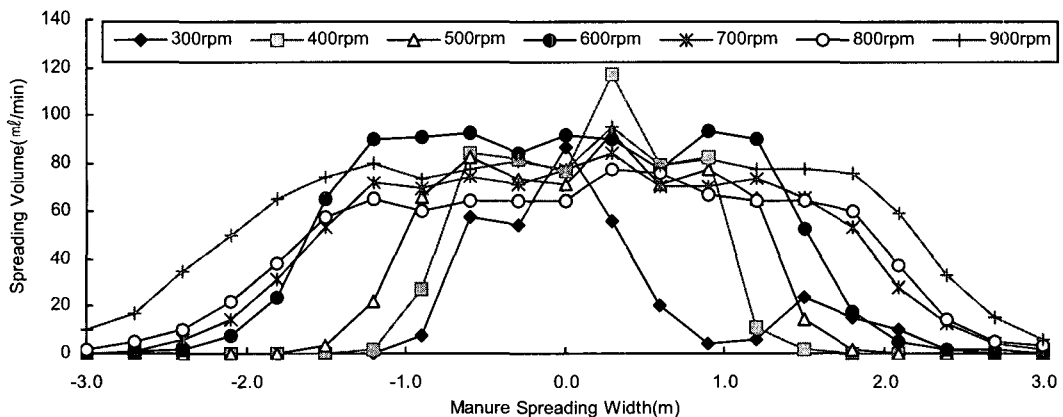


Fig. 14. Spreading distribution of single impact nozzle type spreader.

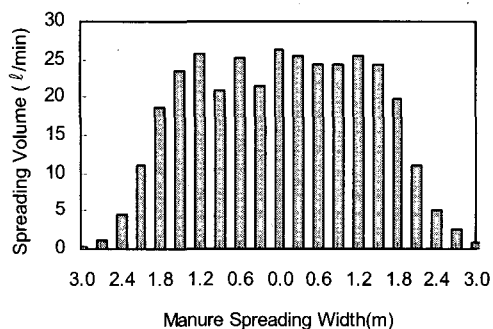
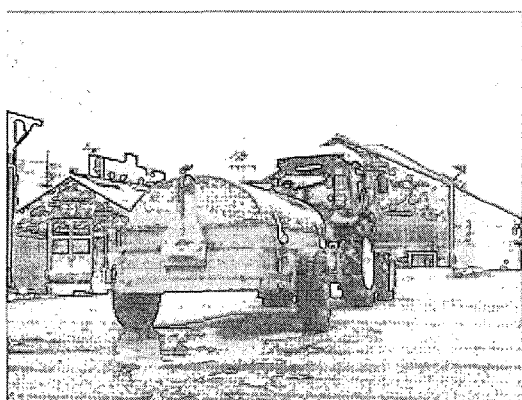
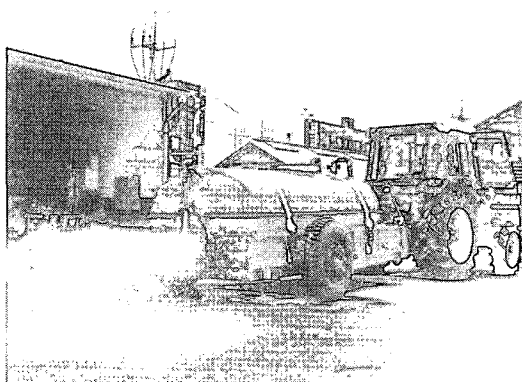


Fig. 16. Particles distribution of single impact nozzle at 600rpm.



Ordinary axle height posture



Lowered axle height posture

Fig. 17. Different axle height of the height adjustable spreader.

6. Wheel axle height adjustable type liquid manure spreader

To ease the manure spreading operation in orchards, the main body of spreader was designed as wheel axle adjustable type so that it can run with ordinary height in the road, and the height can be adjustable in orchards and hilly upland field.

The spreader can also be used as trailer if the tank unloaded, and in this case, the machine was very useful for loading and unloading the agricultural materials and the products. In the tractor static overturning angle test, the spreader did not overturned up to the ultimate overturning angle of 45° in the frame height of 30cm under the 3,000 kgf of water filling in the tank.

CONCLUSION

In order to improve the currently being used animal liquid manure spreader, designed and tested prototype nozzle attached spreaders and evaluated the uniformity of spreading patterns.

The spreading uniformity of the boom nozzle type liquid manure spreader showed 5.2 % of C.V. value, and the uniformity of the wheel axle height adjustable type liquid manure spreader in the central parts showed 6.9% of C.V. value.

For the liquid manure spreading performance, the field work capacity of the lobe pump use boom nozzle type liquid manure spreader was 2.1 h/ha, and the work capacity of the liquid impact single nozzle type was 2.2 h/ha.

To ease the manure spreading operation in orchards and hilly upland field, the wheel axle adjustable type spreader's height can be

adjusted in orchards and hilly upland field, therefore the machine can be practically used in orchards.

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