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REVIEW

Development and Utilization of Narrow-Ditch Type Pasture Renovator

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Abstract

In order to easily and inexpensively renovate grasslands whose yield had declined or botanical composition had deteriorated, a new pasture renovator based on the design of a rotary tilling device that performs narrow ditching, over-sowing in the ditch, fertilizer application, covering with soil and compacting in one pass was developed. It makes a T-shaped ditch with a combination of shallow L-shaped working blades and deep-tilling plate-shaped straight blades. It is mounted on a tractor with a power exceeding 44 kW. Test results revealed that this machine enabled to save more labor in partial tilling renovation than in overall renovation and that it effectively improved the vegetation of the land.

Discipline: Agricultural machinery
Additional keywords: grassland, simple renovation, partial tilling, over-seeding

Introduction

Generally, the yield from an aging pasture decreases with time. Once the rate of yield decrease exceeds a certain limit, it is necessary to renew the grassland to restore the yield by using the overall tillage method (overall tillage of the grassland) or a simple renovation method without overall tillage of the land. The overall renovation method, despite its effectiveness is associated with the following problems: (1) High cost, (2) Very intricate operation, (3) Danger of soil run-off on sloping pasture, (4) Possible exposure of weed seeds in soil.

In contrast, the simple renovation method is effective and enables to avoid the disadvantages of the overall renovation method. Although the need to renovate grasslands is widely accepted, renovation is often not performed.

Therefore, Yamana et al.[3,4] developed a pasture renovator that performs partial tilling at a depth of about 10 cm using a tilling device equipped with plate-shaped straight blades. This renovator was based on the design of a down-cut type rotary tilling device. Under some conditions, the renovator frequently was unable to prepare seed beds or required excessive power, because it performed partial tillage with only straight blades. In order to address these problems, Yamana et al. developed a new renovator with a new ditching method combining tilling blades with different shapes and evaluated its performance through trials.

Outline of the developed pasture renovator

The developed pasture renovator, whose ditching device is based on the design of a down-cut rotary tilling unit, consists of a combination of a special L-shaped blade (ditching blade shaped like “L”) and a straight blade (blade shaped like a plate) fixed to the flange of a rotary tillage shaft. In addition, it is equipped with fertilizer application units, seeding units, press wheels, etc.

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and can perform narrow band tillage with the rotary tilling device, apply fertilizers to the ditch, perform overseeding and covering with soil, and compact the soil in one pass.

The ditching blades on the flange of the rotary shaft of the first test machine (working width 2.4 m) consisted of 2 L-shaped blades and 2 straight blades. After several field tests, however we changed them to a combination of 4 L-shaped blades and 2 straight blades (second test machine) that made a T-shaped ditch approximately 6 cm wide × 10 cm deep, to achieve adequate ditching during high-speed operations (Fig. 1). Fig. 2 shows the lateral view of the second test machine. The inter-row space was 27 cm, there were 8 rows of furrows, and the working width was 2.16 m. The second test machine was mounted directly on the three-point link hitch of a tractor.

The straight ditching blade softened the grassland soil by cutting the root mat of grass, while the L-shaped blade made a ditch wide enough for a seed bed. If the machine had only straight blades, the friction resistance between the ditching blades and the soil, and the power necessary for ditching would increase. However, the combination of straight and L-shaped blades reduced the required power. The power for seeding and fertilizer application was supplied by the ground driving wheel. The press wheel was able to compress only the soil inside the ditch because pressure was exerted with an independent spring for each row. The level of the ditch pressed by the press wheel was lower than the grassland surface, reducing the possibility of damage associated with soil drying.

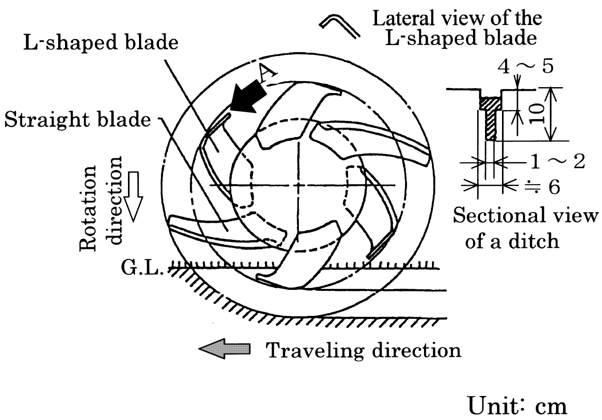


Fig. 1. Outline of the combined ditching blades and sectional view of a ditch

Working performance of the second test machine[5,6]

