Status of Forest Weed Control in Japan —Mainly Herbicides Use Technique Including Tetrapion and Its Mixture—

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We have large areas of forests in our country where various types of trees can grow. Since Japan geographically locates on a wide region with the extention of 3,000 km south and north, the climate varies from subtropical to subarctical one. Many mountains additionally make the climatic condition more complicated. Thus, we are able to see many kinds of trees in our forest areas. We have also frequent rainfalls through whole season and the precipitation reaches approximately 1,500 mm per year in many forests areas. In some rainy regions, it sometimes account for more than 2,000 mm. The condition is so advantageous for the growth of weeds and shrubs that it makes them very strong competitors with plantation trees in our forestries. It, therefore, may be said that the most important problem in Japanese forestries is to combat with undesirable vegetations continuously and to keep trees from weeds.

Fig. 1-1 shows the Japanese Archipelago pictured from Landsat.

Fig. 1-2 shows the mountain occupys 67% of the total land area of Japan. The forest area per capita is 0.2 ha. I understand the figure in Korea is 0.16 ha per capita.

Fig. 1-3 is the picture of weeding by a reaping hook.

Fig. 1-4 is a motor-driven weeding machine. We can expect good weeding efficiency with this machine. It, however, should be operated within 2 hours a day so as to avoid causing Raynoud's phenomena in hands of operators.

Fig. 1-5 shows the land which is heavily covered by Japanese pampas grass (*Miscanthus sinensis*), and Fig. 1-6 the thick grown Sasa group, respectively.

Fig. 1-7 shows the trees are *Chamaecyparis obtusa* covered with kuzu vines. They appear to be almost suffocated to death. Kuzu is disturbing growth of the plantation trees by twisting trunks and covering their crowns. In old days, the weeds was used as fodders for horses and cattle as well as materials for fiber. Since the rural population in Japan has recently been decreasing year by year, power of horses and cattle to plow farms has been replaced by tractors. Consequently, the utility of kuzu has presently been lost and the plant has become a wild vegetation.

Weed control is the most heaviest job in works for the forest maintenance. Japanese forests generally have steep slopes with more than 30°, so we must walk up and down for weed control with heavy appliances in a condition of high temperature and grass emiting fume. Because of recent deficiency of laborers, we have many areas where weeding is not made in proper season or not made at all.

For the past 20 years, the number of forests workers has decreased by 50%. In 1984, it accounted for 150,000. Fig. 2 shows the decreasing tendency. The reduction of laborers is notable particularly in younger generations. In these days, there is a dilemma in the forestry business of Japan ; high costs for forest products and their low market prices due to timber imports from

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Fig. 1-1. The Japanese Archipelago pictured from Landsat

Fig. 1-5. The land which is heavily covered by Japanese pampas grass

Fig. 1-2. Outline of Japanese forests

Fig. 1-6. The thick grown sasa group

Fig. 1-3. The picture of weeding by a reaping hook

Fig. 1-7. Trees are *Chamaecyparis obtusa* covered with kuzu vines

Fig. 1-4. A motor-driven weeding machine

Fig. 1-8. Unloading of the imported logs

Fig. 1. Pictures showing the status of Japanese forest

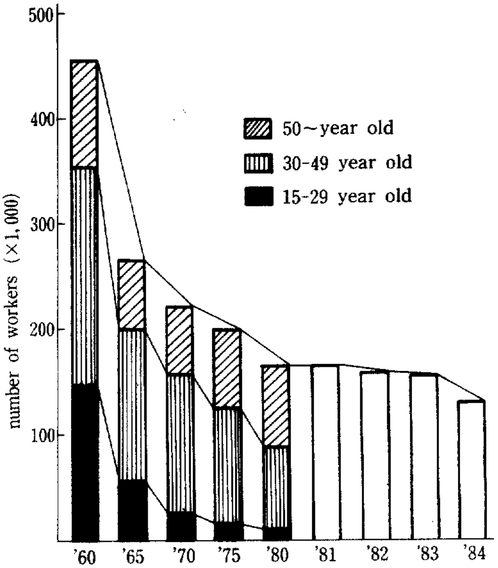


Fig. 2. Forests workers per age group (source : General Administration Agency of Japan)

foreign countries. It seems to me that the prospect of Japanese forestry in future is somewhat gloomy.

Fig.3 is a figure indicating costs for the timber production year by year. The costs in every year are calculrated as indexes based on 1971. It is evident that the business situation has become worse.

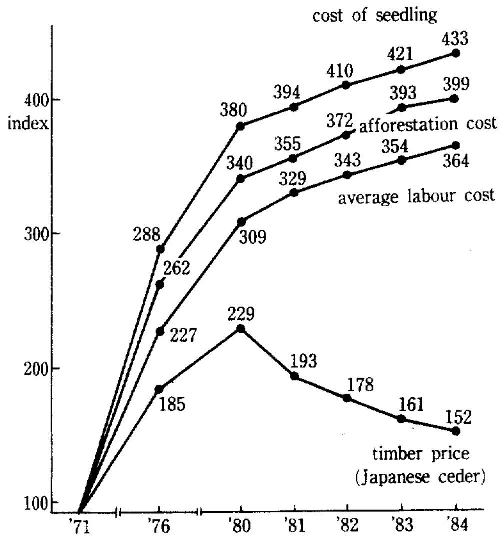


Fig. 3. Factors of afforestation business (source : Forestry Agency of Japan)

Fig. 1-8 shows unloading of the imported logs.

