Management of *Zoysia japonica* and *Imperata cylindrica* by Mowing of Levee Vegetation.

Akihide Fushimi, Ichiro Otani, Masahiro Kamei, Rintaro Okuno, and Jun Kubota.

Nat. Agri. Res. Center for Western Region, 721-8514, Japan

Corresponding author (fushimi@affrc.go.jp)

Introduction

- The Japanese population is rapidly aging. Rural areas, especially, face acute problems associated with an aging population. The number of principal agricultural workers in Japan in 2005 was 2,240 thousand and the percentage of those 65 years old and over was 57%, a considerable increase on figures from 20 years before (20%). Further, the cultivated land area in Japan is continuously decreasing. This tendency has been particularly true in mountainous farming regions.

- Abandoned cultivated land covered 386 thousand ha in 2005, or 5.7 times the size of Lake Biwa, which is Japan's largest freshwater lake, accounting for 8% of total cultivated land area. Plant succession from cultivated land to woodland has started in abandoned areas (Fig. 1). Projects aimed at utilizing abandoned cultivated land have been promoted by encouraging private companies to participate in novel agriculture and infrastructure improvement.

- However, little concern has been given to levee vegetation on paths between rice fields in both mountainous and flat farming areas during the same period of time (Fig. 2) because levee areas have been considered non production areas. From the late 1960s, Japanese people, especially those in city areas, began to see levee vegetation as important to the natural environment due to concerns about environmental issues related to industrialization. Now, levee vegetation is considered an intrinsic part of our coexistence with nature and the environment in Japan.

- Levee vegetation on paths between rice fields in Japan is generally maintained through mowing (Fig. 3). In several levees located in mountainous areas, mowing has been discontinued recently due to labor shortages. Consequently, we introduced *Zoysia japonica* (Fig. 4) and *Imperata cylindrical* (Fig. 5) as new levee vegetation species to suppress weed growth.

- Due to environmental concerns, we aimed to reduce damage to the levee area ecosystems by carefully altering the vegetation. In this study, we used non heading type *Z. japonica* variety, called “Asagake”, to prevent crossbreeding with levee vegetation. After a few years, we introduced *Z. japonica* to suppress woody plants in abandoned cultivated land to delay plant succession.

Materials and methods

- A field experiment was conducted from 2005 to 2007 at the National Agricultural Research Center for the Western Region at Fukuyama in Japan. On 20-May-05, *Z. japonica* (Asagake) with 10cm stolon lengths was planted (9, 25 and 100 stolons per m^2) on bare ground as coverage, not only to curb weed growth, but also to prevent erosion. One 10cm length rhizome with leaves of *I. cylindrica* was planted as a domain plant in the center of all plots on the same date.

- Plant stands were mowed at 8 cm height three times per year (At the end of May, July and Oct.) over two consecutive years. *Z. japonica*, *I. cylindrica* and weed dynamics were examined on each mowing date. We identified all emergent weeds during the experimental period, and measured the height and estimated coverage ratio of all plants in each plot. Coverage by each plants species was estimated using 10cm meshed 1-sqare-meter quadrat. We measured vegetation cover ratio as percentage area covered by each plant per each plot, using a digital image analysis program (Fractal analysis system version 3.4.7 for Windows).

Results and discussion

- The degree of plot coverage by *Z. japonica* at 100 stolons per m^2 was higher than that at both 9 and 25 stolons per m^2 from 28-Jul-05 to 22-May-06. After that period, *Z. japonica* coverage was similar in all treatments (Table 1). On mowing dates in 2005, we observed southern crabgrass dominance in all treatments (44 % to 71% coverage, Table 2). *Z. japonica* tended to dominate plots thereafter.

- The density of *Z. japonica* at planting had little effect on plant height and biomass during the experimental period. On all 2006 mowing dates and on 28-May-07, plant height was less than 30cm in all treatments, however, we found a few tall grasses (Tables 1 and 2). Across density treatments, average *Z. japonica* biomass tended to decrease from 2005 to 2006. Decreasing plant height and biomass, year by year, is considered good for levee weed management because there is little need for weeding in shorter grass conditions (Tables 1 and 2).

- In 2006, plant stands covered by *Z. japonica* had reduced southern crabgrass density. We found a negative correlation between *Z. japonica* coverage ability and southern crabgrass density over the two years (Table 3). Despite being an annual weed in main land Honshu and on Shikoku and Kyushu islands, southern crabgrass is also a troublesome weed in upland areas, primarily due to its node, adventitious root and bud configuration. Crabgrass can thus expand within patches like a perennial weed.