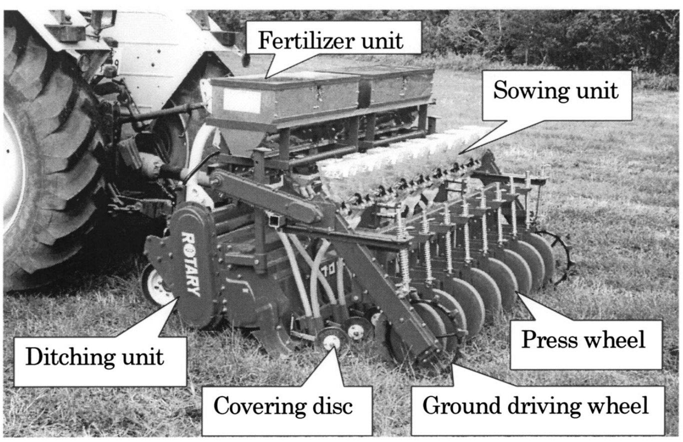
1. Required power for ditching

Fig. 3 shows the required power at the tractor PTO shaft, when we conducted a ditching test in the pasture located at the Institute of Agricultural Machinery.

The required power decreased when the traveling speed was steady and the driving pitch of the ditching blade was large (rotary shaft revolved slowly); it increased when the rotating speed of the rotary shaft was steady and the driving pitch of the ditching blade was wide (decrease of the traveling speed). Approximately 30 kW (40 PS) was required for the test conditions of a ditching blade with a 3 cm driving pitch at a steady rotary shaft speed (283 rpm). Based on these results, we concluded that the tractor power should exceed 44 kW (60 PS).

2. Amount of seeds sown and fertilizer applied

The number of seeds sown could be adjusted by changing the sprocket in the power train from the ground driving wheel to the feeding roll. It may be desirable to adjust the amount sown by one roll if the seed size changes. However this machine selected rolls of holes



Specification of the machine

Total mass	0.752 t
Overall length	1.875 m
Overall width	2.495 m
Overall height	1.340 m
Working width	2.16 m
Inter-row space	27 cm
Number of rows	8

Fig. 2. Lateral view of the second test machine

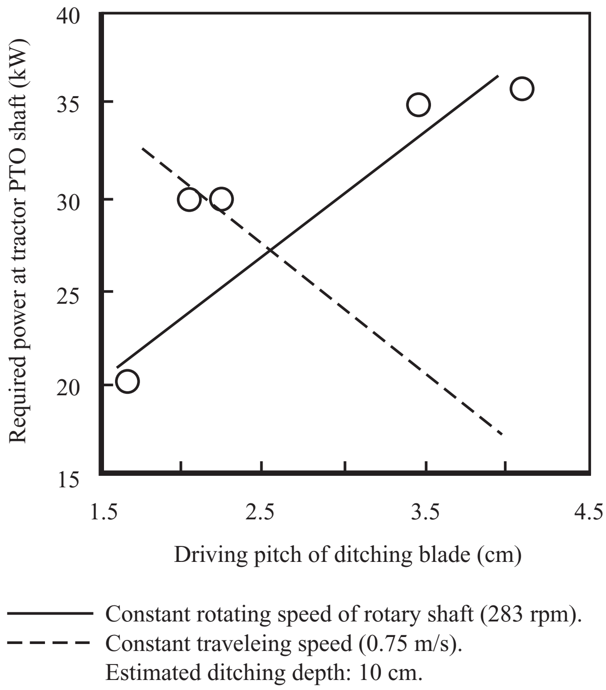


Fig. 3. Results of required power test in the pasture located at Institute of Agricultural Machinery