Immediately after the Second World War, a nation wide plan for afforestation began to convert many naked lands in mountain areas to green forests. These areas, however, have not been increasing since 1961 as shown in the Fig.4 In the meantime, the demand for woods as domestic fuels sharply declined and the consumption of petroleum considerably increased. Kinds of plantation trees have accordingly changed to coniferous trees only for timbers, instead of broad leaf species for domestic fuels. The ratio of afforested area to total forest lands has currently reached high level of 40% that has invited a criticism from a view point of the forest ecology.

A new movement to reevaluate roles of forestries from a view point of conserving public interests has occurred for the past several years. The figure shows indirect contributions of forests to the public interests. The total contribution in 1971 is estimated at 12.82 trillion Yen sharing 15.4% of total GNP for the year. Based on the ratio, values of the forest contribution in 1987 will be 53 trillion Yen. Considering the huge potentiality, I believe that forests must be continuously

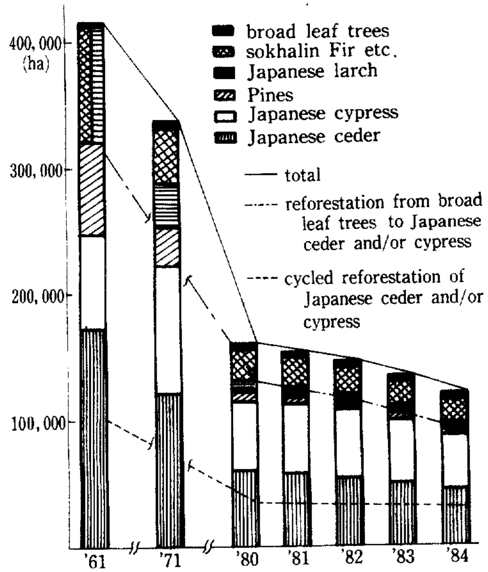


Fig. 4. Trends of afforested area per species (source : Forestry Agency of Japan)

maintained and managed to keep the great profits to the public interests, although future climate in the forest industry may not be bright. Consequently, we are forced to make the forest maintenance reasonasble and to make efforts to minimize costs

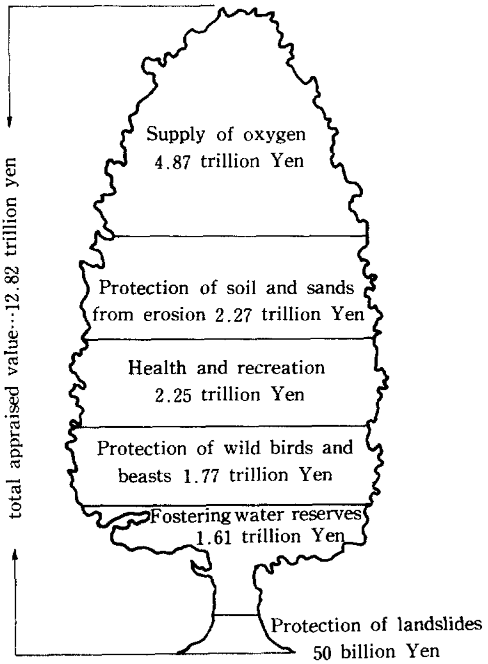


Fig. 5. Appraised valve of forests contribution to public interests in 1971

Remarks : Total amounts of 12.82 trillion Yen represents 15.4% of GNP in 1971. Estimated GNP in Japan in 1987 is 348 trillion Yen. Following the above percentage the estimated value of the forests' contribution in 1987 will be about 54 trillion Yen. (Source : Foresty Agency of Japan)

for the maintenance. This is the reason why we have to introduce herbicides to the forestry business. It seems that herbicides are the last means to minimize the costs. It is at the same time noteworthy that herbicidal chemicals broadcasted on large areas necessarily give rise to adverse effects on the environment. Therefore, rational application techniques are required.

Table 1 is a list of herbicides available for control of weeds such as Sasa, Japanese pampas grass, deciduous shrubs and annual weeds.

Fig.6 shows forest areas applied with herbicides which are classified according to their chemical structures. Total amount of herbicides used has gradually decreased after 1981 because of the decrease of newly afforested areas. It appears that kinds of chemicals have varied from year to year.

As in Table 2, aerial application obtained the share of 17% in 1979 out of the total forests areas applied but since then the share decreased gradually. This is because recently there are not so many large scale afforested areas and majority of the afforested areas is divided into small scale areas and thus merit of economical aerial application is now decreasing.

Fig.8-1 is a picture of aerial application of herbicides by a helicopter which is the most useful machine to apply herbicides on weeds growing at steep slopes in mountain areas, particularly on kuzu expanding its vines to top of trees and

Table 1. List of herbicides for control of forest weeds in Japan

Sodium chlorate 50% G.	Ammonium sulfamate 70% D.
Tetrapion 10% G.	Ammonium sulfamate 97% WSC.
Tetrapion 4% G.	Ammonium sulfamate Tablet
Tetrapion 30% AC.	Fosamin 41% WSC.
Trichloroacetic acid-ca (TCA-ca) 35% G.	Fosamin 4% MG.
Gryphosate 41% EC.	Sodium cyanate 80% WSC.
Karbutilate 4% G.	
Dalapon 15% G.	Mixture
Dalapon 20% MG.	Triclopyr 3%+Tetrapion 5% MG.
Dalapon 50% D.	MCPB 6%+Dalapon 5% MG.
Dalapon 85% WSC.	Dalapon 5%+Tetrapion 2% MG.
Asulam 37% AC.	MCP-Na 7%+Tetrapion 2% MG.
MCPB 60% EC.	MCPB 6%+Ammonium sulfamate 10% MG.
Picloram 6mg/wood-needle	Sodium cyanate 80%+MCP-K 3% D.
Triclopyr 3% MG.	
Triclopyr-triethylamine 44% WSC.	

