BREEDING FOR RESISTANCE TO SOYBEAN DWARF VIRUS IN SOYBEANS

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ABSTRACT

The foreign and domestic germplasm collections of soybean were tested for their resistance against soybean dwarf virus (SDV) under natural infection at Hokkaido Central Agricultural Experiment Station. Among the 2,075 soybean varieties tested, twenty were resistant to SDV though their resistance was not complete. As the agronomic characteristics of these resistant varieties are inferior to those of the cultivars recommended in Hokkaido, artificial crosses between these resistant varieties and the recommended cultivars have been performed since 1971. Hitherto, attempts have been made in 134 pairs of crosses to breed SDV resistant varieties having superior agronomic characteristics. We were able to select about 30 promising lines which showed a low percentage of SDC infection, good plant type, early maturity and good quality in the early generations. In the middle generations, evaluation of SDV resistance in the selected lines was confirmed under natural infection in Date city where SDV usually occurred very seriously. Moreover, the selected promising lines were also evaluated by aphid inoculation tests, using viruliferous aphids. As a result of the soybean breeding program mentioned above, we eventually selected 5 promising lines and one of them, the new cultivar 'Tsurukogane' was released in the southern districts of Hokkaido in 1984. This cultivar which is highly resistant to SDV displays desirable agronomic characteristics such as high yield and good quality.

Introduction

Soybean dwarf virus (SDV) was observed for the first time on the soybean variety 'Tsurunoko' in the southern districts of Hokkaido in about 1952 (Suwa and Chiba, 1969). The virus disease was first called "abnormal growth" or "dwarf" due to the considerable decrease in the growth of soybeans. Thereafter, SDV rapidly spread over all the southern districts of Hokkaido. Presently, SDV has occurred in all the districts of Hokkaido. Especially it has considerably decreased soybean yields in the Iburi, Hidaka and Oshima districts along the Pacific Ocean in Hokkaido (Fig. 1). SDV has been considered as one of the "important diseases for crops in Hokkaido" impairing soybean production since 1969. Furthermore, it has been found that SDV occurs in Aomori and Iwate prefectures which are located in the northern part of Honshu island (Tamada, 1975; Tanimura *et al.*, 1985).

Exhaustive research to identify the causal agent of the disease has been carried out by both the Soybean Breeding and Plant Pathology Divisions of Hokkaido Central Agricultural Experiment Station since 1966. As a result of the research, the disease was found to be caused by a virus (Tamada *et al.*, 1969). The virus disease is aphid-borne and the natural host plants are ladino clover (*Trifolium repens fort. gigantium*), white clover (*T. repens*) and red clover (*T. pratens*) which are widely distributed in Hokkaido (Tamada, 1970). The virus is transmitted by the aphid (*Acyrthosiphon solani*) in a persistent (circulative) manner. In the field, soybean plants are contaminated by viruliferous winged aphids in the late spring season (Fig. 2). The soybean plants infected with SDV in the fields show rugosity of the leaflets and dwarfing of the plants. Two strains of SDV with a different host range and symptoms have been identified. One of them is the dwarfing strain which causes dwarfing of soybean plants, and the other is the yellowing strain which causes interveinal yellowing of older leaves (Tamada, 1973). Mixed infection with both

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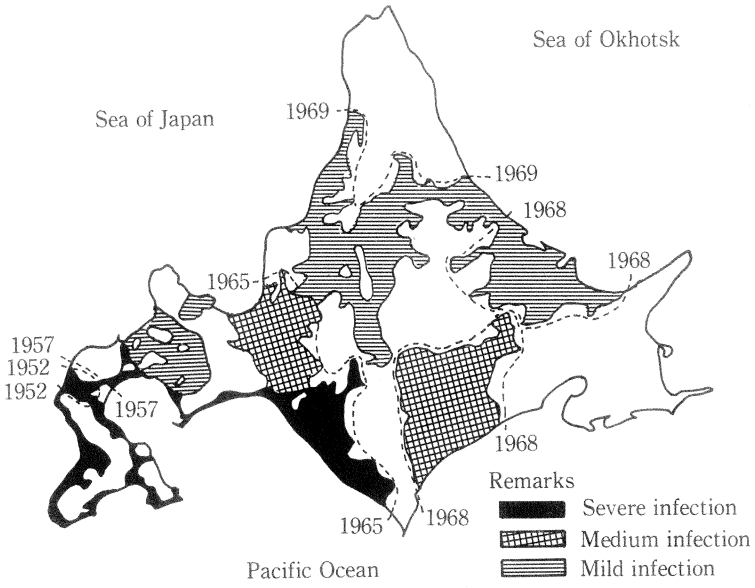

Fig. 1 Occurrence of SDV in different areas of Hokkaido.