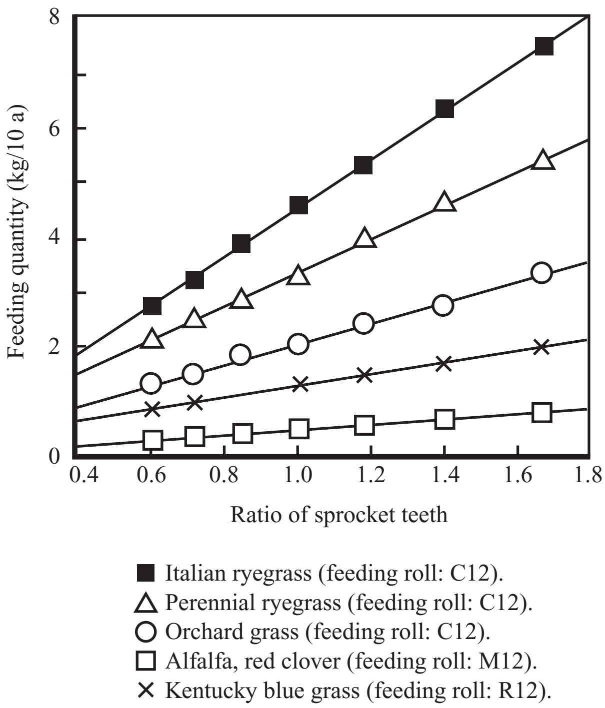


Fig. 4. Relation between the ratio of sprocket teeth and feeding quantity

with different sizes depending on the seed size in order to accurately feed seeds ranging from herbage legume seeds to forage grass seeds. Fig. 4 shows the quantity of each kind of grass fed when the machine was in a stationary position. For all kinds of seeds, the amount fed was directly proportional to the sprocket ratio ([number of teeth of power intake sprocket installed at seeding shaft] / [number of teeth of sprocket installed at power ground driving wheel]). These results show that the method enabled to adjust accurately the amount of seeds fed.

We performed actual ditching and seeding work, setting the amount of seeds sown as shown in Fig. 4. We then compared the selected sowing rate (amount of seeds sown) with the actual rate and found that the rates corresponded well. In Table 1, the set fertilizing rate is compared with the actual one. The range of fertilizer applied was satisfactory in practice, although there was a slight difference between the set amount and the amount actually applied because the fertilizer was applied using a fluted slide feeding roll.

Table 1. Characteristics of granular fertilizer applied

Granular fertilizer	Bulk density (g/L)	Traveling speed of machine (m/s)	Quantity applied (kg/10 a)	
			Set	Measured
A	950	0.41	29.8	28.4
A	950	0.98	29.8	26.7
B	965	0.41	32.2	32.5
C	1126	0.98	28.5	28.9

Operation of developed machine and its effects

1. Pasture management before renewal

In order to determine the conditions for over-sowing

Table 2. Effect of grassland soil pH on the growth of over-sown grass

	Low pH plot 4.7 pH (H_2O)	Normal pH plot 6.2 pH (H_2O)	
		Test plot 1	Test plot 2
Orchard grass[a)]			
Number of stands[b)]	74.2	72.8	77.8
Mean grass height (cm)	4.0	6.2	6.1
Red clover[a)]			
Number of stands[b)]	7.0	11.0	12.0
Mean grass height (cm)	2.5	3.2	3.0

a): Amount of over-sown seeds in the ditch:
Orchard grass, 1.15 kg/10 a; red clover, 0.17 kg/10 a.
b): Per 1-meter long single ditch.

of seeds by the test machine, we investigated the influence of the grassland soil pH on the bud reproduction and growth of over-seeded grass.

Table 2 shows the results, by comparing the number of stands and plant length in a low pH area to those in a normal pH area. Orchard grass tended to be shorter in low pH areas, while the number of red clover stands tended to be smaller there, implying that the improvement of the grassland chemistry was also an important factor for the machine efficiency in renovating grassland.

2. Grassland management after renewal

Since sown grasses grow by competing with the existing vegetation, seeded grasses may become weak due to the competition for shade in areas where the existing vegetation grows profusely. Therefore, existing grasses should be mowed within an optimum period of time and prevented from growing, or their growth should be controlled, such as by using a slow-release fertilizer during renovation.

3. Examples of operation and its effects

Table 3 shows the results of a field trial in a meadow located at the Oita Prefectural Animal Industry Experimental Station using the first test machine. In both Tests 1 and 2, the actual number of seeds sown was almost the same as the amount selected, confirming that accurate operation was practically possible. The number of standing plants after renovation in Test 2 was 50 to 60% of that in Test 1. The amount of seeds sown in Test 2 was also slightly less, but the lack of rainfall after Test 2 may have influenced the results. In Test 1, 69 stands were obtained per 1-meter long ditch compared with the test plot of overall renovation in which sown seeds amounted to 3 kg/10 a and there were 65 stands per 625 cm^2. Therefore, we concluded that sprouting was satisfactory. Furthermore, the summed dominance ratio (SDR_2) of orchard grass, which had been approximately 20, increased to 80 to 100 about one year later due to renovation (Test 1).

