Ref: C0697

Re-improvement method of old pasture grassland developed by improved stabilizer and stone crusher in coral islands of Okinawa, Japan

Yoshiharu Hosokawa, Faculty of Agriculture, University of Miyazaki, Gakuen-kibanadai, Miyazaki, 889-2192, Japan

Abstract

In some coral islands of Okinawa, Japan, beef cattle production had been carried out for a long time by traditional grazing system in pasture grassland. The grassland productivity had been low and cattle production was under little progress. A large scale of grassland development was started from 1984, by “Process 1” using “Improved stabilizer”, improved road stabilizer for digging 40 cm depth. In “Process 2”, “Stone crusher” was used instead of man-hand picking stones on surface after working improved stabilizer. In comparing with distribution of sieving stones and grass root in Processes 1 and 2, the weight content of stone under 30 mm size was 84% in Process 1 and 86% in Process 2, and the stone size in 0~10cm soil layer became small in Process 2. The grass root weight in Process 2 was slightly larger than in Process 1. Process 2 created effectively the top soil layer of grassland than Process 1. As years pass, grassland became hard surface by cattle hooves’ compaction and then indicated gradually lower grass productivity. Re-improvement for old grasslands have been carried out up to 30 cm depth by stone crusher only, but many stones were dig up onto surface from bottom layer. It is recommended that when re-improving old grassland, the depth for working stone crusher should be up to 10 cm (desirable, maximum 15 cm) depth to keep less stones.

Keywords: coral island, grassland development method, re-improvement, improved stabilizer, stone crusher

1. Introduction

1.1 Traditional grassland in coral islands of Okinawa, Japan

There are some coral islands in the Yaeyama Islands of Okinawa Prefecture, in the southern west of Japan, as shown in Figure 1. The ground of coral island is mainly composed with the bedrock of Ryukyu Limestone, formed as an upheaval (in the diluvial epoch) of the sedimentary of huge coral and shell in the Palaeozoic era. The Yaeyama Islands, belonging the Ryukyu Kingdom, former Okinawa Prefecture in Japan, was recorded as people had lived in 1519 (Taketomi Town, 2011). From the investigation by Mr. Sasamori in the southern islands in 1893, he had reported“cattle production in traditional grassland and sugar cane plantation had been carried out about 120 years ago” in his publication (Sasamori, 1894).

1.2 Soil and grassland condition of Kuroshima Island as coral island

Kuroshima Island, one of coral islands of the Yaeyama Islands, is very flat with the highest level of 15.3 m above the sea and the area of 10.0 km^2. Its major industry is almost beef cattle production, especially by grazing in pasture grassland, except for a marine sightseeing. Pastures are divided by stone walls stacked with coral stones from pasture or by barbed wire fence with much rust under marine environment (Hosokawa, 2012). The soil type is the Shimajiri Mahji Soil from Ryukyu Limestone (Tokashiki, 1993). The soil is in a thin layer and also infertile, because the natural soil is based on Ryukyu Limestone, being coral bedrock.

Beef cattle production had been carried out in native grassland and in developed pasture traditionally for grazing, under a grassland condition as shown in Figure 1. In particularly, the pasture had remarkably various sizes coral rocks. Therefore, beef cattle production was always carried in a low land-utilization with a little grazing capacity due to less grass production. To raise a beef cattle productivity, it was necessary to innovate a large scale of grassland development using special equipment to destroy coral bedrock and then to level the ground for grassland.

1.3 A large scale of grassland development by heavy equipents

To make effective soil layer with at least 20cm depth for grassland in the coral area, a heavy equipment of road stabilizer, scratching asphalt road surfaces, was improved for agricultural use to destroy hard coral bedrock up to about 40 cm depth. The improved stabilizer is a wheel type as shown in Figures 3 and 5 and its characteristic is indicated in Table 1. A large scale of grassland development was started by using the improved stabilizer in 1984 (Japan Agricultural Land Development Agency, 1985), while studying the equipment requirement per unit work (Nishida, 1989).

