Technical Session 1: AGRICULTURE LAND & WATER

Development of physical topsoil removal techniques and machines for farmland decontamination

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Background and Purpose

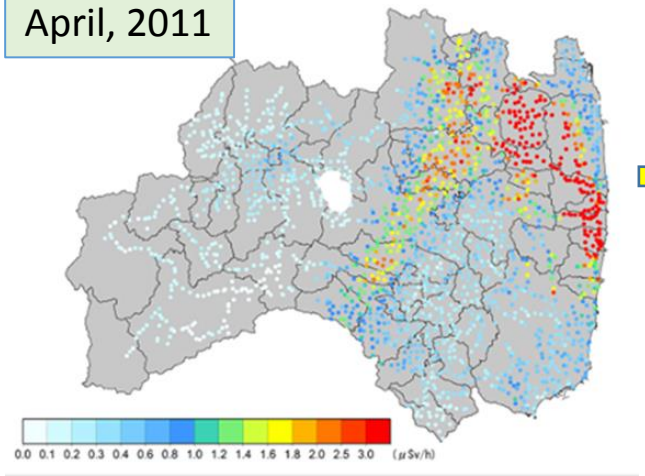
- After the Fukushima Daiichi nuclear power plant accident, radioactive material fell over a wide area of farmland in Fukushima Prefecture.
- Most of this material was concentrated in the topsoil of the farmland, which was several centimeters thick.
- Therefore, to decontaminate the farmland, the topsoil was scraped off.

- Currently, conventional construction machines such as power shovels and dump trailers are being used for this purpose.
- However, these machines operate very slowly and with low efficiency.
- Therefore, we have developed a new machine to improve the efficiency of the topsoil removal work.

Radioactivity measurement map

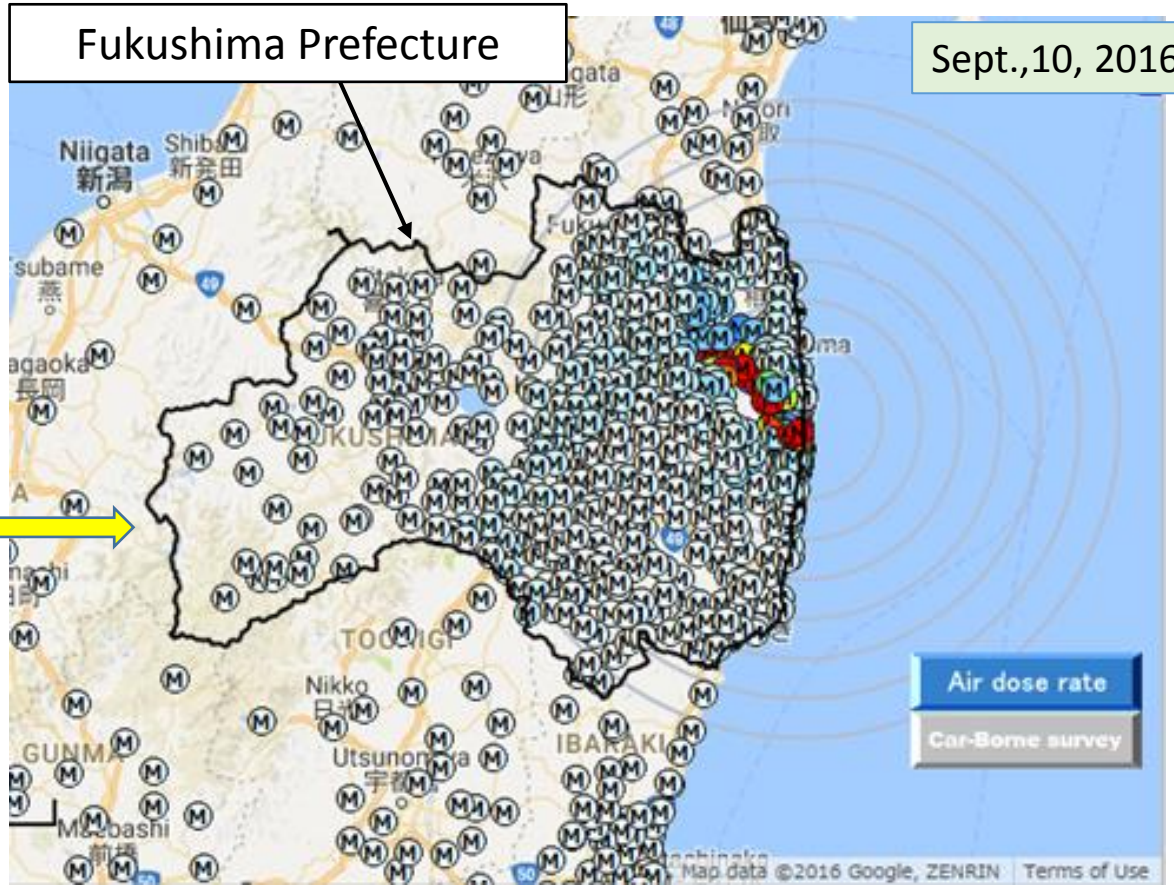
URL= http://fukushima-radioactivity.jp/pc/

