Posters

Weed Invasives and Ecology

WEED INVASION IN AIRPORT CONCRETE PAVEMENT AND WEED CONTROL ISSUES

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ABSTRACT The airport pavement, which ensures safe high-speed taxiing of aircrafts, plays a role in the interruption from FOD (Foreign Object Damage: the engine sucking debris on the ground). Weedy plants usually invade the gaps of the concrete pavement joints over which aircraft wheels do not pass. In the absence of weeding in an airport heightens the risks of FOD, but weeding of paved runways, taxiways and aprons is actually difficult during aircraft operation. Therefore, proper weed control of airport pavement is an important issue for aircraft safety in an international airport under 24-hour operation. In order to obtain a fundamental knowledge of how to carry out weed control on the airport concrete pavement, we monitored weed species in the gaps of pavement joints on the guard concrete slab that have been constructed with materials from the airport pavement. The results indicated a distinct relationship between the occurrence of weeds, joint width, and the texture of concrete pavement. Thirty-five species invaded the concrete pavement in the spring, and the parallel figure was 25 species in the summer. Three hundred and forty four plants including 4 dominant weeds, *Vicia sativa*, *Vulpia myuros*, *Paspalum notatum*, and *Vicia hirsuta* were found in the joints surveyed in the spring. Two hundred and twenty five plants including three dominant weeds, *Paspalum notatum*, *Imperata cylindrica*, *Conyza sumatrensis* were found in the joints surveyed in the summer. There were few weeds in the gaps of pavement joints whose width were 10mm or less. Although the type of damage to pavement joints by a specific weed is unknown, the results revealed that the appropriate control design and management skill for weedy species on airport pavement, and a suitable weed control might help to reduce the need for weeding and maintenance of airport concrete pavement joints.

Keywords: Airport pavement, Alien plant, Gap of pavement, Pavement joint, Seed length

INTRODUCTION

Airplanes are a popular means of delivering commodities and carrying passengers. Due to the increase in the volume of air transportation, plant propagules and/or seeds are being disseminated at the globally. Invasion and colonization of alien plants are due to the long haul of airplanes where the original ecosystem has collapsed. However, there is a paucity of information on species composition and growth of vegetation in airports, although weed species reside in concrete pavement on the runway and apron.

The airport pavements are required to be structurally safe for the taxing and parking of aircrafts. These pavements comprise of the runway, taxiway and apron (Fig. 1) (Japan Civil Aviation Bureau 2013a). The runway is for taking off and landing of the aircraft; the apron is for parking the aircraft, boarding air passengers and loading air cargo; the taxiway is for

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taxing of the aircraft between the runway and apron. Normally, the runway and taxiway are composed of asphalt pavement, and the concrete pavement to the apron. Runway and taxiway pavements require easy maintenance and low roughness, and apron pavement requires high toughness for concentration of aircraft gear load and for oil leaking of the fuel supply.

The concrete pavement requires pavement joints at 5m to 10m intervals for the transverse and longitudinal directions for prevention of random cracking by shrinkage and expansion after placing by temperature changes (Figs. 2, 3) (Japan Civil Aviation Bureau 2013b). Airport pavement requires certain functions that interrupt FOD, Foreign Object Damage, which is due to the engine sucking debris, such as gravel and weeds, from the ground (Japan Civil Aviation Bureau 2012). Sometimes, the concrete pavement joints incur damage due to peeling of sealant material and/or increasing of joint width by weed growth. Consequently, the damage of concrete pavement joints by weed invasion in the apron increases the risk of FOD (Figs. 4, 5).