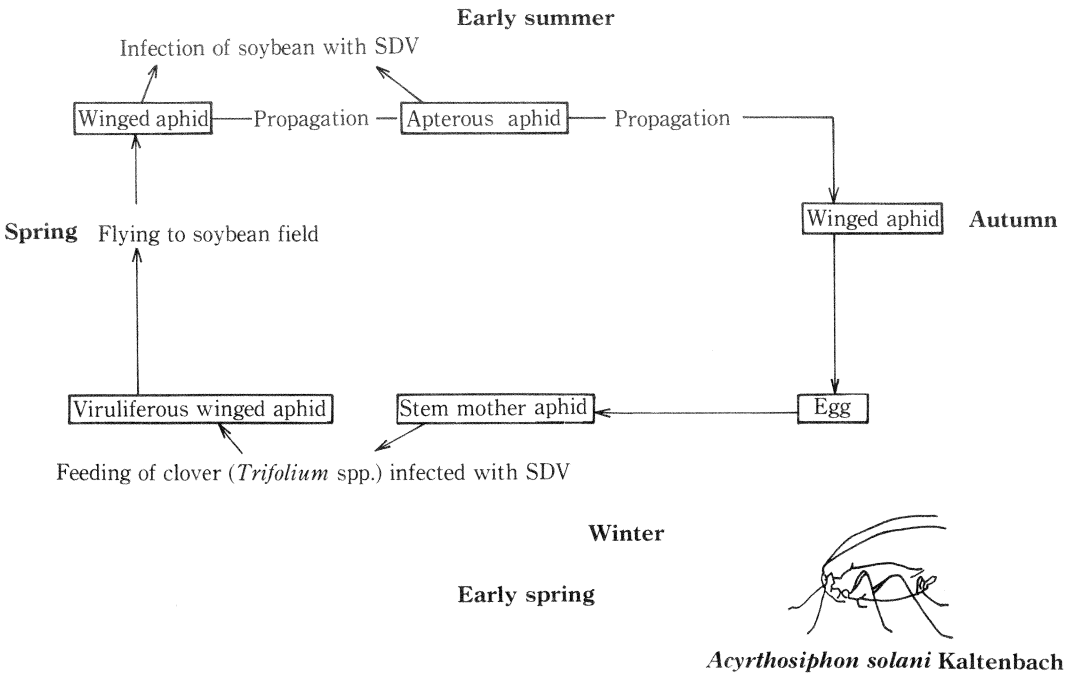

Fig. 2 Diagram of the infection cycle of SDV by aphid (Tamada).

dwarfing and yellowing strains induces markedly rugose or wrinkled leaflets (Tamada, 1975). In nature mixed infection with both strains severely damages soybeans. When the soybeans are infected with SDV, the translocation of photosynthates from the leaflets to the pods is interrupted, causing necrosis in the vascular bundles. The number and growth of pods of infected plants decrease and the leaflets remain green at harvest time. A 50% incidence of field infection may result in as much as 40% reduction in yield (Tamada, 1975). The relationship between the percentage of infection and soybean seed weight is shown in Fig. 3. SDV does not induce symptoms such as mosaic and brown mottled color of seeds.

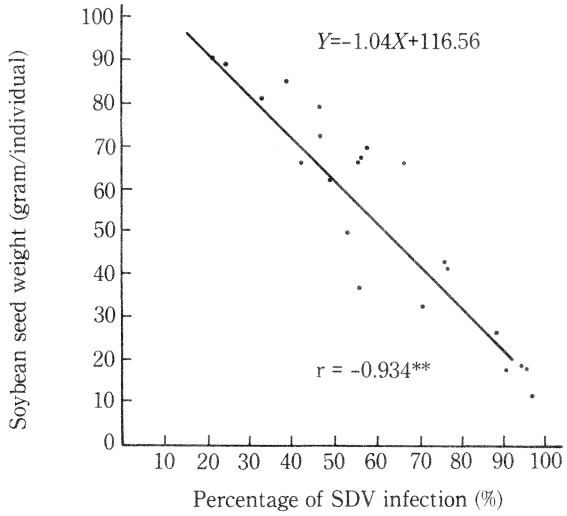

Fig. 3 Relationship between the percentage of SDV infection and soybean seed weight per individual.