April, 2011



Fukushima Prefecture

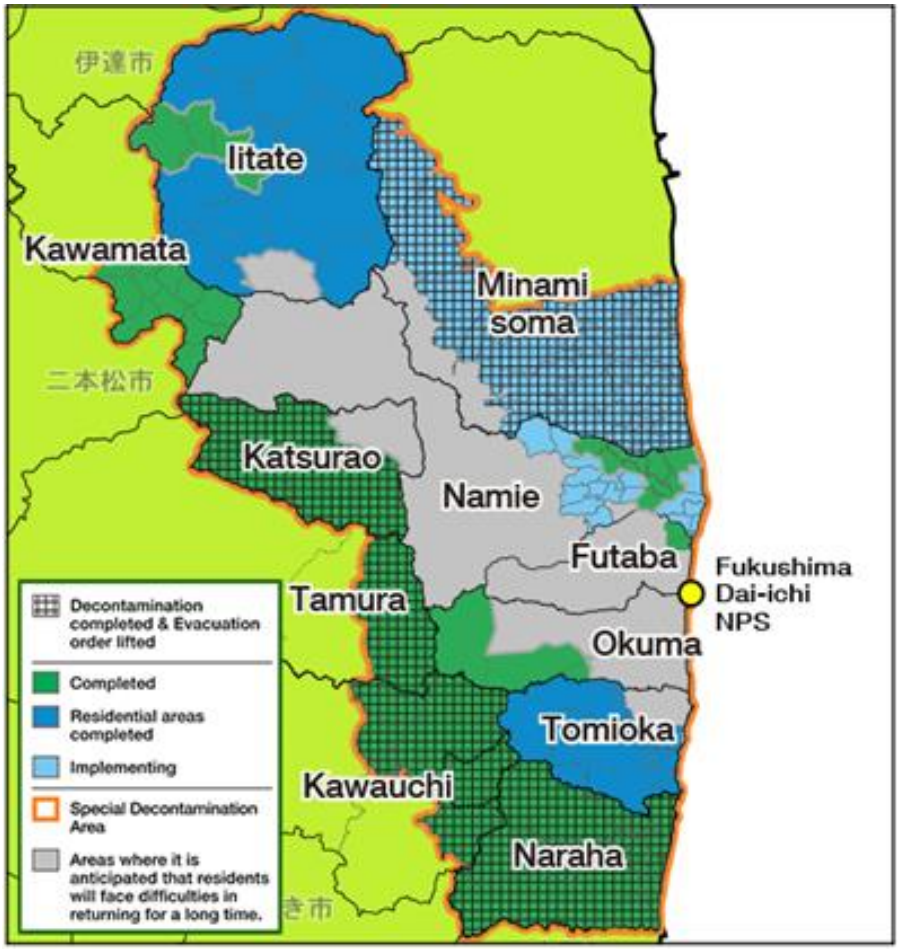
Sept.,10, 2016



Air dose rate (μSv/h)							
	~0.1	~0.2	~0.3	~0.4	~0.6	~0.8	~1.0
	~1.2	~1.4	~1.6	~1.8	~2.0	~2.5	~3.0	3.0~