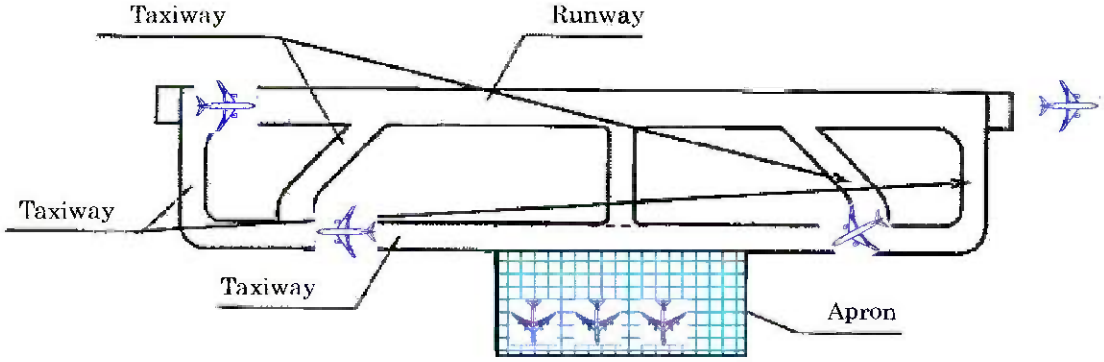

Fig. 1. Airport facilities and pavement.

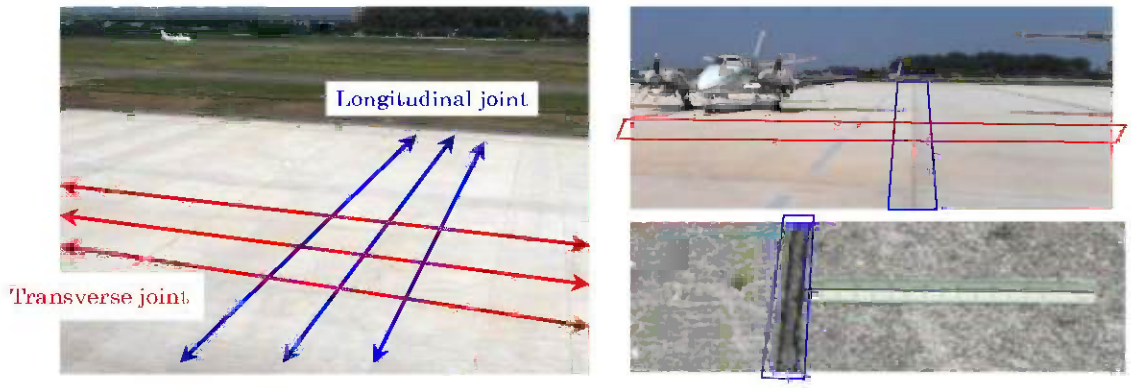

Fig. 2. Apron pavement and pavement joint.

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STUDY SITE AND METHODS

This study was conducted in Phase-2 of Kansai International Airport (KIX), "Monument of the Millennium," the first man-made island for an airport in the world and the biggest and busiest airport in Western Japan, located at 135 E, 34 N, 4 km from the coast of the Osaka gulf. The sea depth around the man-made island is *ca.* from 18m to 20m. The total reclamation island (Phase-1&2) took 430 million cubic meters of soil and rock, and the construction period was 8 years for Phase-1 and 7 years for Phase-2. The airport operation started in 1994 for Phase-1 and 2007 for Phase-2.

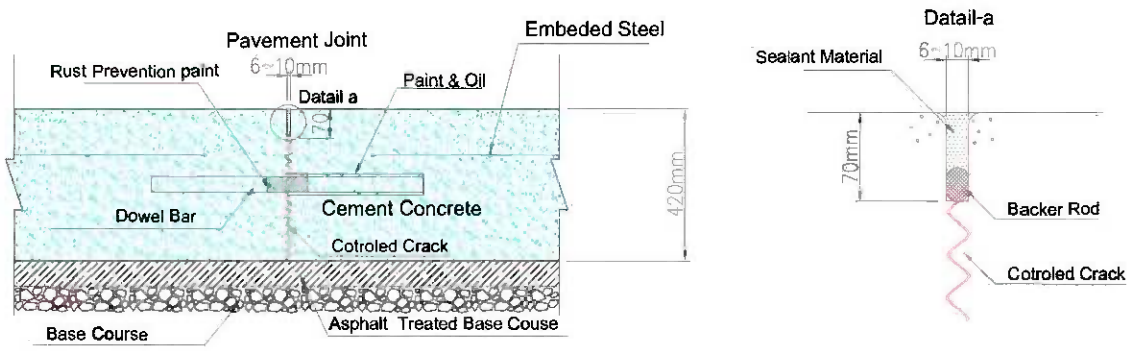

Fig. 3. Concrete pavement cross section (left) and pavement joint (right)