Control of SDV is achieved by application of insecticides (Ethylthiometon) against aphids at the rate of 40 to 60 kg/ha at sowing time. Insecticide application is not effective when there is a large number of aphids in soybean fields. Also the period when insecticides are effective lasts about 50 days. Hence breeding for SDV resistance of soybean has been started at Hokkaido Central Agricultural Experiment Station, Naganuma, Hokkaido since 1966.

It was shown that the soybean varieties 'Ouhouju', 'Adams' and 'Peking' are moderately resistant, whereas 'Shirotsurunoko', 'Koganejiro' and 'Yuzuru' are susceptible (Tanimura and Tamada, 1976). Also, F 2 generations originating from artificial crosses between the resistant and susceptible varieties showed a normal distribution for the disease index of SDV (Fig. 4). Hence, it is suggested that it is possible to develop recommended cultivars with SDV resistance, high yield and good quality by performing artificial crosses (Matsukawa *et al.*, 1977).

Firstly screening tests for resistance to SDV in foreign and domestic germplasm collections of soybeans started in the fields of Naganuma in 1966 (Tanimura *et al.*, 1982).

Thereafter artificial crosses between the varieties recommended in Hokkaido and selected SDV resistant varieties were conducted (Tanimura *et al.*, 1984).

As a result of this soybean breeding program, promising lines with high SDV resistance, high yield and good quality were eventually developed. 'Tsurukogane' was released as a new cultivar in the southern districts of Hokkaido in 1984 (Banba *et al.*, 1985).

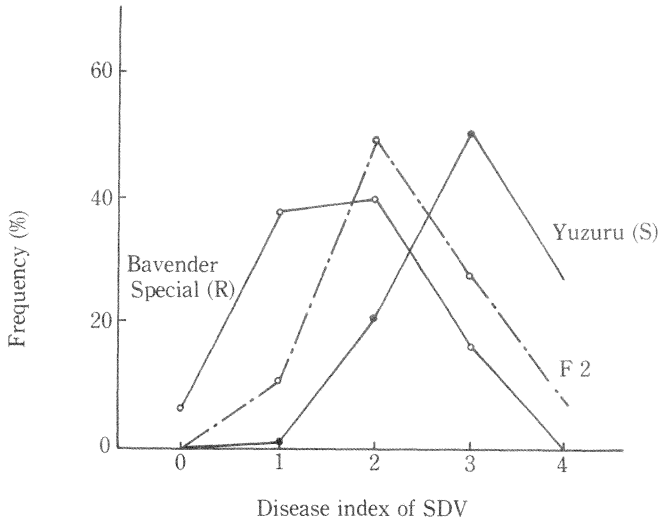

Fig. 4 Distribution of disease index of SDV in F 2 generation, parental varieties 'Bavender Special' and 'Yuzuru'. 'Bavender Special' is resistant to SDV and 'Yuzuru' is susceptible to SDV.

Screening method for resistance to SDV

Screening for resistance to SDV was attempted by both natural infection and aphid inoculation tests.

1 Natural infection method

This method was first employed at Naganuma in 1966, and also since 1978 it has been applied at Date, where SDV usually occurred very seriously. Forty-five plants per plot were used for SDV screening test. A complete randomized design with five replications was applied. Each plant was grown in rows 60 cm wide with hills 20 cm apart. For each plant, two seeds were sown in the middle of May. After germination, seeds were thinned to one. The infection of soybean with SDV was investigated in late August by determining the percentage of infection and the disease index (graded from zero to four on the basis of symptom intensity as follows: zero: no symptoms, four: severe symptoms) for each soybean variety. SDV resistance degree in each soybean variety was evaluated on the basis of the results of continuous screening tests conducted for two or three years as the occurrence of SDV varied from year to year in the tested fields. The percentage of SDV infection in the susceptible and resistant varieties at Naganuma from 1971 to 1980 is shown in Fig. 5.