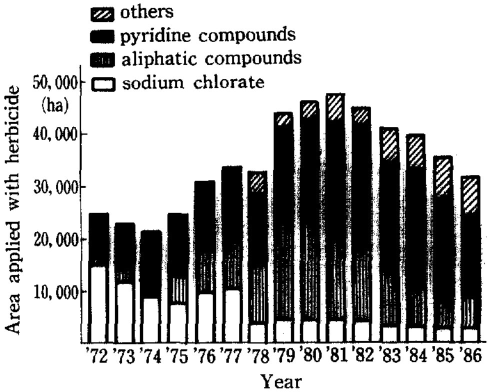


Fig. 6. Herbicides for forests-application area and major herbicides used (source : Forstry Agency of Japan)

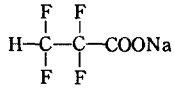
growing up too high to apply herbicides on a whole plant.

Until now, I have mentioned some current situations in Japanese forestry and the reason why we need rational use of herbicides in the forest maintenance. Here, I will introduce you some forest herbicides which contain tetrapion as an active ingredient.

Tetrapion has chemical properties shown in the table 3. We currently have three formulation products of the chemical.

Table 3. Tetrapion-chemical and physical properties

Chem.name : sodium 2, 2, 3, 3-tetrafluoro propionate
Common name : Tetrapion
Trade name : Frenock
Molecular weight : 168
Appearance : white crystalline
Melting point : 165~167℃
Solubility : soluble in water, hardly soluble in non-polor organic solvents



Formulation

Frenock AC.30% : violet coloured aqueous, SG : 1.23, packing : 500ml, 15l.
Frenock G. 10% : whitish granules
packing : 2.5kg, 20kg paper bag.
Frenock G. 4% : whitish granules
packing : 2.5kg, 20kg paper bag.

It has been demonstrated that acute and subacute toxicity of tetrapion to animals are very low. No abnormality was also found in examinations of teratogenicity and reproduction. It is

Table 2. Areas covered by herbicides for forests per application

(ha)

year	1978	1979	1980	1981	1982	1983	1984	1985	1986
ground application	27,583 (84.5)	36,380 (83.0)	38,249 (84.0)	40,797 (86.3)	40,318 (90.0)	37,338 (91.6)	36,265 (91.4)	30,896 (87.2)	27,312 (86.8)
aerial application	5,048 (15.5)	7,478 (17.0)	7,277 (16.0)	6,500 (13.7)	4,464 (10.0)	3,431 (8.4)	3,431 (8.6)	4,549 (12.8)	4,166 (13.2)
total	32,631 (100)	43,858 (100)	45,526 (100)	47,297 (100)	44,782 (100)	40,769 (100)	39,696 (100)	35,445 (100)	31,478 (100)

Remarks : (percentage) (Source : Forestry Agency of Japan)

Area in national forest treated with herbicide per application

(ha)

year	1978	1979	1980	1981	1982	1983	1984	1985	1986
soil preparation	663	1,089	1,572	2,113	2,274	1,736	1,986	1,785	1,249
weeding after tree planting	650	1,262	2,059	3,036	3,703	3,926	3,622	3,101	2,898
vines cutting	8,231	13,649	17,619	17,734	17,396	15,630	14,260	11,309	9,856
others	119	512	1,120	1,913	1,607	1,648	1,971	1,321	1,260
total	9,663	16,512	22,370	24,796	24,980	22,940	21,839	17,516	15,263

(Source : Forestry Agency of Japan)

evident that tetrapion does not remain long in rat bodies and is excreted fast into feces and urine. (Refer to Fig.7)

Tetrapion shows litte toxicity to various fishes and little adverse effect on increase of body weight, hatching rates of eggs, and histopathological symptoms. (Refer to Table 4)

Table 5 indicates directions for proper application of 10% granule formulation of tetrapion. The formulation is very effective to control sasa vegetation without injuring *Cryptomeria japonica*, *Chamaecyparis obtusa*, *Larix lepholepis* and *Abies*

Fig. 7. Toxicity of tetrapion to warm blooded animals

Acute toxicity

test	Test animals	LD 50 mg/kg	experiment institute
Oral	Rat ♂ ♀	12000 10600	Hatano Research Institute Food and Drug Safety Center
	Rat ♂♀	11900	T.N.O.
	Mouse ♂ ♀	9600 11000	Hatano Research Institute Food and Drug Safety Center
	Quail ♂ ♀	6750 11000	Tokyo College of Agriculture
Subcuta-neous	Rat ♂ ♀	6940 6670	Hatano Research Institute Food and Drug Safety Center
	Mouse ♂ ♀	6600 6400	Hatano Research Institute Food and Drug Safety Center
Intrave-nous	Rat ♂ ♀	1687 1437	Hatano Research Institute Food and Drug Safety Center
	Mouse ♂ ♀	1801 1638	Hatano Research Institute Food and Drug Safety Center
Dermal	Rat ♂ ♀	> 5000	Hatano Research Institute Food and Drug Safety Center
	Rabit ♂♀	> 4000	T.N.O.
Intra-peritonial	Rat ♂♀	11900	T.N.O.

Sub acute toxicity

Rat ♂ ♀	3-M	Feeding mix	5.1 mg/kg/Day 6.0 mg/kg/Day	T.N.O.
Mouse ♂ ♀	12-M	Feeding mix	7.2 mg/kg/Day 6.6 mg/kg/Day	Osaka Public Health Research Institute
Rabit ♂ ♀	3-W	Dermal peinting	> 500 ppm > 500 ppm	T.N.O.

