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Research Period : 1987-90
Research Site : International Center for Agricultural Research in the Dry Areas (ICARDA), Syria

Fig. 1.
Experimental field for cereal breeding at ICARDA.

Fig. 2.
Seeds set in wheat self-pollinated (right), and cross-pollinated with maize (left) two weeks after pollination.

Efficient Production of Wheat Haploids through Intergeneric Crosses

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The collaborative research project on cereals between TARC and ICARDA, undertaken during the period of 1986-1990, placed emphasis on the improvement of cereal germplasm (Fig. 1), using the haploid breeding method. The objective of the project on cereal haploid production was to develop breeding methods that could accelerate the release of new varieties, as complementary tools for conventional breeding programs.

Since haploid plants carry only one set of alleles at each locus, after chromosome doubling the doubled haploid lines are completely homozygous and homogeneous. The dihaploidization process can thus provide a rapid method of developing recombinant inbred lines from hybrid progenies. Intergeneric hybridization of wheat with *Hordeum bulbosum* L. results in the formation of haploid embryos of wheat, following the preferential elimination of chromosomes of *H. bulbosum*. However, the success of haploid production depends on which wheat genotypes are used for the crosses because the cross-incompatibility of wheat is genetically controlled. This report deals with the development of a method of efficient production of wheat haploids through intergeneric crosses.

Key words : wheat, haploid, intergeneric cross, embryo culture

Materials and Methods

In order to overcome the cross-incompatibility barrier of wheat, the use of alternative pollen from maize (*Zea mays* L.) and the application of a plant hormone were attempted here. Four check varieties of wheat, i. e., Norin 61, Chinese Spring, Mexipak 65 and Highbury were used as female parents. The two pollen sources consisted of populations of *H. bulbosum* and maize. On each of two consecutive days after pollination, wheat culms with pollinated spikes were needle-injected with a 100 ppm solution of 2, 4-dichlorophenoxyacetic acid (2, 4-D). Two weeks after pollination, immature embryos were aseptically cut out and transferred onto B 5 medium for plant regeneration (Fig. 2). Additionally, twenty wheat varieties grown in West Asia and North Africa were examined for frequencies of haploid production through crosses with *H. bulbosum* and

maize.

Results and Discussion

Table 1 shows the frequencies of embryo formation in the four wheat varieties crossed with *H. bulbosum* and maize. In the cross with *H. bulbosum*, two wheat varieties, Norin 61 and Chinese Spring, produced embryos at frequencies of 23.6% and 16.9%, respectively. These frequencies increased when 2,4-D was applied. Without 2,4-D application, the crosses of wheat with maize did not produce any embryos, whereas with 2,4-D application, all the wheat varieties produced embryos and the frequency of embryo formation ranged from 8.3% to 21.1% among the wheat varieties. Immature embryos ca. 1.0 mm in size obtained from crosses with *H. bulbosum* and maize were regenerated to green plants within three weeks of incubation. A total of 226 plants was obtained from 534 embryos cultured. The frequency of success was 43.1%. All the regenerated plants that were examined cytologically were euhaploids having a complement of twenty one wheat chromosomes (Fig. 3).

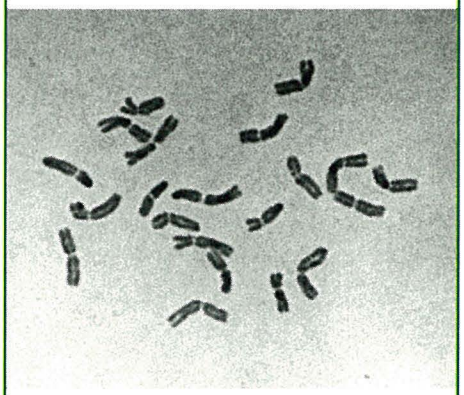

Fig. 3.
Somatic 21 chromosomes of a wheat plant obtained from the cross with maize.

Pollen source	2,4-D application	Wheat variety			
		Norin 61	Chinese Spring	Mexipak 65	Highbury
None	−	0.0	0.0	0.0	0.0
None	+	0.0	0.0	0.0	0.0
H. bulbosum	−	23.6	16.9	0.0	0.0
H. bulbosum	+	38.5	25.0	0.0	0.0
Maize	−	0.0	0.0	0.0	0.0
Maize	+	17.5	21.1	18.9	8.3

Table 1.
Effect of 2,4-D application on embryo formation (%) in four wheat varieties crossed with *H. bulbosum* and maize.