Method for measurement
- (M) Monitoring post
- (R) Real time dose measurement
- (P) Survey meter (The prefecture measurement)
- (C) The air dose rate a city measured

Progress in Special Decontamination Area



Municipalities in which evacuation order were lifted

Municipality	Evacuation order was lifted on
Tamura city	April 1, 2014
Kawauchi village (former "Areas to which evacuation orders are ready to be lifted") (former "Areas in which residents are not permitted to live")	October 1, 2014 June 14, 2016
Naraha town	September 5, 2015
Katsurao village	June 12, 2016
Minamisoma city	July 12, 2016

1. Municipalities implementing whole area decontamination(aimed to complete all the decontamination by March 2017)

	Securement of TSS Note 1	Consent on decontamination	Execution rate(%) Note 2,3			
			Residential area	Farmland	Forest	Road
Iitate	Secured	99.6%	100	74 (62)	97 (96)	72 (62)
Minami soma	Secured	92%	96 (95)	36 (35)	63 (62)	39
Namie	94%	97%	71 Note 4 (63)	42 (39)	91 (83)	73 (71)
Tomioka	Secured	Completed	100	99	100	99.9

http://josen.env.go.jp/en/pdf/progressseet_progress_on_cleanup_efforts.pdf

Processes and machines of topsoil removal

Technologies sorted by radiocesium levels in soil

Radiocesium level in soil	Technology
～ 5,000 (Bq/kg)	Inverting plow, reduction of radiocesium uptake(*), topsoil removal (uncultivated field)
5,000 ～10,000 (Bq/kg)	Topsoil removal, inverting plow, removal of soil after paddling with water
10,000 ～25,000 (Bq/kg)	Topsoil removal
25,000 (Bq/kg)～	Topsoil removal after solidification

* This technology allows to reduce absorption of radiocesium by crops i.e. application of potassium fertilizer or adsorbent.

weed removal

Leveling

Scraping and loading (skimmer)