As part of the multipurpose utilization of the machine, we conducted an over-seeding test of Italian ryegrass in the grassland with Bahiagrass located in Minamitane town, Kagoshima prefecture from 1994 to 1995. The over-sown seed was Tachiwase. The objective of this test was to enable year-round utilization of the grassland by the addition of Italian ryegrass to the grassland with summer tropical grass, thereby dramatically increasing the grassland yield. In this test, the machine was attached to a 58 kW (79 PS) tractor. The number of seeds sown and the amount of fertilizer applied were both almost the same as the selected values. Table 4 shows the results of a survey on the growth conditions of seeded Italian ryegrass. As can be seen, sprouting was better than that in a traditional working plot, and the yield of fresh grass exceeded 2 kg/m^2 in the next spring (March). A similar test conducted in the Bahiagrass grassland located at Kyushu Agricultural Experimental Station also confirmed the machine efficacy. For example, year-round utilization was made possible based on the grassland yield, and a dry matter yield of 2 t/10 a could be obtained[2].

Table 3. Results of field trial using first test machine

	Test 1	Test 2		
		(1)	(2)	(3)
Set sowing rate (g)[a)]	0.3	→	0.24	←
Actual sowing rate (g)[a)]	0.275	→	0.24	←
Actual fertilizer rate (g)[a,b)]	6.5	→	6.2	←
Mean number of stands of over-sown grass[a,c)]	69.1	38.5	38.7	34.0
Mean height of stands of over-sown grass (mm)[c)]	–	21.1	22.3	17.8

Field: Meadow located at Oita Prefectural Animal Industry Experimental Station. Over-sown seed: Orchard grass.
Test 1: Sowing date, 25 Sept. 1991; investigation date, 11 Oct. 1991. Test 2: Sowing date, 9 Sept. 1992; investigation date, 22 Oct. 1992.
(1), (2) and (3) refer to different locations in the meadow.
a): Per 1-meter long single ditch.
b): Compound fertilizer containing CDU-nitrogen.
c): Mean of 10 samples.

Table 4. Growth of over-sown Italian ryegrass

	Second test machine		Conventional
	Test 1	Test 2	method[a)]
Fertilizer used	Compound A[b)]	Compound B[c)]	Manure
Amount of over-sown seeds (kg/10 a)	1.6	1.6	1
Number of stands[d,e)]	70.8	69.2	19.4
Mean height (cm)[d)]	21.0	23.0	–
Yield of over-sown Italian ryegrass (kg/10 a)[f)]	2.333	2.087	Nearly nil
Mean height (cm)[f)]	49.0	46.4	

a): Broad seeding using a broadcaster.
b): Compound fertilizer containing CDU-nitrogen (N-P-K ratio: 15-15-15).
c): Compound fertilizer without CDU-nitrogen (N-P-K ratio: 15-15-15).
d): Investigation was conducted on 2 Dec.1993.
e): Tests 1 and 2 denote stands per 1-meter long single ditch (in the conventional method, the stands are denoted per 1 m^2).
f): Investigation was conducted on 7 Mar. 1994.

Conclusion and outlook

The second machine reduced the pasture renovation labor and enabled inexpensive renewal. For example, Ishiguro[1] estimated that the cost of renovation by the test machine was approximately 30% of the cost of the overall renovation method.

Management before renewal, improvement of pasture chemistry, renewal within an optimum period of time, and appropriate management after sprouting are necessary in order to fully realize the benefit of renewal. In the management before renewal, it is essential to analyze the cause(s) of decreasing yield and to take measures depending on the cause(s).

Although this test machine was developed for renovating grasslands with a low yield, it could also be used as a cropping system of Bahiagrass plus Italian ryegrass as well as for multiple purposes such as cultivation of grass plus oats or direct sowing of forage rice plants. We also consider that it is possible to prevent grassland deterioration and keep the land under optimum conditions by performing regular seeding.

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