- In this study, we demonstrated expanding patches of *Z. japonica* easily reduce southern crabgrass density on levees mowed three times per year. We found the weed suppression abilities of *Z. japonica* on levees encouraging, but *I. cylindrica* did not start expanding by distributing daughter shoots till 22 May 2006.

Table 1. The effect *Z. japonica* stolon desnity at planting on plant cover, *Z. japonica* cover degree, plant height and biomass at mowing dates in 2005, 2006 and 2007 is given.

	2005						2006									2007		
	28-Jul			24-Oct			22-May			31-Jul			15-Nov			28-May		
Treatment	Plant cover[1] %		*Z. japonica* cover degree[2]	Plant cover %		*Z. japonica* cover degree	Plant cover %		*Z. japonica* cover degree	Plant cover %		*Z. japonica* cover degree	Plant cover %		*Z. japonica* cover degree	Plant cover %		*Z. japonica* cover degree
100 stolons m^{-2}	21	a[3]	1	30	a	2	78	a	3	75	a	3	47	a	2	86	a	3
25 stolons m^{-2}	11	b	1	13	b	1	59	b	2	72	a	3	42	a	2	72	ab	3
9 stolons m^{-2}	10	b	1	11	b	1	53	bc	1	71	a	2	31	a	2	69	ab	3
no stolons	13	b		9	b		45	c		70	a		31	a		57	b	
25 stolons m-2 + hand weedi	50		2	68		3	91		4	80		4	58		3	98		4
	Plant height[4] cm		Biomass g m^{-2}	Plant height cm		Biomass g m^{-2}	Plant height cm		Biomass g m^{-2}	Plant height cm		Biomass g m^{-2}	Plant height cm		Biomass g m^{-2}	Plant height cm		Biomass g m^{-2}
100 stolons m^{-2}	43		344	55		272	13		36	17		129	19		241	21		256
25 stolons m^{-2}	50		356	55		283	16		27	20		140	20		231	17		168
9 stolons m^{-2}	46		346	55		285	18		34	17		113	27		226	18		159
no stolons	49		328	53		294	18		31	20		94	37		235	25		199
25 stolons m-2 + hand weedi	–[5]		–	–		–	9		5	14		13	15		17	11		8

1) Mowing height was 8cm. We took digital pictures of each plot after mowing, and calcuated plant cover (%) with Fractal analysis system for Windows.
2) *Z. japonica* cover degree was indicated by the Penfound and Howard methed. 4:(100~76%),3:(75~51%),2:(50~26%),1:(25~6%),1':(5~1%) and +:(Under 1%).
3) Within the same column, means with similar letters are not significantly different at p=0.05 according to Tukey's test.
4) Weighted average by plant cover on each height.
5) Incapable measurement.

Table 2. The effect of *Z. japonica* stolon density at planting on weed species at mowing dates in 2005, 2006 and 2007.[1)]

		2005				2006						2007	
		28-Jul		24-Oct		22-May		31-Jul		15-Nov		28-May	
Treatment	Rank	Weed species	%	Weed species	%	Weed species	%	Weed species	%	Weed species	%	Weed species	%
100 stolons m^{-2}	1	Southern crabgrass	47	Southern crabgrass	70	*Z. japonica*	45	*Z. japonica*	38	*Z. japonica*	50	*Z. japonica*	35
	2	*C. microiria*	35	Livid amaranth	15	Wandering cudw	14	Horseweed	21	Southern crabg	27	White clover	33
	3	Livid amaranth	7	*C. microiria*	5	Oldfield toadflax	11	Common eveningprimrose	9	Japanese mugw	7	Common ever	11
25 stolons m^{-2}	1	Southern crabgrass	56	Southern crabgrass	66	Oldfield toadflax	30	Horseweed	31	*Z. japonica*	35	Common ever	28
	2	Goosegrass	17	Goosegrass	18	Wandering cudw	23	*Z. japonica*	25	Horseweed	22	White clover	27
	3	*C. microiria*	11	Livid amaranth	7	*Z. japonica*	19	Southern crabgrass	10	Southern crabg	20	*Z. japonica*	26
9 stolons m^{-2}	1	Southern crabgrass	58	Southern crabgrass	71	Oldfield toadflax	32	Horseweed	27	Southern crabg	46	Common ever	35
	2	Livid amaranth	20	Livid amaranth	18	Wandering cudw	29	*Z. japonica*	21	*Z. japonica*	25	*Z. japonica*	33
	3	*C. microiria*	14	*C. microiria*	4	*Z. japonica*	10	Southern crabgrass	14	Horseweed	18	White clover	8
no stolons	1	Southern crabgrass	44	Southern crabgrass	46	Oldfield toadflax	48	Southern crabgrass	38	Southern crabg	59	Common ever	60
	2	*C. microiria*	21	Livid amaranth	23	Wandering cudw	16	Horseweed	29	Horseweed	15	White clover	18
	3	Livid amaranth	16	Goosegrass	17	Annual bluegrass	13	Common eveningprimrose	9	Common evenir	12	Japanese mug	7