Teratogenicity test : rat, mouse ······No abnormality
Reproduction study ······No abnormality
Rec Assay ······No abnormality

Metabolism test by rat

Excretion of Tetrapion from rat body
dosage : rat 10mg/kg 3 days

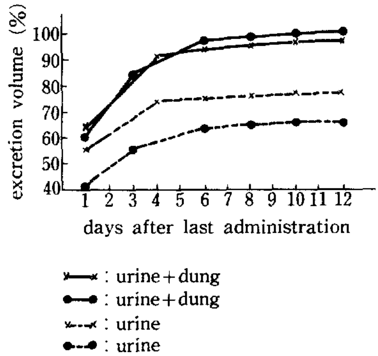


Table 4. Toxicity of Tetrapion to fish

Actute fish toxicity

species	exposure period	results	experiment institute
Ayu-fish	10 days	6,000ppm no abnormality	Shiga Fishery Experiment Station
Rainbow trout (fry)	72h	10,000ppm no abnormality	Mie Inland Water Fishery Experiment Station
Carp. Ayu-fish (fry) Japanese eel Asian pond larch Rainbow trout Dale chub Goldfish	48h	10,000ppm no abnormality	Laboratory of Aquatic Orgenisms, Tohoku University
Waterflea (*Moina macrocopa* STRAUS) Waterflea (*Daphnia pulex* Ley DIG)	(25℃) 3h	TLm.>1,000ppm	Agricultural Chemicals Inspection Station
Carp (fry)	48h	TLm.20,000ppm	Fresh Water Fisheries Research Laboratories, JMAFF

Other fish toxicity studies

1 : Carp (fry) breeding in 50ppm of tetrapion for 90 days body weight increased double. (Agricultural Chemicals Research Laboratories, Sankyo Co., Ltd.)

2 : Goldfish and Rainbow trout effect of 1,000ppm of tetrapion to hatch no abnormality (Laboratory of Aquatic Organisms, Tohoku University)

3 : Goldfish-breeding in 30ppm of tetrapion no abnormality (Laboratory of Aquatic Organisms, Tohoku University)

4 : Carp-haematology and histopathology breeding in 10,000ppm of tetrapion for 72 hours no abnormality (Laboratory of Aquatic Organisms, Tohoku University)

sachalinensis by broadcasting over canopy of sasa in autumn through next spring. Application dose will vary from 20-50 kg/ha depending on tree species. Tetrapion may cause slight phytotoxicity to *Abies sachlinensis* and *Larix lepholepis* when excessively treated. Precise dose and timing of application are, therefore, required to obtain good results. In Japan, the herbicide is not recommended for pine trees because it often causes phytotoxicity and it is not economical.

In next several pictures, I will explain the efficacy of tetrapion granule 10 on sasa and

Table 5. Application method of Frenock (Tetrapion) granular 10

place of application & tree species	dominant weed species	period of application	kg/ha	method of application
Cryptomeria japonica D.Don *Chamaecyparis obtusa* Sieb.et Zuce (soil preparation, weeding)	Sasa group *Miscanthus sinensis*	autumn/winter ~ early budding period	30-50	uniform broadcasting
Larix lepholepis GORDON (weeding)	*Miscanthus sinensis* Sasa group	autumn/winter (before soil freezing)	30-40	
Abies sachalinensis Mast. (weeding)	Sasa group		20-40	

Japanese pampas grass which are current problem weeds in Japanese forestries.

Fig.8-2 is the picture of manual application of tetrapion formulation, and Fig.12-3 shows scene of naturally growing Japanese pampas grass.

Fig.8-4 is growing condition of Japanese pampas grass in spring which was applied with the tetrapion formulation in the previous autumn. The growth of new leaves is inhibited.

Fig.8-5 is a picture of Japanese pampas grass in spring after the application in May previous year. Herbicidal activity can be seen in places dominated by Japanese pampas grass.

Fig.8-6 shows a close-up picture of Japanese pampas grass in the same place as the previous slide. It is in middle April. Usually, in this season we can see new leaves with 30-40 cm height from the ground.

The application was made in early April(Fig. 8-7). After three months the root was dug out. We can see the growth inhibition of buds when compared with control plots in left hand.

When uptake of tetrapion by weeds is not sufficient, then weeds cannot be killed completely and twisting in stems of weeds is observed as shown in the picture(**Fig.**8-8). The symptom is also seen when application is made at an advanced **growth stage of weeds.**

Growth cycles of Japanese pampas grass from emergence to death are shown at top column in **Fig.**9. When tetrapion granule 10 is applied in autumn after death of the weed shoots, it satisfactorily inhibits emergence of the weeds from their rhizomes in next spring and the efficacy continues afterwards during whole growing season.

Herbicidal activity of the chemical, however, is comparably reduced as application timing delays as shown in the other columns. Recommendable season of application is autumn or winter, particularly from November to February. It is also recommendable that the granule should be applied only in areas where snow and soil freezing are not seen.

There are many kinds of sasa ; one of them, *Arundinaria chino* being very sensitive to tetrapion reacts immediatly after application and is gradually killed in two years. Culms of the weeds are finally broken down. For the succeeding 5-6 years the regrowth of new culms can not be seen(Fig.13-1).

Fig.13-2 is a picture of *Sasa palmata* which is known to be to some extent tolerant to tetrapion. Though tetrapion causes damage on foliage and sprouts of the weeds, it cannot provide complete control and lower parts of culms stayed green even three years after treatments.

