Improvement of Harrowing Effect and Stubble Treatment of Rotary Tillers

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Although the harrowing effect of rotary tillers presently on the market is higher than that of plows, it is not enough to permit the sowing immediately after the tilling, and the stubble treatment, ie., incorporation of stubbles or weeds into soils, is less effective than that of plows.

To improve these performances, modifications of rotary tiller was carried out by doubling the number of tines and increasing speed of rotation of rotary shaft as well as improving tilling device. In 1968–1971, the modified tiller was tested on rice fields, wheat field and Italian rye grass field after the harvest of each crop.

Modification of tilling device[1)]

A walking type tiller, Fuji PM2 type (a side-drive type, with the tilling width of 55 cm and the engine of 8 ps and 1400 rpm) was used. As shown in Fig. 1, spiral arrangements of 16 tines and 32 tines on a rotary shaft were designed by utilizing bill tines available on the market (maximum radius of rotation of 260 mm, with cutting width of 55 mm). Rotation of rotary shaft was also modified to increase by 23% more than usual tillers.

Methods of field test[1),2),3)]

Conditions of test fields are given in Table 1. Paddy fields of three different soils, i.e., sandy loam (at Miyazaki), loam (at Miyakonojo) and clay (at Okayama), were used after the harvest of rice. Moisture content of sandy loam was close to the plastic limit (34%), whereas that of loam was very high, being higher than the liquid limit (62%), and that of clay soil was also higher than the plastic limit (30%) in addition to the heavy texture with 52% of clay content. In general, the tilling operation is

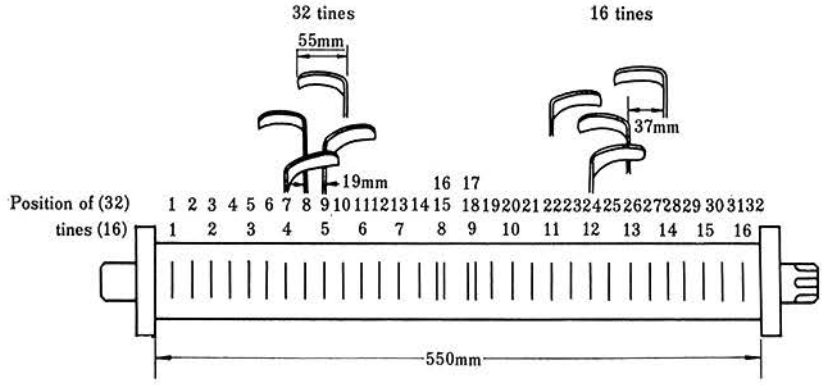

Fig. 1 Arrangement of tines

Table 1. Conditions of test field

Field	Paddy field			Upland field	
Crop	After rice harvest			After wheat harvest	After Italian rye grass harvest
Soil texture	Sandy loam	Loam	Clayish soil	Sandy loam	Sandy loam
Location	Miyazaki	Miyakonojo	Okayama	Miyazaki	Miyazaki
Soil moisture	Dry field	Wet field	Wet field	Dry field	Dry field
Moisture content	36%	93%	45%	33%	37%
Number of stalks (1 m²)	400	460	400	400	1, 200

Table 2. Test conditions of tilling

Test plot	Number of tines	Revolution of rotary shaft (r.p.m.)	Working speed (m/s)	Lead (cm)	Increment of cut (cm)
32 H 0.2	32	H (270)	0.2	4.9	1.6
32 M 0.2	32	M (220)	0.2	6.0	1.9
16 M 0.2	16	M (220)	0.2	6.0	3.1
32 L 0.2	32	L (160)	0.2	8.8	2.6
32 L 0.4	32	L (160)	0.4	12.5	3.8
16 L 0.4	16	L (160)	0.4	12.5	6.5

not practiced on such wet fields as the latter two.

Upland fields were of sandy loam with moderate moisture contents and more porous than the paddy fields. It was easy to pulverize the soil of wheat field whereas it was quite difficult with the Italian rye grass field because of dense stubbles and roots remaining on the field.