2 Aphid inoculation test

The method of aphid inoculation was developed by Tamada (1970). The tested field is surrounded by cheesecloth 3 meter high, to prevent viruliferous aphids from escaping by strong wind. Aphid inoculation was performed in 12 plants per plot. At the same time check plots were prepared for each variety. Insecticides against aphids such as Ethylthiometon were applied to the soil at sowing time. A complete randomized design with two replications was used. Each plant was planted in rows 60 cm in width with hills 20 cm apart. For each plant, two seeds were sown in the middle of May. After germination, seeds were thinned to one. Two strains of SDV, dwarfing and yellowing, were inoculated by viruliferous aphids to each variety at the third leaflet stage in

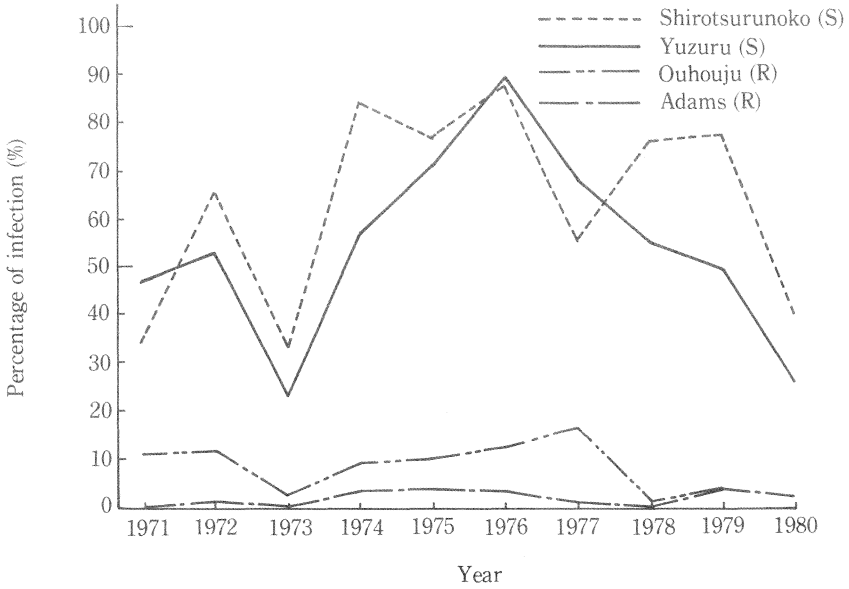

Fig. 5 Changes in the percentage of infection on susceptible and resistant varieties at Naganuma from 1971 to 1980.

early July. For the aphid inoculation tests, the aphids were allowed to feed on the infected plants for 2 days, and then they were transferred to healthy soybean plants in the field. Each seedling of each soybean variety was inoculated by a group of 5 viruliferous aphids and these aphids were killed by spray of insecticide 7 days after inoculation. Symptom appearance on the plants was observed from more than 6 weeks after inoculation. Finally, the main agronomic characteristics of the infected plants in each variety were compared to those of healthy plants as check at harvest time. The relative percentage was calculated as (I/H × 100), where I is the value obtained in the infected plots and H is that in the check plots.

Screening for SDV-resistant varieties in soybeans

1 Natural infection

Two thousand seventy five varieties of soybeans were investigated for SDV resistance during the past 16 years. These screening materials were introduced from several foreign countries, e.g. US Regional Soybean Laboratory of the University of Illinois, USA, Mae Jo Agricultural Experiment Station in Thailand, National Agricultural Experiment Station in Poland, etc. Also domestic soybean germplasm was offered from several National and Prefectural Agricultural Experiment Stations in Japan.

It was found that 20 out of the 2,075 varieties tested were resistant to SDV as in the case of the moderately resistant variety 'Ouhouju'. These varieties are listed in Table 1. The percentage of infection in the field ranged from 2.7 to 89.9% in the susceptible variety 'Yuzuru' during the past 12 years, whereas it ranged from 0.0 to 6.9% in the moderately resistant variety 'Ouhouju'. Many varieties selected for resistance to SDV exhibited less than approximately 5% resistance. Three varieties, 'Gokuwasechishima', 'Kimame' and 'PI 90763', showed no disease sumptoms during the test period at Naganuma. However, it was found that 'PI 90763' and 'Kimame' were infected with SDV at Date, whereas 'Gokuwasechishima' still showed no symptoms.