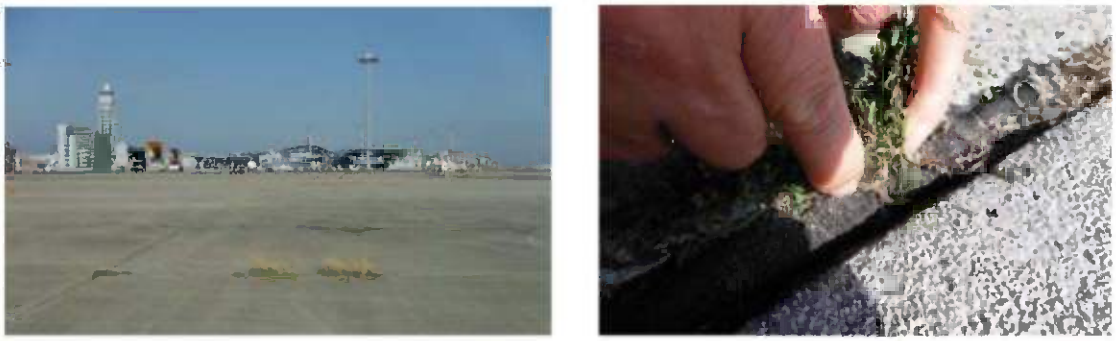

Fig. 4. Weed invasion to concrete pavement in airport apron

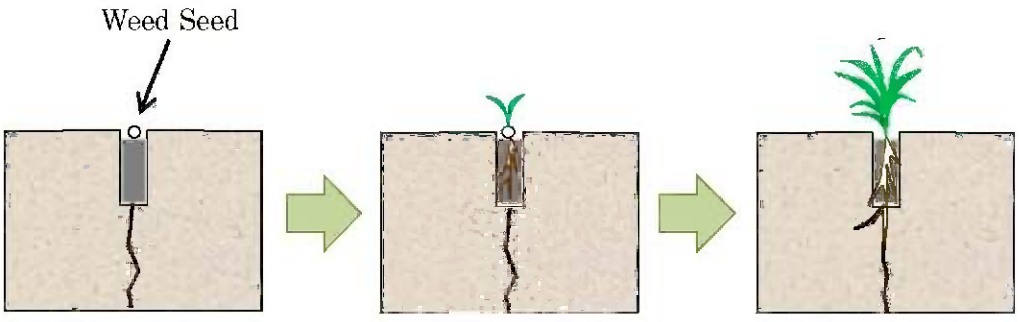

Fig. 5. Theoretical invasion process of weeds into concrete pavement joint

Due to the difficulty in surveying the concrete pavement in the operational area, we examined weeds on the concrete blocks that formed a remote apron of Phase-1 by cutting them into small pieces and settling them along the fence beside airport perimeter for security reasons (Fig. 6). The growth of weeds in the concrete blocks and the conditions of the concrete blocks were monitored, and four types of gaps or cracks were measured in length and width (Fig. 7). Joint width of surface (3point for each block), crack width of section

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(depth of 10cm/20cm/30cm) and dimensions of concrete block (width, length and thickness) were measured.

Weed growth was monitored on 300 blocks including on four gaps, longitudinal and transversal joints, cracks and on cutting tracks; measurement of crack size, taxonomic name, number of plants, and plant size were recorded on April 18, 27 (Spring) and on July 28 (Summer) in 2013. The vegetation was analyzed in the 1m square quadrat on the green belt per every 10 block-interval along a block array for comparison. Scientific name and seed size (longitudinal length) were referred to published botanical illustration books (Nakayama *et al.* 2000, Osada 1976, Satake *et* al. 1981, 1982a, 1982b, Shimizu 2003, Shimizu et al. 2001, Uemura et al. 2010).