Tests were conducted by combining following factors, as shown in Table 2: number of tines: 16 or 32, rotation of rotary shaft: high (H), medium (M, which is equal to maximum speed of usual tillers), and low (L), walking speed: 0.2 and 0.4 m/s, and tilling depth of 5 and 10 cm. However in this report, results of six plots representing typical treatments are described.

Lead (f cm) in Table 2 is given by $f = 60\,v/n$, taking the walking speed as V cm/s, and the rotation speed of rotary shaft as n rpm. Increment of cut (P) is shown by $P = f/N$, in which N refers to the mean number of tines operating in a same vertical plane of the rotary shaft ($N = 1.66$ when the number of tines is 16, and $N = 3.10$ with 32 tines).

Harrowing effect was assessed by measuring the percentage of clods smaller than 1 cm and those larger than 4 cm to the total amount of clods tilled. Stubble treatment was assessed by determining percentage of stubbles incorporated into soil up to 4 cm depth to the total amount of stubbles existed at the time of tilling.

Accuracy of tilling was rated based on a scale of A to E, with A indicating the highest and E indicating the lowest. For the sowing of rice or wheat, no additional pulverization is needed with A and B, whereas 2 strokes or 5–6 strokes of break harrow are required with C and D respectively. Additional 1–2 times of rotary tilling are needed for E.

Result of test on paddy fields

1) Harrowing effect

At a same level of lead, an increase of tines from 16 to 32 caused an increased harrowing effect, giving less percentage of clods larger than 4 cm, and larger percentage

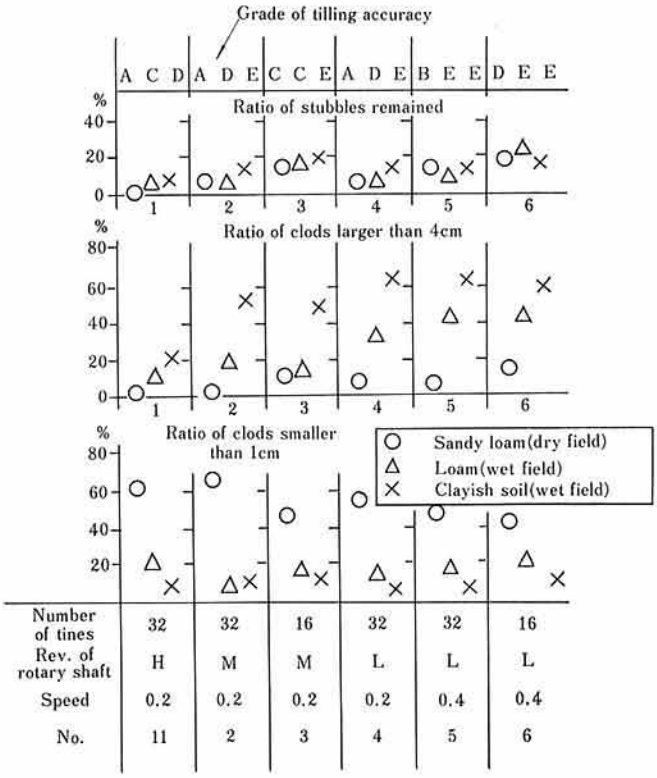

Fig. 2 Results of tilling paddy field after rice harvest (Depth of tilling: 10 cm)

of clods smaller than 1 cm (Fig. 2). However, it was not the case with too wet soils (of Miyakonojo and Okayama). Thus, it can be said that under the moderate moisture content of soils the harrowing effect can be increased by increasing the number of tines and the speed of rotary shaft, and decreasing the increment of cut, but not with the too wet soils which do not permit the usual tilling operation.

2) Stubble treatment

Irrespective of kinds and moisture contents of soils, stubbles were treated more effectively by the increased number of tines at a same level of lead. At a same increment of cut, the deeper tilling (10 cm) was more effective than the shallow tilling (5 cm).