Table 1 Resistance to SDV of varieties of soybenas introduced from 1966 to 1982 at Naganuma

Variety name	Country of introduction	Test Period (year)	Percentage of infection SDV (%)	
			Mean	Range
Adams	USA	16	1.4	0.0 - 3.8
Akanita	Japan	5	2.7	0.0 - 4.7
Bavender Special	USA	14	2.7	0.0 - 6.9
Gokuwase chishima	Japan	7	0.0	0.0
Habriska 231	Yugoslavia	5	1.4	0.0 - 4.8
Kimame	Japan	5	0.0	0.0
M-14	Yugoslavia	6	0.6	0.0 - 2.4
Montreal Manchu	China	5	1.4	0.0 - 6.3
Ouhouju	China	17	5.6	0.0 - 16.9
Pando	Korea	5	3.8	0.0 - 19.1
Peking	China	3	0.9	0.0 - 2.8
Peking kurodaizu	China	4	2.5	0.0 - 4.4
PI 89772	China	4	3.5	1.8 - 4.9
PI 90763	China	5	0.0	0.0
Shutai 4	China	4	1.4	0.0 - 4.6
Timiriazerevskaja 144	USSR	6	0.6	0.0 - 2.2
Yoshiokachuryu	Japan	7	0.2	0.0 - 1.6
Wabash	USA	3	3.3	0.0 - 5.5
634-13-108-9B	Sweden	6	1.3	0.0 - 5.6
840-2-7	Sweden	6	0.5	0.0 - 3.1
Shirotsurunoko (S)	Japan	14	53.9	11.2 - 87.8
Yuzuru (S)	Japan	12	47.9	2.7 - 89.9

Remarks 1) 'Shirotsurunoko' and 'Yuzuru' are susceptible varieties.

2 Aphid inoculation

Aphid inoculation test was performed in 20 soybean varieties which showed a low percentage of infection in the fields of Naganuma and Date. The results are shown in Table 2. The relative percentage for each agronomic characteristic of the varieties inoculated with yellowing strain was higher than that for the varieties inoculated with the dwarfing strain. For the dwarfing strain, the relative percentage for each agronomic characteristic in 20 resistant varieties was much higher than that of the susceptible varieties 'Shirotsurunoko' and 'Yuzuru', suggesting that these 20 varieties were much more resistant to the dwarfing strain.

On the other hand, inoculation tests of the yellowing strain showed that the relative percentage for the seed weight varied with the varieties. Fifteen varieties, except for 'M-14', 'Montreal Manchu', 'Shutai 4', 'Wabash' and '634-13-108-9B', showed a high percentage for the seed weight, which is one of the important characteristics indicative of resistance. It is suggested that these 15 varieties are moderately resistant to the yellowing strain.

Table 2 Results of aphid inoculation tests using two strains of SDV, yellowing and dwarfing, in 20 varieties of soybeans

Variety name	Relative percentage							
	Plant height		Number of pods		Weight of seeds		Weight of 100 seeds	
	Dwarf	Yellow	Dwarf	Yellow	Dwarf	Yellow	Dwarf	Yellow
Adams	86	84	60	39	49	34	88	94
Akanita	90	69	90	61	85	35	99	96
Bavender Special	102	75	77	72	65	47	89	74
Gokuwase chishima	100	83	82	67	90	63	89	78
Harbinska 231	81	70	77	46	76	31	95	88
Kimame	98	100	65	85	42	35	60	60
M - 14	83	77	37	23	39	10	91	67
Montreal Manchu	60	71	50	50	37	23	91	80
Ouhouju	80	83	75	67	66	59	79	75
Pando	95	100	89	55	85	44	81	74
Peking	82	82	63	45	74	54	96	89
Peking kurodaizu	98	106	94	71	86	63	99	98
PI 89772	116	107	103	73	109	55	92	86
PI 90763	97	87	68	57	92	40	98	80
Shutai 4	63	79	49	39	33	25	88	79
Timiriazerevskaja 144	84	92	53	46	46	30	94	82
Yoshioka churyu	105	95	99	63	97	46	94	77
Wabash	80	73	73	24	80	15	90	73
634-13-108-9B	103	100	90	34	91	22	92	53
840-2-7	94	106	68	51	55	35	100	89
Shirotsurunoko (S)	48	97	23	6	9	1	85	73
Yuzuru (S)	36	92	13	38	10	16	86	84

Remarks: 1) Relative percentage was calculated as (I/H × 100), where I is the value obtained in infected plots and H is that of healthy plants as check.
2) 'Dwarf': dwarfing strain of SDV and 'Yellow': yellowing strain of SDV.
3) 'Shirotsurunoko' and 'Yuzuru' are susceptible varieties.