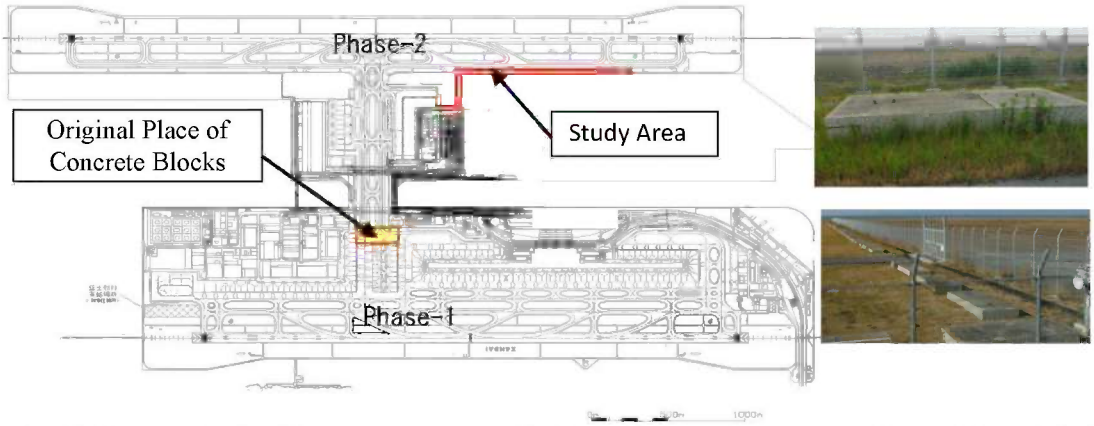

Fig. 6. Study site (Left) and monitored blocks and green belt along airport fence (Right).

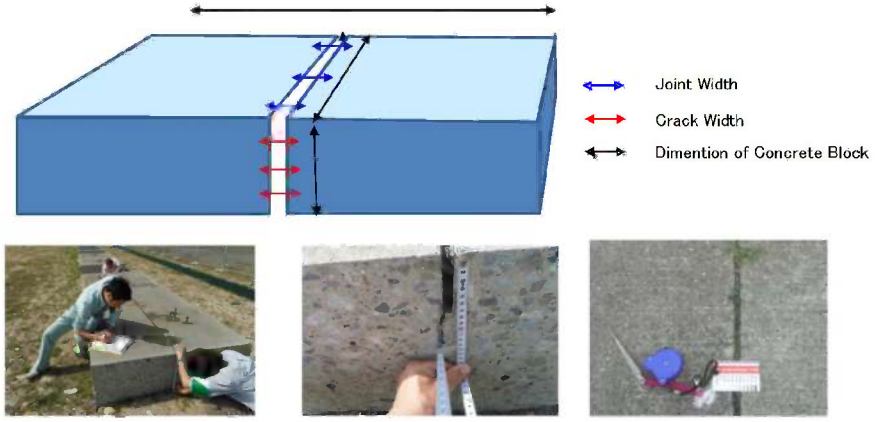

Fig. 7. Gap terminology (Up) for pavement and measurement of joint width on concrete block (Bottom)

RESULTS AND DISCUSSION

Species composition of weeds in the green belt of airport perimeter and gap of concrete blocks: There were 53 species in the spring and 39 species in the summer (total 68 species) in the green belt around the airport runway (Table 1). Although most airport weeds were alien, *ca.* 22% (15 species) of them were weeds true indigenes of Japan. Among them, *ca.* 53% (36 species) were annual and *ca.* 38% (26 species) were perennial. Thirty-five species were registered in the spring and 25 species in the summer on concrete blocks (total 45 species), which were composed of 24 annual species (53%) and 15 perennials (33%), which are similar to those of green belt vegetation (Tables 2, 3). Their seed length ranged from 0.4mm to 3.0mm. Twenty-two species in spring and 14 species in the summer inhabited the green belt and concrete blocks. In contrast, 18 species in the spring and 14 species resided in the summer

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only in the green belt; 13 species in the spring and 11 species in the summer only in concrete blocks.