1) The dominance ratio (%: Dominance value / Summation of dominance value ×100) of the top three ranked weed species is given.

Table 3. Relationship between dominance value of southern crabgrass in 2005 and *Z. japonica* cover in 2005, 2006 and 2007.[1)]

		Dominance value of southern crabgrass on mowing dates in 2005.	
		28-Jul-05	28-Oct-05
Z. japonica cover (%)	28-Jul-05	−0.37 *	−0.26 NS
	24-Oct-05	−0.32 NS	−0.24 NS
	22-May-06	−0.35 NS	−0.33 NS
	31-Jul-06	−0.34 NS	−0.28 NS
	15-Nov-06	−0.48 *	−0.39 *
	28-May-07	−0.44 *	−0.37 *

1) NS: $p > 0.05$; *$p < 0.05$, from Spearman's coefficient of rank correlation.

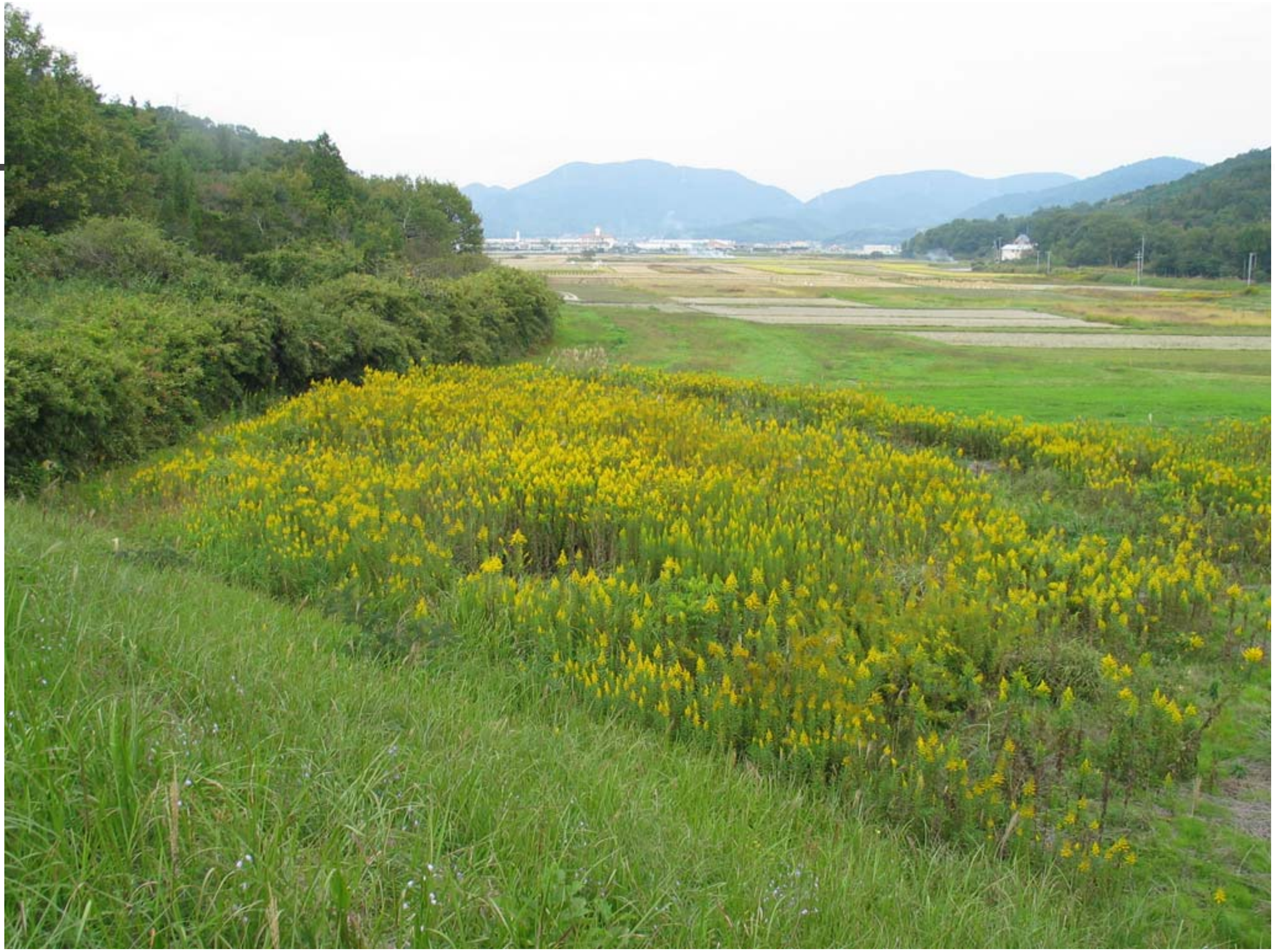

Fig. 1. Plant succession from cultivated land to woodland. Tall goldenrod has invaded an abandoned paddy field.