In fact, about 50 mm size stones were remained on grassland surfaces, being troublesome for grazing cattle. So some treatments needed to pick up and gather them, and then to carry them to some damping sites. However, it was very difficult to find workers in local and small islands, meaning a high cost construction by using manpower and the severe working under hot environment in the subtropical zones. Instead of these heavy working, they selected

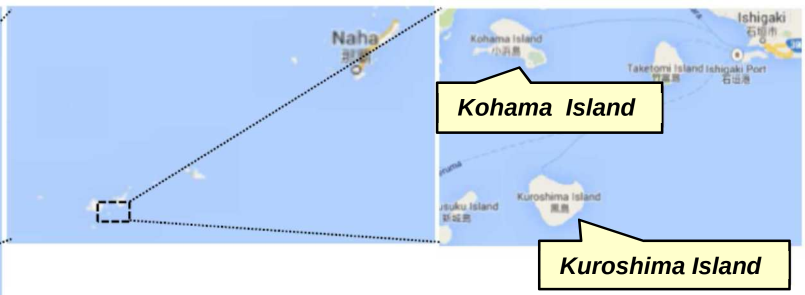

Figure 1: Maps of Japan, Okinawa Prefecture, and a part of Yaeyama Islands, from left (2014 Google map)

Figure 2: Native grassland with many coral rocks before the grassland development by the improved stabilizer

Figure3: Grassland development by the improved stabilizer, showing 30-cm-depth-cross-section

Figure 4: Construction by the stone crusher after working by the improved stabilizer

stone crusher, as shown in Figures 4 and 6 and in Table 1. In grassland development, the double methods, by firstly using the improved stabilizer and secondary using the stone crusher, were carried out in 1994.

These construction methods were treated as “Processes 1 and 2”, as shown in Figure 7 (Japan Agricultural Land Development Agency, 1994). The work from “Lumbering” to “Crushing coral bed” in Process 1 was similarly in Process 2, but the difference was to use

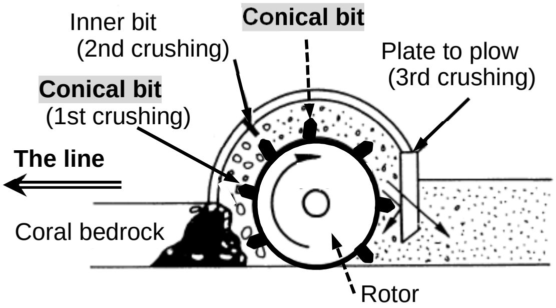

Figure 5: Equipment using improved stabilizer (Wheel type, Made in Japan)

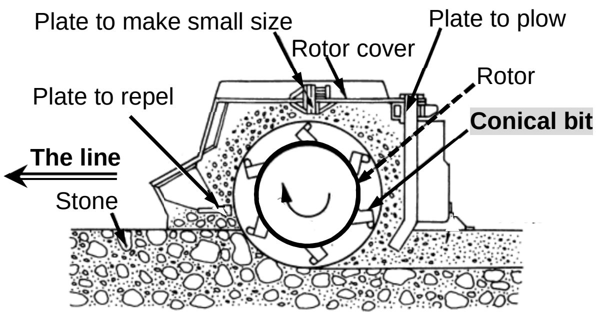

Figure 6: Equipment using stone crusher (Crawler type, Made in Japan)

Table 1: Characteristics of the improved stabilizer and the stone crusher (Hosokawa, 1998)

Fig.	Major equipment	Depth	Construction and driving method	Construction evaluation
5	Improved stabilizer for agriculture (Wheel type, Made in Japan)	About 40 cm (30 cm actually)	This work fits mainly for grassland development in coral bed rock while destroying by conical bits to small sized stones. The original machine was a stabilizer for a road construction.	1. Destroying work to about 40 cm depth is by a 2 m wide's rotor with many conical bits and 360 PS. Its movement is easy by a wheel type in a wide field. 2. Destroying to small size stones, but about 50 mm size stones are still remained.
6	Stone crusher (Crawler type, Made in Japan)	30 cm	The destroying equipment is fixed to a bulldozer or a crawler-type stabilizer. Stones and rocks are directly destroyed by over 100 hard-conical bits. Without former treatment like leveling land, it fits to a large field.	1. It fits to various construction condition with crawler shoes for wetland. 2. Stones made small size by some plates are distributed smaller stones to upper soil layer and bigger one to lower layer.