Artificial crosses

It was observed that the soybean varieties 'Adams', 'Bavender special' and 'Ouhouju' are moderately resistant to SDV based on the research results obtained until 1971. But the agronomic characteristics of these resistant varieties are inferior to those of the cultivars recommended in Hokkaido. Artificial crosses between these resistant varieties and the recommended cultivars have been performed since 1971. Hitherto, we have attempted to cross 134 pairs to breed SDV resistant varieties with high yield and good quality. The moderately resistant varieties used for the artificial crosses were 'Adams' (31 pairs of crosses), 'Bavender special' (8 pairs), 'Kimame' (2 pairs), 'Ouhouju' (23 pairs), 'Wabash' (2 pairs) and hybrids originating from the above mentioned moderately resistant varieties and the recommended cultivars in Hokkaido (68 pairs).

In the early generations (F 1 to F 4), selection was based on the absence of symptoms of SDV, good plant type, early maturity and good quality from segregated populations at Naganuma. In the middle generations (F 5 to F 8), the resistance of the breeding lines was evaluated in the field at Date. Morevover, aphid inoculation tests using dwarfing and yellowing strains of SDV were carried out to evaluate the SDV resistance and performance tests of the selected promising lines.

We have been able to select 30 breeding lines resistant to SDV with good agronomic characteristics. They originated from the 134 pairs of artificial crosses performed at Naganuma. The reaction of 14 breeding lines among them and of check varieties by natural infection at Date and

Table 3 Results of natural infection and aphid inoculation tests in breeding lines of soybean

Line or variety	Percentage of infection with SDV under natural condition at Date (%)	Relative percentage							
		Plant height		Number of pods		Seed weight		Weight of 100 seeds	
		Dwarf	Yellow	Dwarf	Yellow	Dwarf	Yellow	Dwarf	Yellow
Chukei 66	23.6	76	122	76	84	80	99	78	104
Chukei 67	32.8	65	102	66	65	52	63	84	92
Chukei 76	37.3	87	116	79	65	65	50	81	66
Chukei 78	40.8	67	100	68	46	45	27	76	77
Chukei 82	36.8	86	108	75	67	67	32	96	76
Chukei 83	51.4	65	126	84	88	56	63	83	79
Chukei 88	35.3	69	127	54	68	35	53	70	71
Chukei 89	55.6	88	110	74	64	79	57	105	95
Chukei 91	41.4	81	108	66	43	55	30	99	62
Chukei 92	73.5	55	100	69	66	41	42	77	90
Chukei 93	63.6	95	93	59	34	52	70	93	66
Chukei 94	68.6	63	104	84	68	55	52	83	79
Chukei 95	65.8	92	120	67	58	62	44	95	81
Chukei 98	78.1	75	96	55	25	42	66	73	74
Mean value	50.3	76	109	70	60	56	53	85	79
Koganejiro (S)	93.9	-	-	-	-	-	-	-	-
Shirotsurunoko (S)	87.3	-	-	-	-	-	-	-	-
Yuzuru (S)	94.2	48	98	17	34	10	7	72	67
Mean value	91.8	48	98	17	34	10	7	72	67
Adams (R)	20.1	88	89	45	40	38	29	95	79
Bavender Special (R)	39.5	-	-	-	-	-	-	-	-
Ouhouju (R)	51.2	100	105	83	81	83	95	102	110

Remarks: 1) The investigation was conducted in 1981 and 1982.
2) - not investigated.