It is true that excessive dose of tetrapion makes weed control excellent, but simultaneously leads to succession of vegetations after eradicating preceding weeds as shown in the picutre(Fig. 13-3). This is a **undesirable** phenomenon in forestries. We, therefore, should be cautious to keep the application dosages properly.

An experiment(Table 6) was conducted to study sasa control by applying tetrapion granule 10 from 1978 to 1985. In the experiment, *Sasa palmata* was firstly eradicated by hand weeding in July 1978 before planting tree seedings. The granule was treated in April of next spring, 6 months after the Japanese cypress tree planting. Six years later, weeds as well as tree seedlings increased their height and fresh weight. Satisfactory control was obtained in plots treated with tetrapion 20, 30 and 50 kg/ha as compared to hand weeding plots where second weeding had been carried out simultaneously along with the herbicide treatments.

It is also evident that the growth of Japanese cypress is better in plots treated with the chemical than manual weeding plots. It is additionally observed that 50 kg/ha of tetrapion causes persistent inhibition of sasa and resulting succession of vegetation to broad leaf weeds.

There are many kinds of sasa with morphological or ecological differences. But a mode of action of tetrapion on every species remains to be common. When absorbed by weeds roots, the chemical is easily translocated to rhizomes and buds, preventing emergence of new sprouts or

Fig. 8-1. Aerial application of herbicides by a helicopter

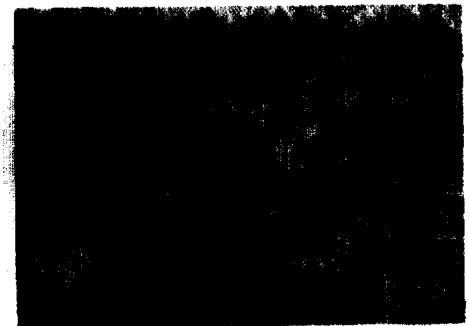


Fig. 8-5. Japanese pampas grass in spring after the application in May previous year

Fig. 8-2. Manual application of tetrapion formulation

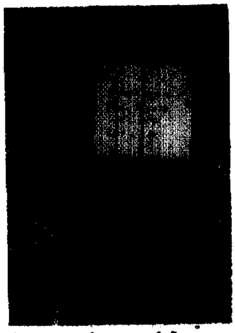


Fig. 8-6. A close-up picture of Japanese pampas grass in the same place as the previous picture

Fig. 8-3. Scene of naturally growing Japanese pampas grass

Fig. 8-7. The application was made in early April

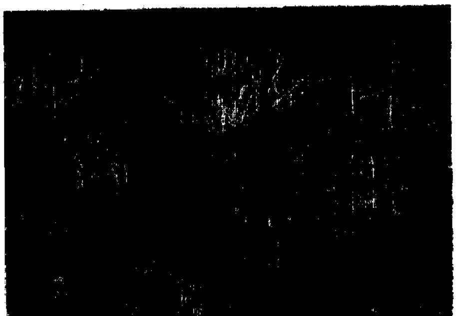


Fig. 8-4. Growing condition of Japanese pampas grass in spring after tetrapion application in the previous autumn

Fig. 8-8. The symptom after tetrapion application

Fig. 8. Pictures showing the status of Japanese forest its weed control

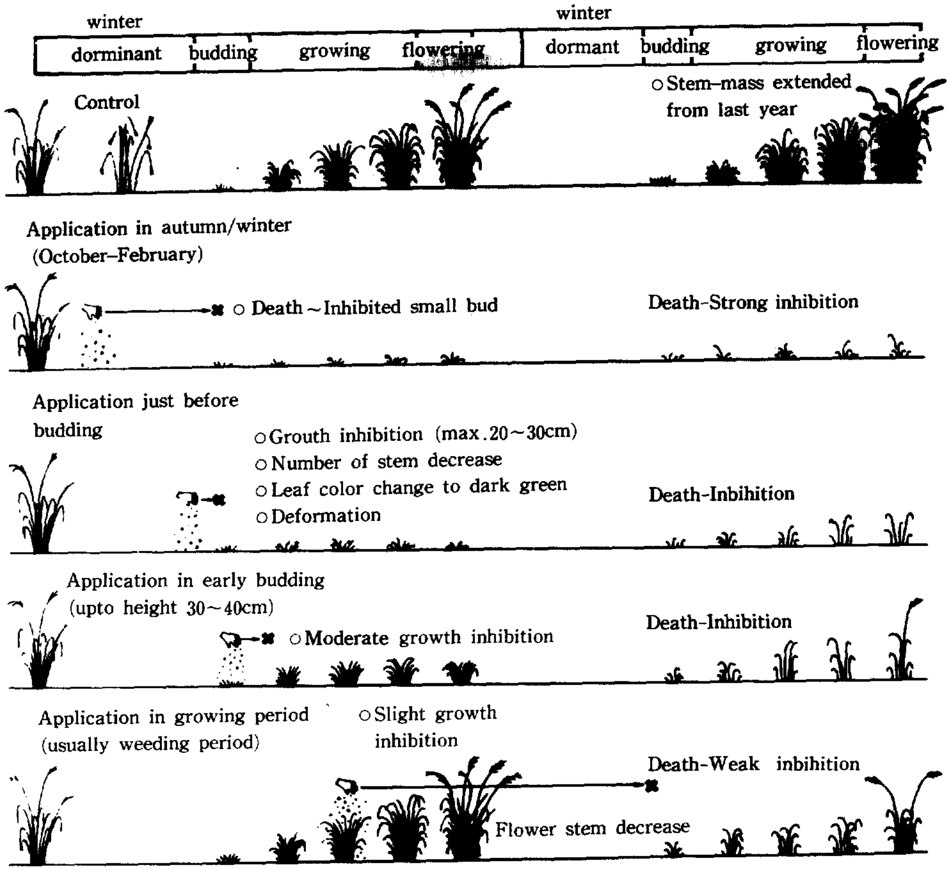


Fig. 9. Frenock (Tetrapion) granular 10 Target weed : Japanese pampas grass (*Miscanthus sinensis* ANDERSS) application manifestation of effect

branchs. Then it inhibits growth of new culm elongation and also decreases numbers of new leaves. In addition to this, tetrapion causes late defoliation of weeds that firstly occurs in old leaves and then in new branch leaves. It will take at least one year to defoliate all leaves. On some species, 2 to 3 years will be needed for complete defoliation. (**Fig.10**).