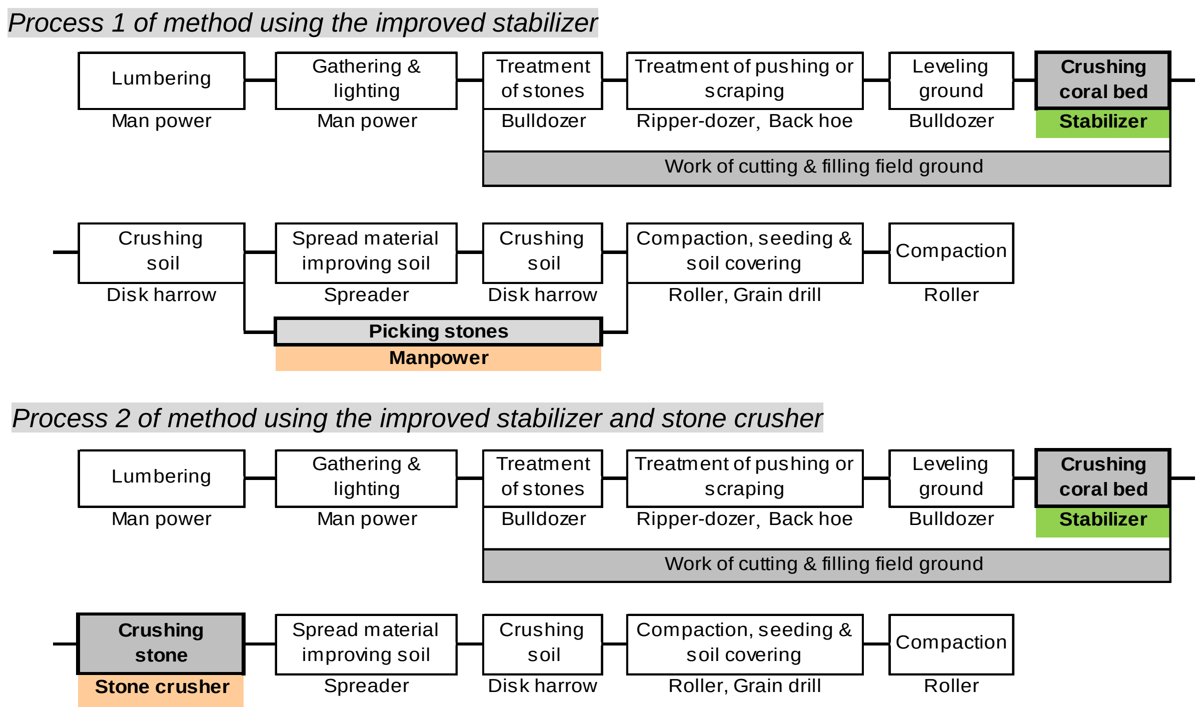

Figure 7: Processes using improved stabilizer and using improved stabilizer and stone crusher

the stone crusher instead of the work of "Picking stones" by a lot of manpower

2. Materials and methods

2.1 Investigation of stone distribution and grass root in each 10 cm layer up to 30 cm depth, in Processes 1 and 2

In two sites of 1 m squire quadrat developed in Processes 1 and 2 in Kuroshima Island, each 10 cm soil layer containing stones up to 30 cm were dig up and the stone was sieved by 30, 50, 80, 100 mm mesh sieves, and then measured each size weight of stones. Also, the grass root of 10 cm layer up to 30 cm depth was picked and dried for 2-day-forced-air-drying at 80 centigrade degrees, and measured the weight. Furthermore, the root growing in soil cross section up to 30 cm depth was observed finding stones, after digging there in March, 2013.

2.2 Investigation of remaining stone on grassland surface after Process 2

The remaining stones on the grassland surface was investigated in March, 2013. The investigated grassland was already developed by Process 2 before in Kohama Island, coral island near Kuroshima Island, as shown in Figure 1. In 2009, the re-improving grassland by using stone crusher only was treated there.

3. Results and Discussion

3.1 Stone distribution and grass root in soil layer of grasslands developed in Processes 1 and 2

Figure 8 shows the percentage of total sieving weight of stones. Those of stones under 30 mm size was averaged 84% in Process 1 and averaged 86% in Process 2, respectively. In Process 2, stone was forced into the bottom by the stone crusher because the percentage was remarkably 97% in 0~10 cm layer. However, in 10~20 cm and 20~30 cm layers, those were almost similarly in two Processes in case of 30 mm size. In case of 50 and 80 mm sizes, it was found a slightly improvement to make small or to force into the bottom. Kawamoto (2001) reported similarly that fine soil was composed in the top layer from his investigation. It is important for stone size and quantity in each soil layer to influence to grass production.