aphid inoculation using dwarfing and yellowing strains of SDV at Naganuma is shown in Table 3. The mean value of the percentage of natural infection in the breeding lines was 50.3% and the infection percentage in the susceptible and moderately resistant varieties was 91.8% and 36.9%, respectively. The mean value of the percentage in the breeding lines was intermediate between those in the susceptible and moderately resistant varieties. Also, the mean value in Chukei 66 and Chukei 67 was less than those of other breeding lines tested. Based on the results of natural infection at Date, it was shown that the degree of resistance of Chukei 66 and Chukei 67 was almost the same as that of the resistant varieties tested. Based on the results of aphid inoculation tests using dwarfing and yellowing strains of SDV for the 14 breeding lines which are shown in Table 3, it was found that one line with resistance to SDV was similar to the moderately resistant varieties. Therefore, the relative percentage for the seed weight of Chukei 66, Chukei 89 and Chukei 82 which were infected with the dwarfing strain was higher than that of other lines. On the other hand, the percentage for the seed weight of Chukei 66, Chukei 93, Chukei 67, Chukei 83 and Chukei 98 infected with the yellowing strain was higher than that of the other lines.

Moreover, breeding lines were established in a preliminary test at Naganuma. Five lines were selected from many promising ones showing SDV resistance, high seed yield and good quality (Table 4) as follows: Chuiku 14 (first designated as Chukei 67), Chuiku 15 (Chukei 76), Chuiku 16 (Chukei 83), Chuiku 17 (Chukei 66) and Chuiku 18 (Chukei 95).

In order to determine whether three promising lines could be released to the farmers, they were tested in insecticide-treated and non-treated fields at Date in 1983. The results are shown in Table 5. In the non-treated fields, the percentage of infection and reduction of seed yield of the three promising lines were lower than those of 'Ouhouju' and Adams', whereas those of the susceptible varieties, 'Yuzuru' and 'Koganejiro' were high as compared with the resistant varieties. In the insecticide-treated fields, there were a few differences between the suceptible and resistant varieties.

Table 4 Characteristics of several breeding lines of soybean in insecticide-treated fields at Naganuma in 1981

Line or variety	Date of maturity	Lodging score	Seed yield (ton/hectare)	Relative yield (%)	Weight of 100 seeds (grams)
Chuiku 14	October 7	1.0	3.13	115	36.4
Chuiku 15	October 12	0.5	2.69	99	38.6
Chuiku 16	October 9	0.3	2.79	103	31.5
Chuiku 17	October 11	2.0	2.88	106	38.0
Chuiku 18	October 11	1.0	3.04	112	33.1
Yuzuru (S)	October 16	1.0	2.71	100	40.9
Ouhouju (R)	October 4	0.5	2.01	74	25.3

Table 5 Results of performance tests for infection with SDV in insecticide-treated and non treated fields at Date in 1982

Insecticide	Line or variety	Percentage of infection with SDV (%)	Plant height (cm)	Number of pods	Seed yield (ton/hectare)	Relative yield (%)	Weight of 200 seeds (gram)
Not treated	Chuiku 14	13.3	80	66.8	1.78	81	26.4
	Chuiku 15	36.0	84	59.6	1.77	82	34.1
	Chuiku 17	12.3	82	53.5	1.82	88	25.3
	Koganejiro (S)	96.6	58	30.4	0.31	17	13.8
	Yuzuru (S)	92.5	71	12.1	0.27	17	32.3
	Adams (R)	30.2	103	46.0	1.15	53	14.7
	Ouhouju (R)	-	85	56.6	1.27	64	18.0
Treated	Chuiku 14	6.3	81	62.6	2.20	100	26.4
	Chuiku 15	12.6	88	54.4	2.15	100	33.1
	Chuiku 17	11.8	84	57.1	2.06	100	26.7
	Koganejiro (S)	14.2	78	85.4	1.85	100	18.9
	Yuzuru (S)	34.5	78	42.2	1.62	100	37.4
	Adams (R)	13.0	114	77.0	2.18	100	16.3
	Ouhouju (R)	10.9	90	63.6	1.99	100	20.9

Remarks: 1) - not investigated.