Surface disruption

Scraping

Agricultural machinery use

Transportation

Scraping

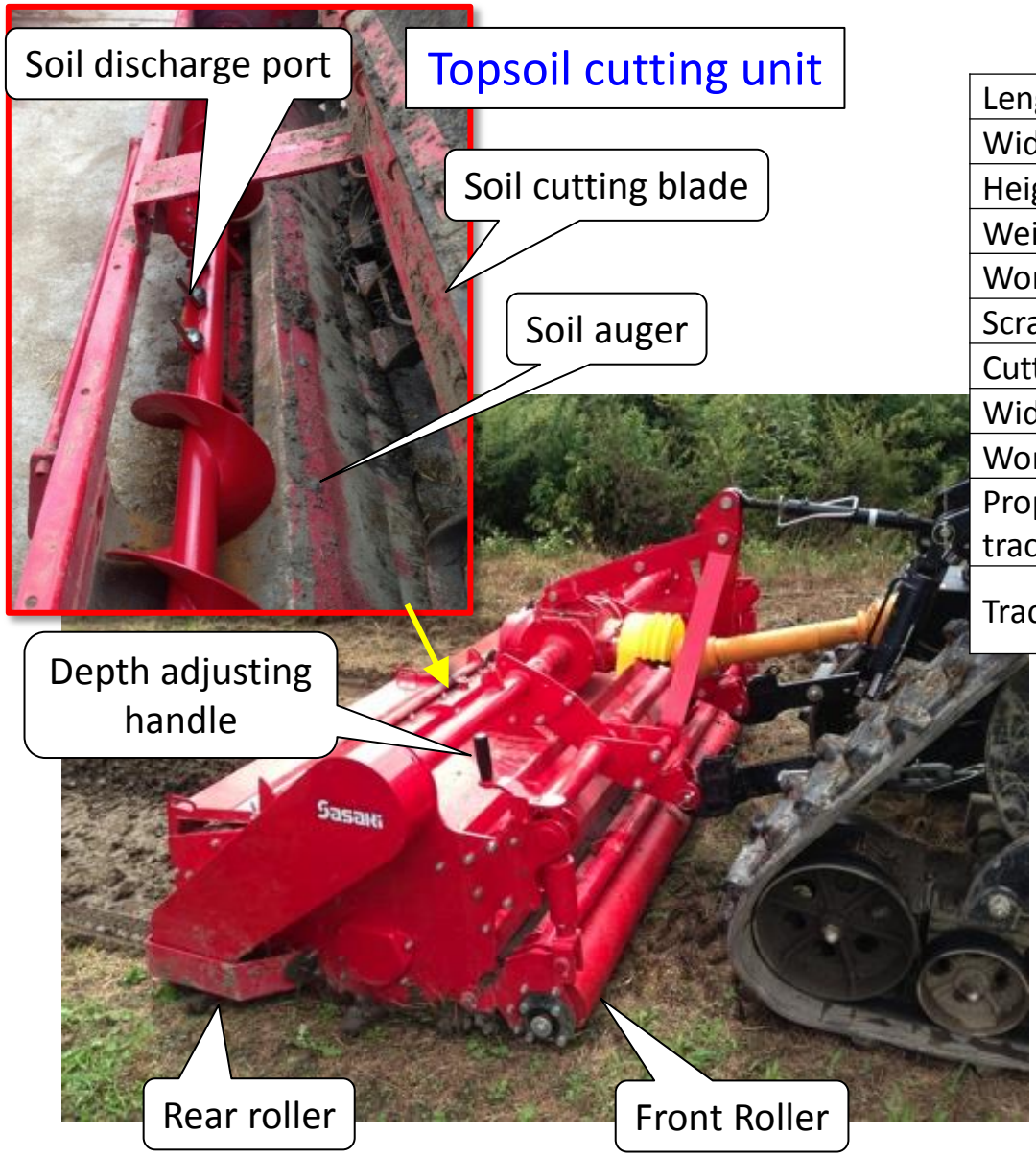
Loading

Civil engineering machinery use

Flexible container filling and transportation

Transportation and accumulation

Proposed topsoil removal machine



Specifications of the developed machine

Length, mm	1,274
Width, mm	2,512
Height, mm	1,157
Weight, kg	798
Working width, mm	2,200
Scraping depth, cm	0～8
Cutting blade, set	48 (L-shaped)
Width of soil discharge, mm	770
Working speed, m/s (km/h)	0.1～0.2 (0.36～0.72)
Proper engine output of the tractor, kW (PS)	more than 64 (85)
Tractor mounting unit type	Standard 3-point link, Direct attach type 2 (JIS)

Proposed topsoil removal machine

- Location: Iitate-mura, Fukushima prefecture
- Working speed: 0.2m/s, scraping depth: 4cm

Video:50s

Performance tests

- Tractor: semi-crawler-type tractor (engine power: 77kW).
- Test location: IAM attached farm (soil texture: SiC, moisture content: 45.9%)

PTO power requirement test results

Scraping depth Setting (cm)	Scraping depth Actual (cm)	Working Speed (m/s)	PTO torque (Nm)	PTO revolution (rpm)	PTO power Requirement (kW)
3	2.3±0.8	0.19	516.5	431.5	23.3
5	4.2±0.8	0.12	656.5	435.0	29.9
7	The test was discontinued because the scraped soil clogged the outlet of the soil discharge port.				