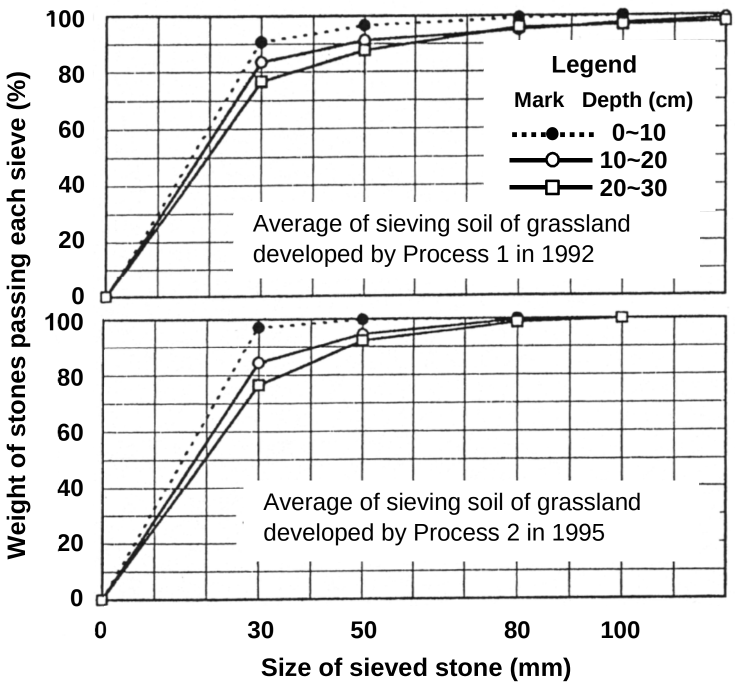

Figure 8: Distribution of stones in soil layer by diffferent grassland development method

Table 2 shows the maximum stone size and stone content comparing with two Processes. The maximum stone size in 0~30 cm layer was 200 mm in the 1st site and 120 mm in the 2nd site in Process 1, and 100 mm in both sites in Process 2. The averaged stone content of two sites was 11.0% in Process 1 and 9.3% in Process 2. Particularly, the stone content of 10~20 cm and 20~30 cm layers were almost similarly, however, the different in the top layer was obviously measured 1.9% in Process 2 against 6.2% in Process 1 (Hosokawa, 2013).

3.2 Grass root in soil layer of grasslands in Processes 1 and 2

Table 3 indicates the weight and percentage of grass roots in two Processes. The grass in both sites was Giant Star grass (*Cynodon nlemfuensis Vandery*), preferred by many farmers for grazing pasture in Yaeyama Islands. The average weight of grass roots in Process 1 was 57.8 g against 41.2 g in Process 2. The former pasture was developed 6 years ago in 1992 against the latter one 3 years ago in 1995 at the first investigation in 1998, and in case under same grassland maintenance, it may be slightly influenced by year pass. Furthermore, the averaged percentage in Process 1 was 91.1% in 0~10 cm layer, being slightly large against 82.3% in Process 2. However, in 10~20 cm and 20~30 cm layers, the average percentages in Process 2 indicated larger than in Process 1.

In Figure 9, the grass root and stones is shown in cross section of soil layer up to 30 cm depth. In case of the grassland development by both Processes, the root was grown to about 20 cm depth. However stones of 6~3 cm sizes in Process 1 and 9~3 cm sizes in Process 2 were observed. Therefore, in Process 2, larger stones were forced into bottom soil layer and made fine soil in top soil layer by stone crusher.

Table 2: Comparison of maximum stone size and stone content with above 30 mm size

Method	Depth (cm)	Max. stone size (mm) *		Stone content (%) *		
		1st site	2nd site	1st site	2nd site	Average
Process 1	0～10	80	100	5.9	6.5	6.2
	10～20	200	120	10.3	11.9	11.1
	20～30	170	120	15.5	15.9	15.7
	Max. or Ave.	200	120	10.6	11.4	11.0
Process 2	0～10	80	80	2.0	1.8	1.9
	10～20	80	100	11.0	9.4	10.2
	20～30	100	100	14.4	16.9	15.7
	Max. or Ave.	100	100	9.1	9.4	9.3

* Size of above 30 mm

Table 3: Comparison of dried grass root weigtht and its percentage

Method	Depth	1st site		2nd site		Average	
	(cm)	(g)	(%)	(g)	(%)	(g)	(%)
Process 1	0～10	62.0	91.2	43.3	91.0	52.7	91.1
	10～20	4.3	6.3	4.0	8.4	4.2	7.2
	20～30	1.7	2.5	0.3	0.6	1.0	1.7
	Total	68.0	100.0	47.6	100.0	57.8	100.0
Process 2	0～ 10	31.2	79.4	36.6	85.1	33.9	82.3
	10～20	5.2	13.2	4.0	9.3	4.6	11.2
	20～30	2.9	7.4	2.4	5.6	2.7	6.5
	Total	39.3	100.0	43.0	100.0	41.2	100.0