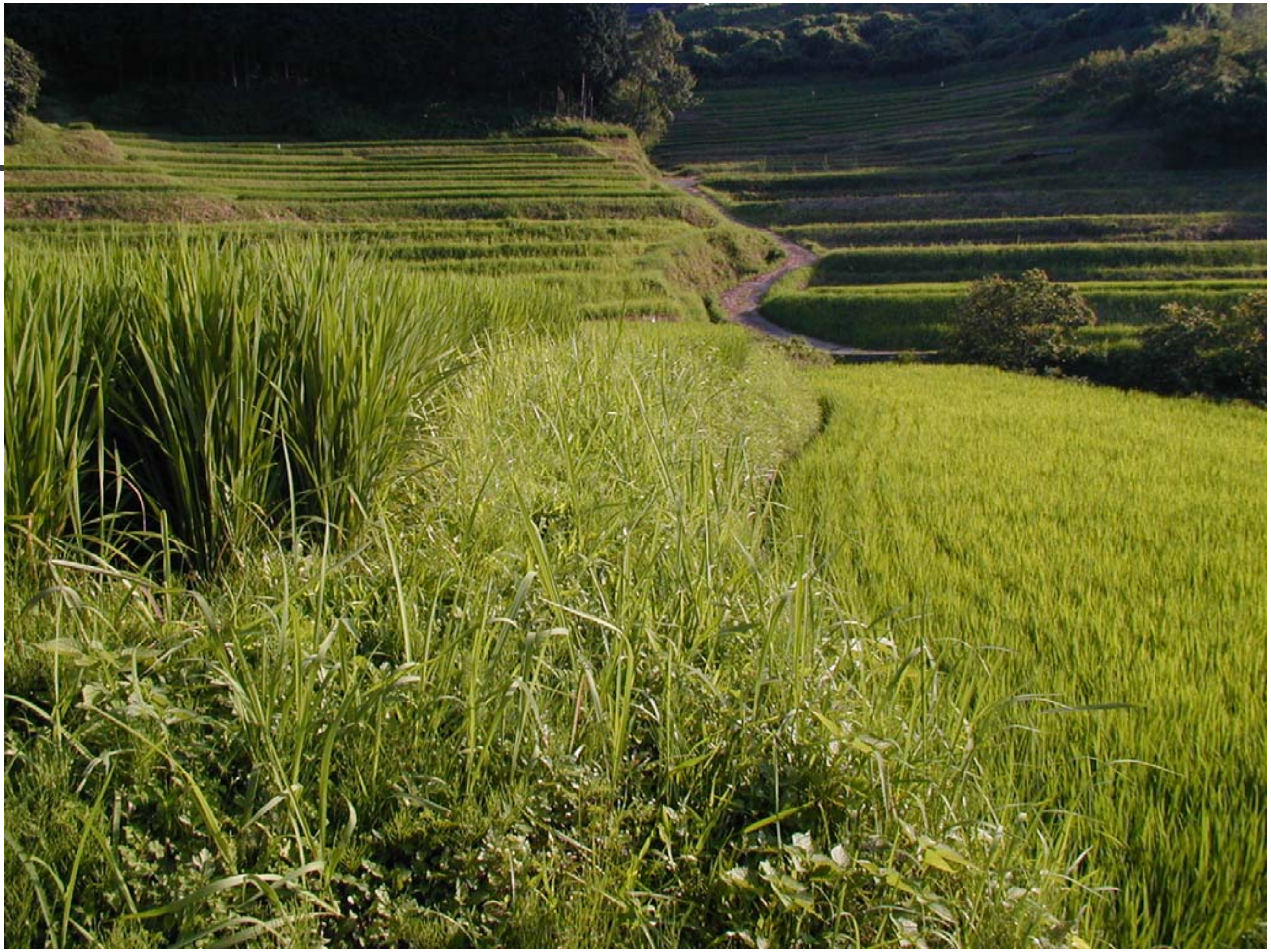

Fig. 2. Levee vegetation on paths between rice fields in a mountainous farming area.