A new resistant variety 'Tsurukogane'

The new variety 'Tsurukogane' originated as a F 12 line developed from the cross 'Chuiku 1' × 'Ouhouju'. 'Chuiku 1' was selected by pure line selection from the local cultivar 'Tsurunoko' which had been cultivated at Otobe town in the southern districts of Hokkaido. This variety has a

white hilum, gives high yield and has a large seed size (approximately 45 gram per 100 seeds). In addition, 'Ouhouju' was similarly selected by pure line selection from the local cultivar 'Yonryuki' which had been cultivated in the Jilin districts of mainland China. It has a white hilum, gives high seed yield and has a medium seed size (approximately 25 gram per 100 seeds). It is also moderately resistant to SDV. The cross was performed in 1971 and early generations were evaluated in the field at Naganuma, while the later generations were evaluated in the field at Date. The variety was also evaluated by aphid inoculation test at Naganuma in 1981, 1982, 1983. The performance tests were conducted in both insecticide-treated and non treated fields in 1983 at Date and Biratori where SDV usually occurrred very seriously. The results are shown in Table 6. In the non treated fields at Biratori, the percentage of infection and the reduction of seed yield of 'Tsurukogane' were much lower than those of the susceptible cultivar 'Kitahomare'. Also, 'Kitahomare' remained immature at harvest time and the plant was shorter in the non treated plots. In the non treated fields at Date similarly the percentage of infection and the reduction of seed yield of 'Tsurukogane' were much lower than those of 'Yuzuru'. It was shown that 'Tsurukogane' is resistant to SDV as in the case of the variety 'Ouhouju'. In the performance tests in the insecticide-treated fields at Naganuma, the mean seed yield for 3 years was 2.89 ton per hectare and it was approximately 17% higher than that of a check cultivar 'Toyosuzu'. The variety was registered by the Ministry of Agriculture, Forestry and Fisheries as 'Soybean Norin No. 79' and it was released as recommended cultivar in the southern districts of Hokkaido in 1984. It was designated as 'Chuiku 14' before its release.

Table 6 Results of performance tests for infection with SDV in insecticide-treated and non treated fields at Date and Biratori in 1983

Location	Insecticide	Variety name	Percentage of infection with SDV (%)	Maturity date	Plant height (cm)	Seed yield (ton/hectare)	Relative yield (%)
Date	Not treated	Tsurukogane	23.0	October 11	66	2.28	80
		Yuzuru	52.9	October 16	54	0.82	39
	Treated	Tsurukogane	11.3	October 11	68	2.84	100
		Yuzuru	22.5	October 16	57	2.10	100
Biratori	Not treated	Tsurukogane	35.9	October 12	78	2.49	87
		Kitahomare	96.4	Immature	40	0.33	11
	Treated	Tsurukogane	15.1	October 11	87	2.86	100
		Kitahomare	35.7	October 11	58	2.94	100

Problems to be solved in the future

As stated previously no immune varieties to SDV were detected among the soybean materials collected. We have already screened 2,075 soybean varieties for SDV. It would be desirable to evaluate the resistance to SDV of the 10,000 specimens of the world soybean germplasm which are stored in the USA, Taiwan and other countries.

Almost all the lines selected for resistance to SDV originated from 'Ouhouju' whereas only 4 lines were derived from other materials. Although the agronomic characteristics of 'Ouhouju' are inferior to those of other SDV resistant varieties, e.g. 'Adams', 'Bavender special', etc., the breeding lines originating from pairs of 'Ouhouju' have excellent agronomic characteristics. However based on the results of natural infection at Date the percentage of infection in 'Ouhouju' was found to be higher than in the other resistant varieties. Attempts were made to cross 'Ouhouju' with other SDV resistant varieties, but the breeding lines derived from these crosses had a low combining ability. Therefore, we should breed hybrids with a high combining ability

and SDV resistance. A new variety having better agronomic characteristics than 'Tsurukogane' should be bred by artificial crosses between these excellent hybrids and the cultivars recommended in Hokkaido.

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Discussion

Rossel, H. W. (IITA): Does the vector (aphid) of soybean dwarf reproduce on soybean?
Answer: Yes, it does.

Rossel, H.W. (IITA): It appears to me that the resistance screening process could be made easier since the vector is breeding on the host, as in the case of groundnut rosette. Therefore one can multiply a large number of aphids on the infected plants by interspersing a few among segregated populations and one can readily obtain 100% infection incidence with this virus which is transmitted in a persistent manner, even under field conditions. This would be preferable than putting aphids on individual plants, which is rather laborious.

Answer: Inoculation is difficult as the sensitive period of soybean is too short in spite of the large number of insects that multiply on the plant.