Field tests

- Tractor: semi-crawler-type tractor (engine power: 77kW).
- Test location: Iitate-mura, Fukushima prefecture (Sept. 6, 2013)

1. The working speed : 0.2 m/s (0.7 km/h) => the work efficiency was 0.8 h/10a
   - the maximum scraping depth was set to 5 cm
2. The working speed: 0.1 m/s (0.4 km/h) => the work efficiency was 1.4 h/10a
   - the maximum scraping depth was set to 8 cm

- The error of the scraping depth was approximately equal to “the depth setting - 1 cm”.
- The scraping performance was affected by various conditions of the topsoil, such as the surface undulation, hardness, moisture, and presence of weeds.
- Before the field test was conducted,
- The radiation dose rate:
  - Before: 0.23μSv/h at a height of 1cm (0.78μSv/h at a height of 1m)
  - After scraping to a depth of 5cm : 0.08μSv/h = “65% reduction”

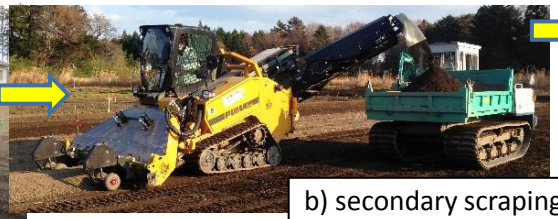
Improvement by the developed machine

The work efficiency of topsoil removal was improved from those of a power shovel or a skimmer, which is a self-propelled type of topsoil scraping and scooping machine.

Individual work (skimmer)

Cooperation work
(developed machine and skimmer)

a) primary scraping (depth 4 cm) and discharge soil (developed machine)



b) secondary scraping (depth 1 cm), scooping, and transportation (skimmer and dump trailer)

c) Soil transportation and accumulation

d) Flexible container filling and transportation

Place		Location: Fukushima-ken, Souma-gun, Iitate-mura								
Methods, machines		Period (2015)	Workers (person /day)	Working hours (h/day)	Working days (day)	Total area (ha)	Total hours (h)	Efficiency (h/10a)		
								Ave.	Max.	Min.
Individual work										
Skimmer A	scrape/5 cm ＋ Transport	5/13～9/24	2～3	6	28.5	3.79	171	4.5	2.1	20.0
Skimmer B	scrape/5 cm ＋ Transport	5/26～8/20	2～3	6	14.5	2.05	87	4.3	2.7	8.8
Cooperation work (a+b or a+c)										
a）developed	scrape/4 cm	5/18～6/8	1～2	6	17.0	6.14	102	1.7	1.0	2.1
b）Skimmer A	scrape/1 cm ＋ Transport	5/21～6/13	3	6	15.0	3.89	90	2.3	1.7	3.3
c）Skimmer A	scrape/1 cm ＋ Transport	5/26～6/13	3	6	8.0	2.13	48	2.3	1.7	3.0

Note: ＊ Calculated from the actual work data recorded and provided by the local office.

Individual work / Skimmer

Video:25s

Scraping (depth 5cm), scooping by a skimmer, and transportation by a dump trailer

Iitate-mura, Kami-iitoi area, 2015/11/17

Cooperation work / Two-step scraping

Primary scraping (depth 4cm) and discharge soil (developed machine)

Kwamata-machi, Yamakiya area, 2015/6/17

Video:25s

Video:30s

Secondary scraping (depth 1cm), scooping, and transportation (skimmer and dump trailer)

Conclusion

In conclusion, the developed topsoil scraping machine has been commercialized, and generally performs well. However, it is difficult to use under wet soil conditions, and struggles to perform conventional rotary tilling work. Therefore, it is necessary to consider the soil moisture content, and the presence of weeds or stones.

Furthermore, it was confirmed to contribute to improvements in the efficiency of topsoil scraping in the working fields of the introduced site.

Note: The relationship between cultivation methods and the moderating effect of cesium absorption in farmland after topsoil scraped decontamination is under investigation in different research groups of NARO.




Thank you for your attention.

Acknowledgment

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