Table 1. Floral composition of airport weeds

Species	Spring	Summer	Ecological feature	Species	Spring	Summer	Ecological feature
Agrostis gigantea		○		*Petrorhagia nanteuilii*	◎		a
Artemisia indica	◎	◎	N, p	*Phyllanthus urinaria*	△		N, a
Aster subulatus	◎	◎	a	*Plantago lanceolata*	○	○	a
Briza minor	○		a	*Plantago virginica*	○		a
Cerastium glomeratum	○		a	*Poa annua*	◎		a
Chamaecrista nomame		○	N ,a	*Poa* sp.	△		p
Chamaesyce maculata	△	△	a	*Poa sphondylodes*	◎		p
Chenopodium album		△	a	*Polygonum aviculare*		△	a
Chenopodium ambrosioides		◎	a	*Senecio madagascariensis*		○	p
Conyza canadensis		○	a	*Silene gallica*	○		a
Conyza sumatrensis	◎	◎	a	*Silene nocturna cf.*	◎	◎	a
Cynodon dactylon	◎	◎	p	*Sisyrinchium rosulatum*	◎	◎	a
Dianthus armeria	○		p	*Solanum americanum*		△	a
Dianthus sp.	○		p	*Solidago altissima*	◎		p
Digitaria ciliaris		△	a	*Sonchus oleraceus*	○	○	a
Elymus tsukushiensis		△*	p	*Spiranthes sinensis*	○	○	N, p
Erigeron annuus	○	○	a	*Stellaria media*	◎	△	N, a
Festuca pratensis		○	p	*Trifolium arvense*		○	p
Festuca rubra	△	◎	p	*Trifolium dubium*	◎	○	a
Festuca sp.	○		p	*Trifolium repens*	○		p
Geranium carolinianum	○		a	*Verbena brasiliensis*	◎		p
Gnaphalium pensylvanicum	◎		a	*Veronica arvensis*	◎		a
Imperata cylindrica	△	◎	N, p	*Vicia hirsuta*	◎		N, a
Kummerowia striata		◎	N, a	*Vicia sativa*	◎	△	N, p
Lepidium virginicum	△	○	a	*Vicia tetrasperma*	◎		N, a
Lespedeza cuneata	○	◎	N, p	*Vulpia myuros*	◎		a
Lolium multiflorum	◎	◎	a	*Zoysia japonica*	◎	◎	N, p
Lysimachia japonica	△		N, p	*Zoysia pacifica*	○	○	N, p
Nuttallanthus canadensis	○		a	unknoun (A)	△		-
Oenothera perennis	○	○	a	unknoun (B)	△		-
Ophioglossum sp.	○		p	unknoun (C)	△*		-
Oxalis corniculata	△	△	N, p	unknoun (D)	△		-
Parentucellia viscosa		△	a	unknoun (E)	△*		-
Paspalum notatum	◎	◎	p	unknoun (F)		△	-

-, unknown
◎, found both in green and gap
○, found in green
△, found in concrete gap or slit

N, native (domestic)
a, annual
p, perennial
*, in cutting track

Weed species frequency in relation to gap width on concrete blocks: There were 35 species and 344 plants/unit area? in the spring, and 25 species and 225 plants/ unit area? in the summer in the gap of concrete blocks (Tables 4, 5). Although many weeds existed in the gaps and cracks of the cutting track, transversal and longitudinal pavement joints are still a major element in the invasion gaps. The gap width was larger in the cutting track, and many more weeds were present during two seasons (Tables 4, 5). In cases where the gaps width were less than 10mm, 7 plants (3.2% to total 222 plants except for in the crack of the cutting track) were found in the spring and 6 plants (4.3% to total 139 plants except for in the crack of the cutting track) in the summer. The first five dominant species were *Vicia sativa*, *Vulpia myuros*, *Paspalm notatum*, *Vicia hirsuta*, and *Cynodon dactylon* in the spring, while *Paspalm notatum*, *Imperata cylindrica*, *Conyza sumatrensis*, and *Chamaesyce maculata* were dominant in the summer. Concerning the gap width and seed length, invasion seemed more frequent among smaller seeds rather than in larger ones.

Almost all airport weeds are alien, and there are more annual plants than perennial (Table 1). Since the area surveyed was a reclaimed area in the foreshore prior to greening, many alien plants originated from seed sources in adjacent areas and plants. The ratio of alien plants in the residential district, paddy field and paved road is *ca.* 40 % (Suto et al. 2004,

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2005). The ratio in the airport is much higher than the average in Japan. About 35% of species registered only in the green belt in each season, hence it assumed that plants in the gap need particular conditions in order to invade and colonize. A larger gap size indicates where the plants with larger seeds invaded. Therefore, seed size is one of the factors that needs to take into account when considering how weeds invade pavement gaps.