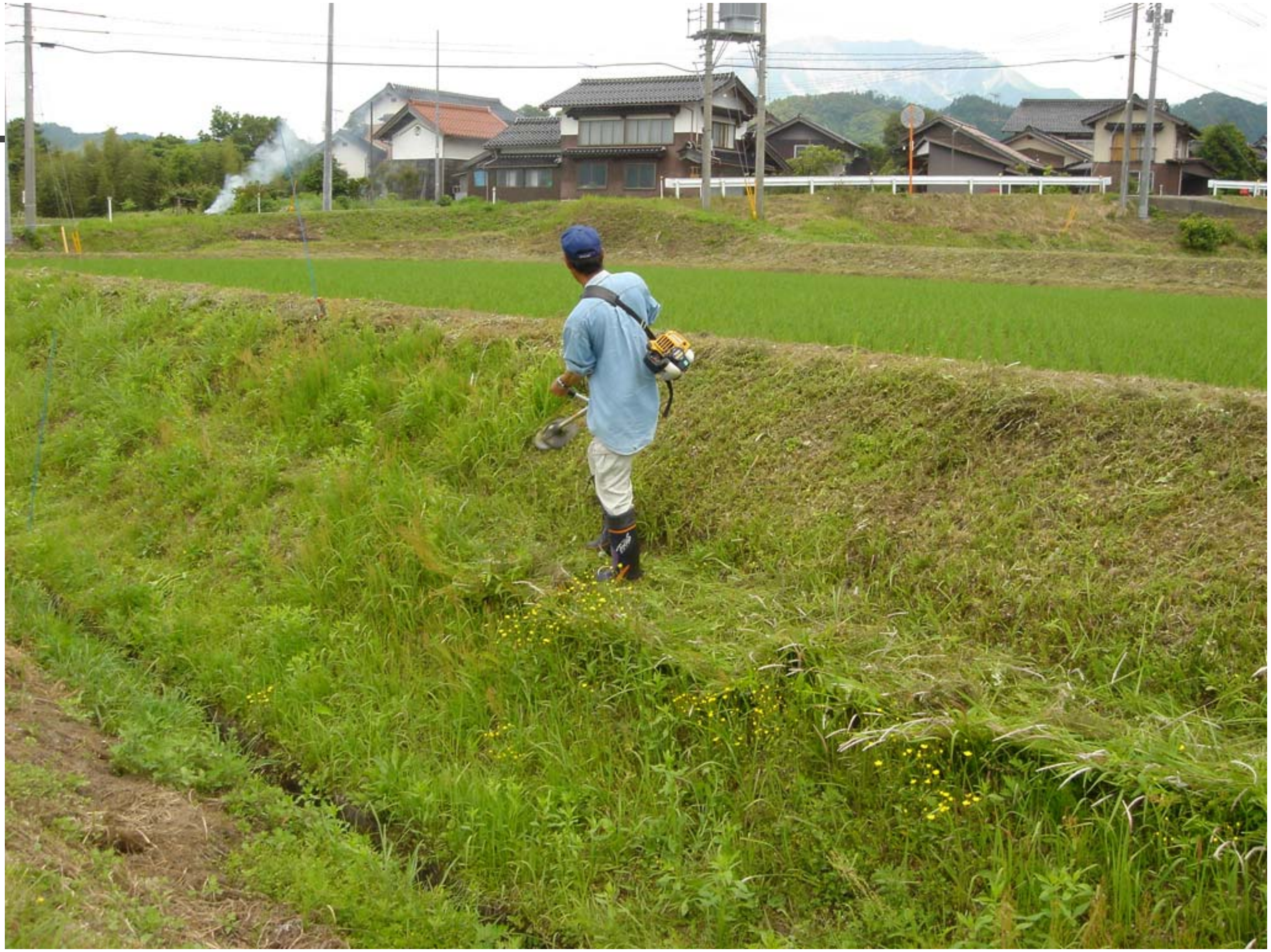

Fig. 3. We usually suppress weeds on levee areas with a shoulder grass cutter.