There are many forests of pine trees in Korea. As I mentioned briefly before, pine trees are sensitive to tetrapion. Severe injury may occur at heads of every branch of pines soon after the chemical is absorbed. Therefore, it is very important to examine residue level of tetrapion in plants and soil after application.

We had carried out experiments to study the fate of tetrapion in soil at 5 District Forests Offices in Hokkaido. In the experiments, tetrapion granule 10 treated at the rate of 30 kg/ha could control sasa. The dose presumably provides a concentration of tetrapion 1 ppm in 20 cm layer of soil surface. The table shows that the chemical disappears fast from soil and residue level become very low 2 or 4 weeks after appliction.

The analysis was made on the samples taken out after 1 year in the same plot from new culm and leaf of sasa and leaf of Sakhalin Fir (*Abies sachalinensis*). The results show that higher concentration was found in sasa while Sakhalin Fir showed lower concentration. It will be necessary for us to study further this interesting relations between the residue results.

This is also an experimental result of residue

Table 6. Frenock (Tetrapion) granular 10 Inhibition on sasa and growth of Japanese cypress 6 years after application

		before soil preparation	control	manual weeding	Frenock G10 applied areas		
					20kg/ha	30kg/ha	50kg/ha
Japanese cypress	height (cm)	-	150	170	210	210	200
	diameter of the root (mm)	-	20	25	40	35	40
sasa	height of culm (cm)	170	110	70	80	80	80
	no.of culm (m^2)	110	220	220	220	220	120
	leaf fresh weight (g/m^2)	400	400	400	400	400	300
	culm fresh weight (g/m^2)	1600	1000	450	750	650	450
perennial weeds	fresh weight (g/m^2)	0	0	0	0	0	1050
Outine	growth index Japanese cypress grade		small	small	large	large	large
	index (height×root diameter)		300	425	840	735	800
	regrowth index sasa grade		much	medium	medium	medium	less
	index (culm height×no.×1/100)		242	254	176	176	96

Note : plot : each $50m^2$, two replications, weeding of *Sasa palmata* NAKAI……July, 1978, planting of Japanese cypress………October, 1978, application of Frenock G10………April, 1979, re-weeding in manual weeding plots…October, 1979 (remained untreated until 1984)
(T.Kawahara, K.Kamo : Growth Inhibition of *Sasa palmata* NAKAI by Herbicides Tetrapion and its growth effects on planted Japanese cypress ; Ringyo to Yakuzai No.103(1988)

analysis in Sakhalin Fir which is widely regarded to have the same sensitivity against tetrapion as pine trees.

The analysis **was conducted** in branchs of the trees treated with 20 and 40 kg/ha during 4 years after application. Concentration of tetrapion in the trees were around 70-90 ppm in first 2 years, then sharply decreased to 10 ppm after 3 years. Heavy **damage** were observed in trees which contained about over 70 ppm of tetrapion, but no phytotoxicity was shown at 10 ppm level (Fig.11).

Tetrapion is potent enough to control some

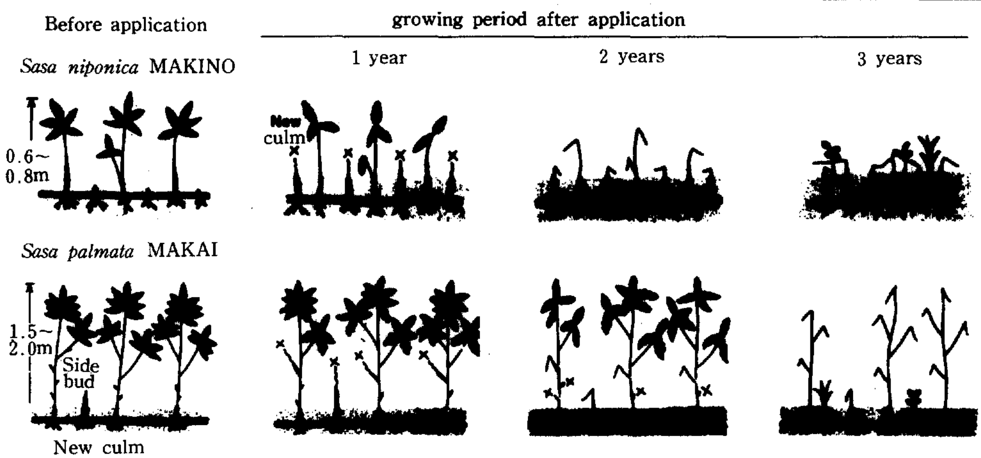


Fig. 10. Frenock (Tetrapion) granular 10

Table 7. Frenock (Tetrapion) granular 10 residue in soil of Tetrapion and the absorption into Sasa and afforested trees in afforested areas of Sakhalin Fir (*Abies sachalinensis*)