Disseminating behavior of weed seeds, water requirement for germination and juvenile growth are some of the eco-physiological features may determine the success of invasion by weeds. Since block height is *ca.* 40cm, it is difficult for seeds to fall from the tops of plants. However, any species that has smaller seeds than gap width does not invade, but a particular species such as *Vicia sativa* with relatively large seeds (2.5-3mm in length) tends to invade the gaps. One of the possible factors for seed disseminations in this case is due to hard wind from sea and aircraft. The gap feature may select weed species establishments from potential seed sources of weeds in the green belt including in far distance seed disseminating species, which are almost alien to Japan.

Table 2. Life form and seed size of weeds found in the green belt of airport perimeter

Season	No. of species	Life form			No. of native species	Seed length (mm)
		Annual	Perennial	Unknown		
Spring	53 (4)	27	21	5	13	0.4–3.0
Summer	39 (1)	22	16	1	11	0.4–4.3
Total	68 (3)	36	26	6	15	0.4–4.3

In parentheses, not found in cutting track

Table 3. Life form and seed size of weeds found in the gap of concrete blocks

Season	No. of species	Life form			No. of native species	Seed length (mm)
		Annual	Perennial	Unknown		
Spring	35 (6)	17	13	5	10	0.4–3.0
Summer	25 (3)	14	10	1	9	0.4–3.0
Total	45 (0)	24	15	6	12	0.4–3.0

In parentheses, found in only cutting track

Although the damage to pavement joints by a specific weed is unknown in our evaluation, the result may provide an appropriate control design and management skill for weedy species at airports, and a suitable weed control may reduce the needs for weeding and maintenance of airport concrete pavement joints. However, easy application of herbicide causes biodiversity loss in the airport environment, where human habitats affect those of animals and plants. Establishment of weed control skill at the airport is an enterprise issue to be overcame for FOD problems and invasive plant protection during this era of globalization. Basic information on weeds in airports may provide us with an Eco-airport-conserving natural conventional environment.

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Table 4. Number of plants occurring in the gap of concrete blocks in spring

	Gap of pavement joints						Crack	Cutting track	Total
	Longitudinal			Transverse					
Gap width (mm)	Less than 10	10–12	More than 12	Less than 10	10–12	More than 12		6–7	
No. of gaps	35	34	39	17	18	18	5	75	241
No. of species	5	15	11	2	13	16	2	18	35
No. of plants	8	26	56	2	47	83	8	114	344
Seed length (mm)	1.0–3.0	0.4–3.0	0.4–3.0	0.4–0.8	0.4–3.0	0.4–3.0		0.4–3.0	0.4–3.0
Species									
Vicia sativa	2	2	16		8	18		30	76
Vulpia myuros			10	1	15	9		12	47
Paspalum notatum		1	4	1	4	17	1	16	44
Vicia hirsuta	4		13		5	5		13	40
Cynodon dactylon		3			1	5		13	22
Conyza sumatrensis	1	1	1		2	7		1	13
Festuca rubra			4				7		11
Artemisia indica			3		3			3	9
Lolium multiflorum		1	1			3		4	9
Imperata cylindrica								7	7
Others (25 species)	1	18	4		9	19		15	66

Table 5. Number of plants occurring in the gap of concrete blocks in summer

	Gap of pavement joints						Crack	Cutting track	Total
	Longitudinal			Transverse					
Gap width (mm)	Less than 10	10–12	More than 12	Less than 10	10–12	More than 12		6–7	
No. of gaps	35	34	39	17	18	18	5	75	241
No. of species	2	11	11	2	11	12		14	25
No. of plants	2	23	25	4	29	56		86	225
Seed length (mm)	0.9–1.0	0.6–1.5	0.4–3.0	0.8–0.9	0.7–1.2	0.7–3.0		0.7–3.0	0.4–3.0
Species									
Paspalum notatum		1	5	1	4	16		13	40
Imperata cylindrica								31	31
Conyza sumatrensis	1	2	1		2	10		8	24
Chamaesyce maculata		2	3	3	6	8		1	23
Cynodon dactylon		3			1	9		5	18
Lolium multiflorum	1		1		3	4		7	16
Artemisia indica			2		3			7	12
Kummerowia striata			1		4	2		5	12
Vicia sativa			9			1		1	11
Aster subulatus		3			1	3		3	10
Others (15 species)		12	3		5	3		5	28

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