Average frequencies of embryo formation in twenty wheat varieties from West Asia and North Africa crossed with *H. bulbosum* and maize are compared in Table 2.

Pollen source	No. of florets pollinated	No. of seeds set (%)	No. of embryos obtained (%)	No. of plants regenerated (%)
H. bulbosum	2296	1354 (59.0)	7 (0.3)	5 (0.2)
Maize	1128	906 (80.3)	245 (21.7)	107 (9.5)

Table 2.
Average frequencies of haploid production from twenty wheat varieties in crosses with *H. bulbosum* and maize.

Overall frequencies of wheat haploid production were 0.2% using the *H. bulbosum* cross and 9.5% using the maize cross, indicating that the maize cross was more efficient than the *H. bulbosum* cross. This high frequency of haploid production has been confirmed using F_1 hybrid plants as starting materials.

This study demonstrated that maize pollination with subsequent 2, 4-D application onto wheat florets resulted in the production of wheat embryos capable of regenerating haploid plants, even for wheat genotypes not crossable with *H. bulbosum*.

Cross-incompatibility barrier in wheat has been successfully overcome by using maize pollen. The maize technique is currently being improved as an alternative to the bulbosum technique for wheat haploid production. After chromosome doubling of haploids, a random sample of recombinant inbred lines can be used for selection of breeding purposes. These lines may be also used as materials for the detection of the loci of quantitative traits of agronomic importance, through molecular techniques including DNA sequence polymorphisms and physical linkage maps.

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New Rice Varieties "Dian Jing No. 23" and "Dian Jing No. 24", Registered in Yunnan Province in China.

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Research Period : 1982-91
Research Site : Yunnan Academy of Agricultural Sciences, Peoples' Republic of China

Since 1982, the Tropical Agriculture Research Center, Japan and the Yunnan Academy of Agricultural Sciences, Peoples' Republic of China, have been implementing a joint research program entitled "Breeding of Rice Varieties for High-Yield and Resistances to Cold Weather and Blast Disease through the Utilization of Unexploited Genetic Resources".

The area planted to geng-rice in Yunnan province is located at an elevation between 1, 500-2, 400 m above the sea level. For the breeding of geng-rice varieties adapted to the Yunnan conditions, it will be necessary to use the characteristics of rice varieties which vary among the locations, and many kinds of varieties with different characteristics should be developed.

In 1990 and 1991, the provincial government of Yunnan officially approved the registration of three and two new cultivars developed through the Sino-Japanese cross-hybridization programs, respectively, due to the superior performance of these cultivars in the province.

Key words : Rice breeding, high-yield, cold and blast disease resistance, Sino-Japanese cross hybridization

Fig. 1.
Hexi No. 2 in the test field, Yunnan.

Fig. 2.
Hexi No. 22 in the test field, Yunnan.

Materials and Methods

(1) Japanese rice varieties "Todoroki-wase" and "Kihoh" were selected as parent materials for cross-hybridization.

(2) Chinese rice varieties "Jinghong No. 1" and "Chugeng No. 4" were also used as parent materials for cross-hybridization.

(3) In 1983 and 1985, cross-hybridization between the Japanese varieties and Chinese Varieties was initiated.

(4) The rapid generation advance method was applied for the F 1 and F 2 progenies derived from cross-hybridization in Hainan island.

(5) After the F 3 progeny, selection for high-yield and resistance to cold weather and blast disease was initiated within the Yunnan district and 27 lines were eventually selected from the progeny.

(6) Twenty seven lines, "Hexi No. 1-No. 27" were tested for their performance including yield, resistance to cold weather and blast disease and some other characteristics, in more than 12 different locations in the Yunnan districts.

(7) Five lines, "Hexi No. 2, 4, 5, 10 and 22" out of the 27 lines showed a good performance in the above tests during a period of 2 years. These 5 lines were examined for their adaptability in the large scale verification trials conducted in farmers' fields.

(8) We already reported that 3 lines, "Hexi No. 4, 5 and 10" out of 5 lines were officially recognized as new rice varieties, "Dian Jing No. 18, 19 and 20" respectively, in the Yunnan province in 1990.