(T.Yamada eta/., 1988)

location	Tetrapion analysis in soil detection (ppm/wet w.)			*Sasa spp*-new culm and leaf detection (ppm/dry w.)	*Abies sachalinensis* side branch-old leaf detection (ppm/dry w.)	
	sampling depth (cm)	2-weeks after treatment	4-weeks after treatment	1-year after treatment	1-year after treatment	2-year after treatment
A. Hamaton-betsu	0~5	0.18	ND	145	14.0	—
	5~15	ND	ND			
	15~20	0.11	ND			
B. Asahi	0~5	0.15	0.03	59	22.0	24.0
	5~15	0.20	0.07			
	15~20	0.46	0.20			
C. Hukaga-wa	0~5	0.04	0.06	376	—	27.0
	5~15	ND	0.04			
	15~20	ND	0.05			
D. Ikutora	0~5	0.53	0.17	20	36.0	31.0
	5~15	0.40	0.53			
	15~20	0.30	0.61			
E. Kotan-betsu	0~5	0.54	0.04	90	13.0	—
	5~15	0.57	0.05			
	15~20	0.42	0.04			

Note : * ND : none detected

* Application : Oct. 21-29, 1985

* The detection limit of this nalitical method : 0.03ppm

* Applied quantity is 30kgs/ha×Frenock G10, thus logical applied quantity per m^2 is 30g.

* Soil from 0-20cm in depth is 200l/m^2 and its weight per m^2 becomes 300kg/m^2 if apparent specific gravity of soil is 1.5.

* Tetrapion active ingredient becomes 1.0 ppm provided Frenock G10 is applied equally to the soil of 0-20cm in depth.

forests weeds. Its mixtures with other herbicides, however, often provide better herbicidal performance such as enhanced activity, wider spectrum, and faster reaction than tetrapion alone. We now have some marketable mixtures containing tetrapion. One of them is Kuzunock which consists of tetrapion and dalapon. Both of the herbicides cannot control kuzu by each alone, but they obtain herbicidal activity to kuzu when combined.

Fig.13-4 shows the results of application of Kuzunock microgranule. Before the application, the top of kuzu vine is stretching long, but after the application the growth of the vine is inhibited.

Fig.13-5 is a picture of kuzu in spring applied with Kuzunock in the previous year. Kuzu vine is seen on the ground, but it now has no power for sprouting new buds.

Table 8 also shows herbicidal efficacy by applying of Kuzunock microgranule. It is easily understood that good retention of the granule on kuzu leaves provides excellent herbicidal efficacy.

Fig.12 shows an experiment carried out to demonstrate a mode of translocation of Kuzunock. A plot of 5m by 5m was set where kuzu vines grew thick and tangled in previous year and then, Kuzunock microgranule was applied to the plot with the dose of 100 ka/ha.

In next year, it was observed that kuzu vines which penetrated to the treated plot were

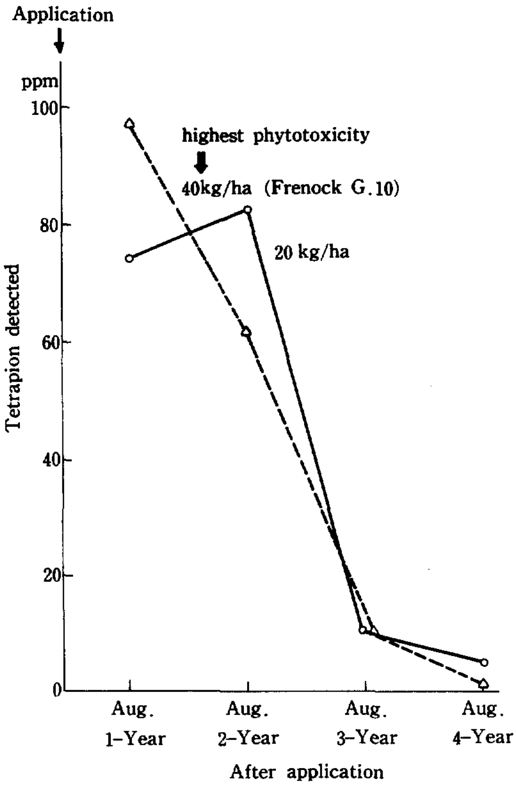


Fig. 11. Frenock (Tetrapion) granular 10 Tetrapion detected in side branch of Sakhalin Fir (*Abies sachalinensis*)

completely controlled and remaining vines outside of the plot were strongly inhibited to sprout by translocated chemicals.

Zytron-Frenock was developed after marketing Kuzunock microgranule. Even though the price of

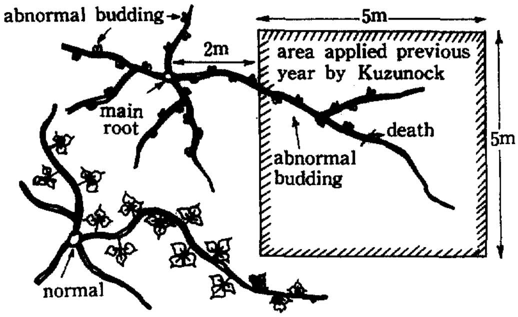


Fig. 12. Kuzunock (Tetrapion 2%+Dalapon 5%) MG

the product is relatively high it is economical due to the long duration of inhibitory effect.

Besides these combination products there are many interesting combined products of tetrapion with such herbicides as MCP, Fosamin, Round-up and so on. Therefore, I think that tetrapion could be one of the most promising herbicides with many possibilities in future developments and studies.

Fig.13-6 shows young afforested areas just after weeding, and Fig.13-7 is the last picture showing beautiful adult forests.