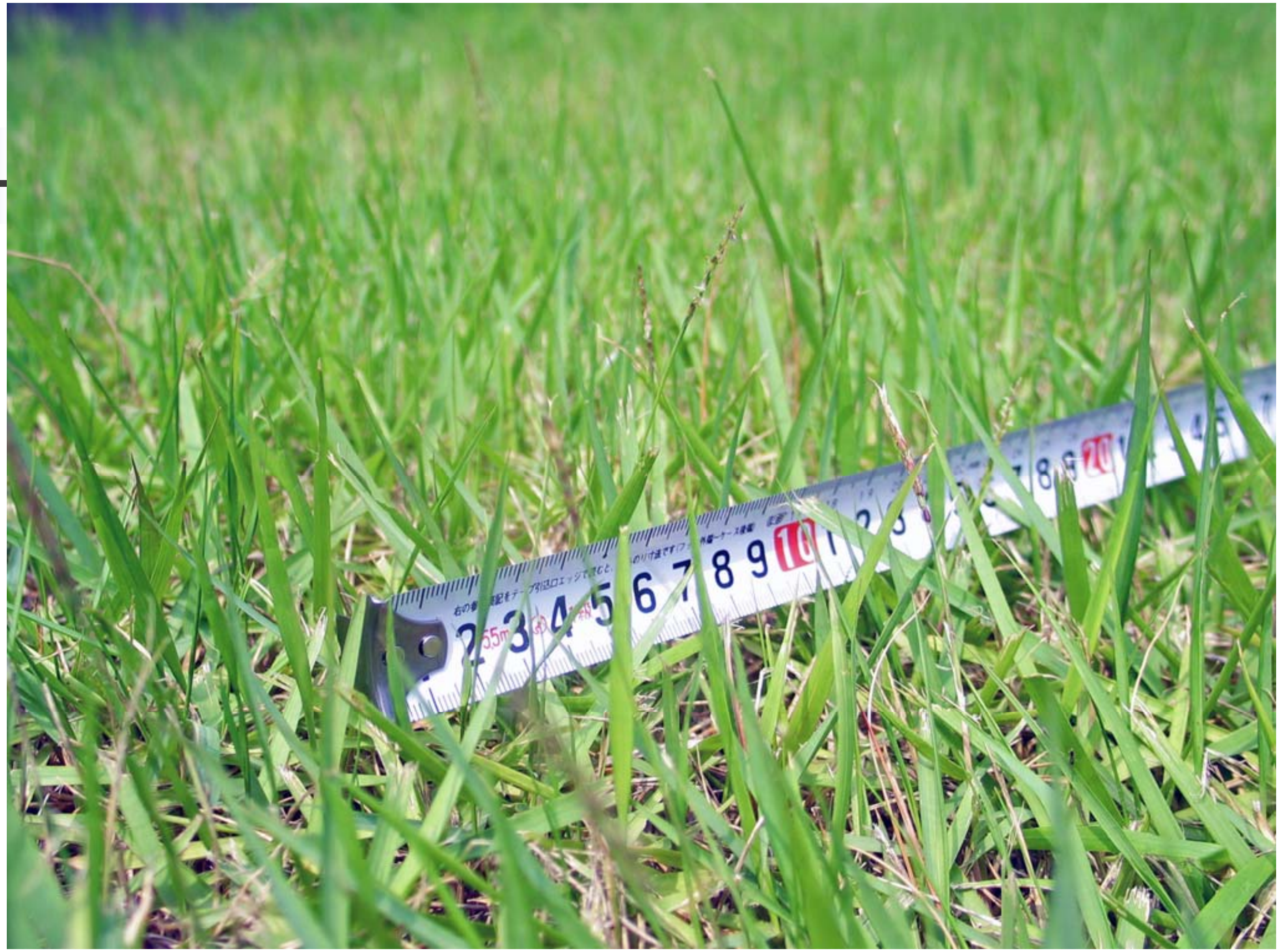

Fig. 4. *Zoysia japonica* (cv. Asagake) demonstrates quick expansion by stolon. This variety was released by the National Institute of Livestock and Grassland Science in Japan.

Fig. 5. *Imperata cylindrical* maintains Japanese rural aesthetics.