Results and Discussion

(1) In 1991, the provincial government of Yunnan officially approved the registration of two new cultivars developed through the Sino-Japanese cross-hybridization programs, due to the superior performance demonstrated by these cultivars in the province. Especially, "Hexi No. 2" showed a good performance in the tests conducted in the paddy fields located at an elevation between 1, 700-1, 850 m from the sea level, while "Hexi No. 22" showed a good performance in the tests conducted in the paddy fields located at an elevation between 1, 500-1, 850 m from the sea level.

(2) Their characteristics are described as follows :

1. Dian Jing No. 23 = Hexi No. 2 : This progeny from the cross Todoroki-wase x Jinghong No. 1, is characterized by a high-yielding ability, early maturity, panicle number plant type, cold resistance and high-quality of hulled rice. It is anticipated that this variety will be cultivated in several districts located in the central western part of Yun-

nan province, such as Dali, Baoshan, Chuxiong, etc. The planted area to the variety developed which covered more than 9,000 ha in 1991 will be increased in future.

2. Dian Jing No. 24 = Hexi No. 22 : This progeny from the cross Kihoh x Chugeng No. 4, is characterized by a high-yield, intermediate maturity, intermediate plant type, moderate cold resistance, blast resistance, intermediate shattering habit, good ripening and intermediate lodging resistance. It is anticipated that this variety will be cultivated in several districts of Yunnan and Sichuan province, such as Yiliang, Yaoan, Lunan and Tonghai in Yunnan province and Liangshan in Sichuan province. The planted area to the variety developed which covered more than 1,300 ha in 1991 will be increased in future.

Table 1. Major characteristics of the two new varieties compared with standard ones.

Name of variety	Dian Jing No. 23	Yun Jing No. 9	Dian Jing No. 24	Chugeng No. 3
Promising lines	Hexi No. 2	(Standard)	Hexi No. 22	(Standard)
Maturity	Early	Late	Intermediate	Early
Plant type belonging to :	Panicle number	Panicle weight	Intermediate	Panicle weight
Heading/Ripening time	Jul. 21/Sep. 2	Jul. 30/Sep. 16	Jul. 20/Aug. 25	Jul. 15/Aug. 23
Culm height cm	68	101	80	83
Panicle height cm	13.7	16.0	16.5	16.6
Number of panicles/m^2	593	418	438	415
Color of apiculus	White yellow	White yellow	White yellow	White yellow
Shattering habit	Limited	Very limited	Intermediate	Limited
Lodging resistance	High	Low	Intermediate	Intermediate
Leaf blast resistance	High	Intermediate	Very high	Low
Panicle blast resistance	Very high	High	Very high	Low
Genotype for blast resistance	Pi-k	+	Pi-km	+
Tolerance to cold weather	High	Very high	Intermediate	Intermediate
Yield (unhulled) kg/a	94.4	82.7	84.3	76.1
Yield (hulled) kg/a	78.3	69.4	70.3	62.7
1,000 grain weigh g	21.9	19.7	19.9	21.0
Quality of grain	Good	Poor	Good	Intermediate
Testing location	Kunming		Yiliang	

Development of a Sexually Reproducing Tetraploid Line for Breeding Apomictic Guineagrass

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Research Period : 1986-90
Research Site : Tropical Agriculture Research Center, Okinawa Branch, and Kyushu National Agricultural Experiment Station, Japan

Apomixis, an asexual method of reproduction, provides a method for cloning plants through seed. One of the main advantages of apomixis is that it enables the development of hybrids or genotypes that breed true regardless of heterozygosity which simplifies commercial seed production.

Guineagrass (*Panicum maximum* Jacq.) is an apomictic grass native to tropical Africa. Breeding of guineagrass is difficult unless plants with sexual reproduction (hereafter referred to as sexual) are available for hybridization. Sexual plants both at the diploid level (2n = 16) and at the tetraploid level (2n = 32) have been reported. However, most guineagrasses are tetraploid and apomictic.

In Japan, about 140 accessions of guineagrass were collected in East Africa by S. Hojito and T. Horibata under the project sponsored by the Tropical Agriculture Research Center during 1971-1973. Among them, one diploid obligate sexual strain, 73-1126 (GR 297), was identified and this accession was early-flowering and grew rapidly.

The most effective way to use the tetraploid apomictic germplasm is to cross it with sexual tetraploids. Therefore, the major objective of the study was to double the chromosome number of sexual diploid GR 297 by colchicine treatment and develop tetraploid sexual lines so that a guineagrass breeding program could be established.