3) Power requirement of rotary shaft

Power requirement increased by 10–15% with the use of 32 tines, when compared at a same lead. Using usual walking type rotary tillers with 60 cm of cutting width and 10 cm of tilling depth, an engine of about 8 ps is sufficient enough for the work with 32 tines at a speed of rotary shaft 20% more than usual tillers on the market.

4) Tilling accuracy

Use of 32 tines at an increased speed was effective in increasing the tilling accuracy. Particularly at a moderate moisture content of sandy loam soil, the tilling of A grade was obtained by [32 H 0.2] and [32 M 0.2]. Tillers on the market (with 16 tines) give a minimum increment of cut at [16 M 0.2], which does not allow the sowing without an additional harrowing.

Results of test on wheat and Italian rye grass field

1) Harrowing effect

As the soil of the wheat field was porous, and the number of stems remaining on the field was not much (Table 1), tilling operation with 16 tines gave a good pulverization with more than 60% of small clods (<1 cm). However, when compared at a same lead, 32 tines gave more or less better result. On the other hand, a large amount of stubbles and roots remaining on the field after the harvest of Italian rye grass made the soil pulverization difficult. Under this condition, an increased number of tines expressed a remarkable effect in pulverizing soil. At [32 H 0.2] the pulverization was enough for the sowing.

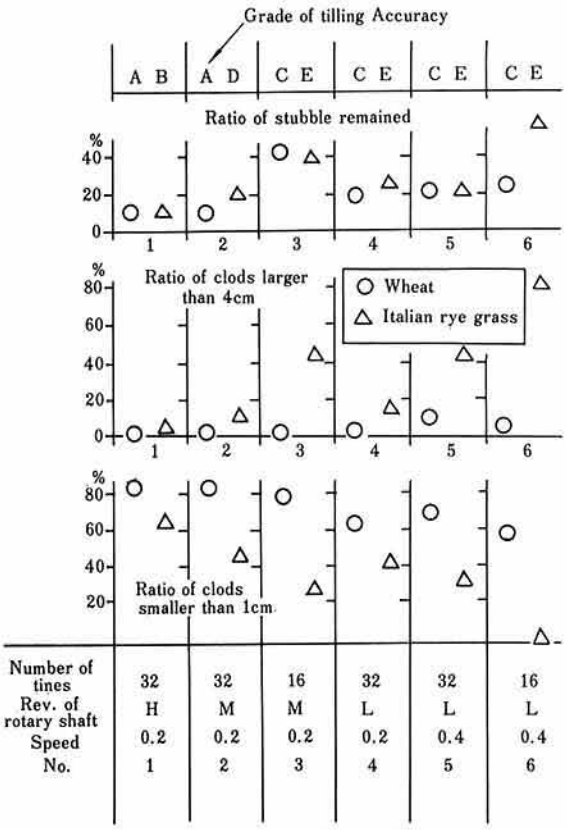

Fig. 3 Results of tilling after harvest of wheat and Italian rye grass on upland. (depth of tilling: 10 cm)

2) Stubble treatment

Effectiveness was increased by 32 tines, particularly remarkable on the Italian rye grass field (Fig. 3), although stubbles left unincorporated were more as compared to paddy fields.

3) Power requirement

Power required for tilling the Italian rye grass field was almost the same as that for paddy fields, whereas it was 30% less for the wheat field. Using tillers with 8 ps for rotary shaft, it was difficult to work on the Italian rye grass field at a speed of 0.4 m/s, when 32 tines were used with a tilling depth of 10 cm, but it was easy to work at lower speeds.

4) Tilling accuracy

On the wheat field, [32 H 0.2] and [32 M 0.2] gave A grade tilling (Fig. 3). In the Italian rye grass field too, 32 tines gave a better result (Fig. 3). It is a significant improvement that in tilling the Italian rye grass field usual tillers available on the market gave E grade at the minimum increment of cut [16 M 0.2], whereas B grade, which permits sowing without additional harrowing, can be obtained by usuing 32 tines at the minimum increment of cut [32 H 0.2], as shown in Fig. 3.

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