* Kind of the grass was Giant Star grass (*Cynodon nlemfuensis Vandery*) in both sites

Figure 9: Cross sections with about 20-cm-depth-roots in 30 cm layer and stones (left: 21-year-past in Process 1 showing 6~3 cm stones, right: 18-year-past in Process 2 showing 9~3 cm stones)

3.3 Remaining stones on surface of grassland re-improved by stone crusher only

The condition of remaining stones on grassland surface after re-improving is shown in Figure 10. The grassland, passed 4 years already after re-improving grassland in 2009 by using stone crusher only, has still stones on surface. The farmer of the grassland picked them up and accumulated at the corner. These works are troublesome for farmers.

The stone crusher can crush stones by many conical bits if stones are restricted in hard ground. In actual grassland cross section, the top soil layer compacted by cattle hooves could be hard, but in bottom layer, many stones might be under a weak restriction and then dig up from ground by Process 2: the improved stabilizer and the stone crusher, because the soil layer is not so hard than the original coral bedrock. It is estimated that stones are dig up from bottom layer by the stone crusher when re-improving grassland.

Therefore, re-improvement method for old grassland, developed by Process 2 before, is recommend to work the stone crusher up to 10 cm (desirable, maximum 15 cm) depth, to make fine soil with less stones in top soil layer, being important for growing grass.

Figure 10: Stones on surface of grassland, 4 years passed already after re-improving grassland by Process 2 in 2009 (left), and accumulated stones at corner of grassland (right).

4. Conclusions

The grassland development in coral islands was started by using improved stabilizer in 1984, and their effective grasslands could lead a better beef cattle production in this area. In case of using the improved stabilizer, the work of picking stones on surface and carrying them to damping sites was needed by man-hand, being a high cost construction. Instead of the troublesome works, the stone crusher was used after working the improved stabilizer, to force stones into the bottom by many conical bits. The method for re-improving old grassland is recommended to work the stone crusher up to 10 cm depth (desirable, maximum 15 cm), to make fine soil with less stones in a top layer for better grass growing.

5. Acknowledgements

The author would like to thank Mr. Matsubara (in Kohama of Taketomi Town, Okinawa Prefecture, a former engineer of Taketomi Town Office).

6. References

Hosokawa, Y., Ogasawara, H., Watanabe, T. & Muraoka, S. (1998). Improvement of the stony farmland by stone crusher, *Jour. JSIDRE. Vol.66*, 501-506. (In Japanese)

Hosokawa, Y. (2012). Grazing effect in radial pasture from the watering point in beef cattle management of Japan, *Proceedings of International Conference of Agricultural Engineering, Pdf papers (ISBN:978-84-615-9928-8, CIGR-AgEng2012: Valencia, Spain):137-C0960,* pp.1-6, USB proceeding.

Hosokawa, Y. (2013). Effect of grassland development methods on soil structure in the coral island (Kuro-shima) of Okinawa, Japan, *Proceedings of 2013 Conference of Australia Society for Engineering in Agriculture (Mandurah, Australia)*, Paper No.26, pp.1-8, USB proceeding.

Japan Agricultural Land Development Agency (1985). Technical report on the grassland development method by Stabilizer, pp.1-25. (In Japanese)

Japan Agricultural Land Development Agency (1994). Technical report on the grassland development in Okinawa Prefecture, pp.32-59. (In Japanese)

Kawamoto, Y. (2001). On the relationship between grassland development methods, year pass difference in construction, stone distribution, and grass production in grassland of coral bedrock of Ryukyu-limestone, *Report of Kyushu District of Japanese Grassland Society*, *Vol.31(1)*, 47-53. (In Japanese)

Nishida, K. (1989). Creating soil from Ryukyu Limestone (coral bedrock), *Water and Soil*, *Vol.76*, 45-51. (In Japanese)

Sasamori, G. (1894). Southern Islands Exploration, (*Original: Sasamori published in Hirosaki, Aomori Prefecture. 532p.)*, [Reprint: Southern Islands Exploration 1 (326p, 1982) & 2 (324p, 1984), Heibonsha, Tokyo]. (In Japanese)

Taketomi Town (2011). Statistical Survey of Taketomi Town, 20p. (In Japanese)

Tokashiki, Y. (1993). Properties of the Shimajiri Mahji and Jahgaru Soils in Okinawa Prefecture, *Japanese Pedologist. 37(2)*, 99-112. (In Japanese)