Key words : guineagrass, apomixis, colchicine

Materials and Methods

In 1986, germinating seeds of GR 297 were treated with 0.1% colchicine for 4 hours at the Coastal Plain Experiment Station, Tifton, Georgia, U. S. A. Seedlings from 88% of 660 seeds treated died, while 3 tetraploids were

Table 1.
Characteristics of "Noh PL 1" and diploid sexual strain, GR 297.

Strain	Heading date	Culm length (cm)	Inflorescence length (cm)	Culm width (cm)	Culm number	Node number	Flag leaf length (cm)	Flag leaf width (cm)	Sexuality[1] (%)
Noh PL 1	Sep 14	131	30.2	8.5	31.7	6.1	15.0	2.26	100
GR 297	Sep 6	149	26.9	9.1	34.9	7.4	15.9	2.19	100

1) Ovules were observed with the paraffin sectioning method or the clearing method.

obtained. The induced tetraploid sexual plants were placed in a separate greenhouse and were open-pollinated. In 1987, all the 26 progenies were found to be tetraploid and sexual. Eight selected tetraploid sexual plants were open-pollinated in a separate greenhouse and eight maternal lines were developed by collecting seeds from each plant at Kyushu National Agricultural Experiment Station, Nishigoshi, Kumamoto. In 1988, three lines were selected and designated as Col 1-1, Col 1-2, and Col 1-3 at the Tropical Agriculture Research Center, Okinawa Branch, Ishigaki, Okinawa. In 1990, a promising line, Col 1-3, was renamed "Nekken 1" guineagrass after the evaluation of the lines and progenies from hybridization between sexual lines and apomictic germplasm. The "Nekken 1" was registered by the Ministry of Agriculture, Forestry and Fisheries of Japan and named "Noh PL 1" guineagrass in 1991.

Characteristics of "Noh PL 1" Guineagrass

The "Noh PL 1" guineagrass is tetraploid (2n = 32 : Fig. 2) and can reproduce sexually (Fig. 3) by cross-pollination. It is annual and grows rapidly though most of the guineagrasses are perennial and grow slowly. The morphological characteristics of "Noh PL 1" and GR 297 are shown in Table 1. This line crossed with apomictic tetraploids should produce vigorous apomictic hybrids which are true breeding and could rapidly be incorporated into a testing program for desirable characteristics. The sexual x apomictic crosses should also produce sexual progeny with modified genotype. The new sexual plants will be extremely useful for broadening the genetic base of sexual female parents. Preliminary data indicated that the hybrids between "Noh PL 1" guimeagrass and apomictic males grew fast and the productivity in the first growing season was high though the productivity of the line itself is not very high. The hybrids between annual and perennial are perennial and some show hybrid vigor.

This true-breeding induced tetraploid sexual line propagated by seed should enable the development of an effective breeding program in *Panicum maximum*.

References

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Fig. 1.
"Noh PL 1" guineagrass at the flowering stage.

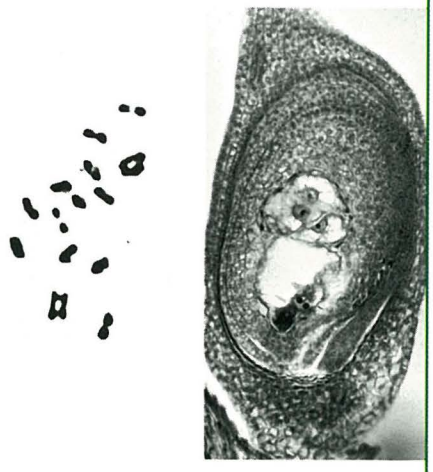

Fig. 2. (left)
Meiotic chromosomes at metaphase I of "Noh PL 1" showing 2 quadrivalents and 12 bivalents.

Fig. 3. (right)
Sexual embryo sac in an ovule of "Noh PL 1" observed with the paraffin sectioning method.