These are all of my presentation. I do hope that the technical and scientific cooperation and joint studies could be generated between you and us with this herbicide use technique developed in Japan leading to the contribution to your national afforestation movements.

Thank you very much for your attention.

Table 8. Regrowth inhibition effects of Tetrapion and Dalapon mixture on Kudzu

Herbicide (kg a.i/ha)	Formulation product dosage (kg/ha)	Application time	Fresh vine (g/m²)	Leaf weight (g/m²)	Vine length (cm/m²)	Leaf number (no./m²)	Node interval (cm)	Petiol (cm)
T.3+D.9	100	Day/dry	3.0	1.7	20.3	3.5	4.6	4.9
T.2+D.5	50	Morning/wet	40.8	5.3	229.7	10.5	6.0	5.4
	100	Morning/wet	16.8	2.5	155.4	12.0	2.8	2.8
	100	Day/dry	46.3	7.5	237.6	4.0	3.8	5.8
Control	—	—	883.5	823.0	4910.0	216.5	19.6	26.1

Note : 1. Application : Aug. 1972. 2. Observation : June. 1973(11 Months after)
Manabe, T.K.Ishii, T.Yamada, Y.Kato : Effects Mixture of TFP and Dalapon on kudzu, *Pueraria lobata* OHWI/Proc. of the 5-th APWSS (1976)

Table 9. Economical efficiency of weeding at afforested areas by application of Zytron–Frenock MG

(per ha)

<table>
<tr><th rowspan="2"></th><th rowspan="2"></th><th rowspan="2">works</th><th rowspan="2">manpower (number of workers)</th><th colspan="3">cost</th><th rowspan="2">remarks</th></tr>
<tr><th>abour costs (yen)</th><th>cost of herbicides (yen)</th><th>total (yen)</th></tr>
<tr><td rowspan="5">manual weeding combined with Kuzunock application</td><td rowspan="2">1st year</td><td>manual weeding</td><td>7.3</td><td>70, 943</td><td>—</td><td>70, 943</td><td rowspan="5">65kgs of Kuzunock used as control</td></tr>
<tr><td>kuzunock treatment</td><td>3.0</td><td>30, 019</td><td>34, 645</td><td>64, 664</td></tr>
<tr><td>2nd year</td><td>manual weeding</td><td>7.3</td><td>74, 344</td><td>—</td><td>74, 344</td></tr>
<tr><td>total</td><td>—</td><td>17.6</td><td>175, 306</td><td>34, 645</td><td>209, 951</td></tr>
<tr><td>ratio</td><td>—</td><td>100.</td><td>100</td><td>100</td><td>100</td></tr>
<tr><td rowspan="4">application of Zytro–Frenock</td><td>1st year</td><td>Z・F treatment</td><td>4.5</td><td>50, 910</td><td>104, 000</td><td>154, 910</td><td rowspan="4">100kgs of Zytron–Frenock used</td></tr>
<tr><td>2nd year</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td>total</td><td>—</td><td>4.5</td><td>50, 910</td><td>104, 000</td><td>154, 910</td></tr>
<tr><td>ratio</td><td>—</td><td>26</td><td>29</td><td>300</td><td>74</td></tr>
</table>

* Application July 9, (1984). Weeding effects of Zytron–Frenock were widely found with every green shrub, deciduous shrub, *Miscanthus sinensis* ANDERSS and perennial weeds. The applied areas could remain untreated upto the 2nd year.

(Sonoda Y. et al : Effect of Zytron–Frenock MG/Sage District Forest Office ; Ringyo to Yakuzai No. 98, 1986)

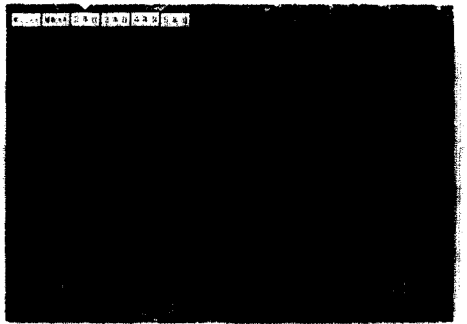


Fig. 13-1. Tetrapion reacts at 2-styles after application

Fig. 13-5. Kuzu in spring applied with kuzunock in the previous year

Fig. 13-2. *Sasa palmata* which is known to be to some extend tolerant to tetrapion

Fig. 13-6. Young afforested areas just after weeding

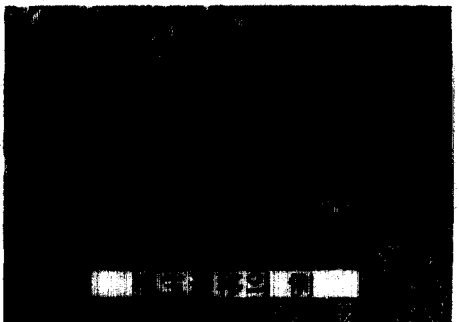


Fig. 13-3. Succession of vegetations after excessive tetrapion application

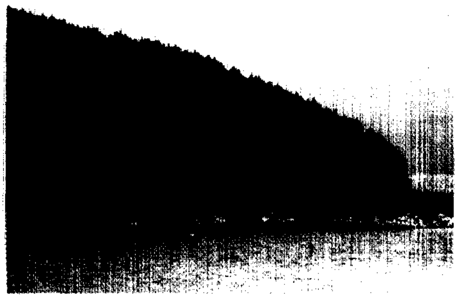


Fig. 13-7. The beautiful adult forests

Fig. 13-4. The results of application of kuzunock microgranule

Fig. 13. Pictures showing the weed species to be controlled