Research Period : 1987-91
Research Site : Chainat Field Crops Research Center, Thailand

Breeding of Bruchid-resistant Mungbean Line in Thailand

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In Thailand, two species of bruchid beetles (*Callosobruchus chinensis*, azuki bean weevil, and *C. maculatus*, cowpea weevil) were reported to cause serious damage to mungbean (*Vigna radiata*) seeds during storage. The initial infestation starts in the field, where the adult beetles lay eggs on green pods and the larvae bore into the pod and feed concealed within developing seeds. When such seeds are harvested and stored, the larvae continue to feed, emerge as adults, and cause secondary infestation which at times results in total destruction within a period of 3 to 4 months. One accession (TC 1966) of *V. radiata* var. *sublobata*, a wild ancestral form of mungbean, exhibited a complete resistance against *C. chinensis* in Japan. The resistance of TC 1966 was controlled by a single dominant gene (proposed gene symbol *R*). Moreover, TC 1966 was resistant to four species of bruchids, i. e., *C. chinensis*, *C. maculatus*, *C. phaseoli* and *Zabrotes subfasciatus* in Japan. Since TC 1966 is cross-compatible with cultivated mungbean, it was considered that a mungbean cultivar with good agronomic characters that would be resistant to *C. chinensis* and *C. maculatus* could be developed under the environmental conditions of Thailand. Against this background, a breeding program to develop a bruchid-resistant mungbean variety was initiated in Thailand in 1987.

Key words : *Vigna radiata*, *Vigna radiata* var. *sublobata*, bruchid resistance, wild germplasm

Materials and Methods

The breeding procedure to incorporate bruchid resistance from TC 1966 to 'CN 60' is illustrated in Fig. 1. 'CN 60', which is the earliest mungbean cultivar (maturing in 55-60 days) bred at Chainat Field Crops Research Center (Chainat FCRC) in 1987, was used as a female parent and was crossed with TC 1966. Recurrent back-crossing using 'CN 60' as a male parent was started in the F_2 generation to improve the agronomic characters of the hybrids. After the F_2 generation, resistant seeds were selected using *C. chinensis* and planted for backcrossing. BC_3F_1 plants were selfed to produce BC_3F_2 seeds. Resistant phenotypes (*R/R*

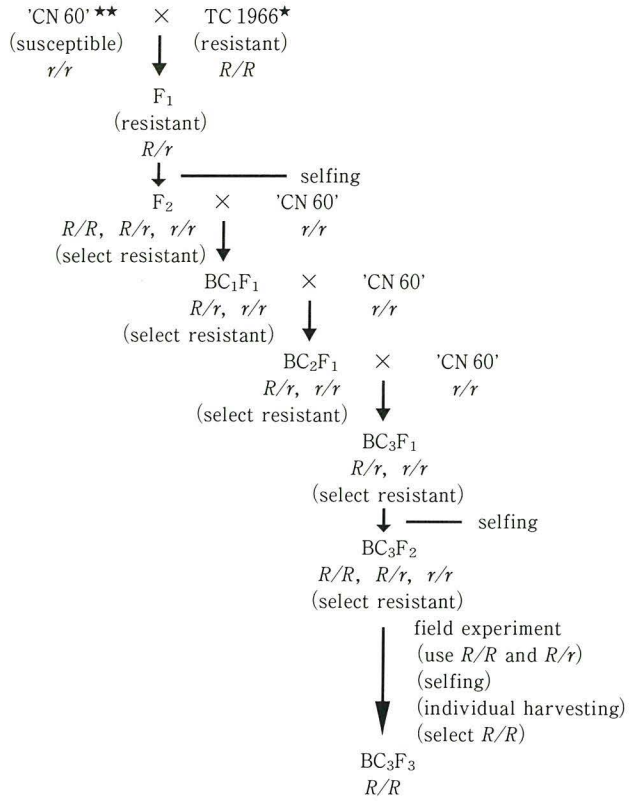

Fig. 1.
Breeding procedure to incorporate bruchid resistance from TC 1966★ to 'CN 60'★★.

★TC 1966 is a bruchid-resistant accession of wild mungbean (*V. radiata* var. *sublobata*).
★★'CN 60' is a recommended mungbean cultivar (*V. radiata*) in Thailand.

and *R/r*) of the BC_3F_2 seeds were selected, and were used for the field experiment. The BC_3F_2 plants were harvested individually. Resistant BC_3F_3 line (*R/R*) was selected by checking the bruchid resistance of the BC_3F_3 seeds of each BC_3F_2 plant separately. A field experiment for comparing agronomic characters was conducted in the early rainy season in the field of Chainat FCRC.

Results

Tests for bruchid resistance

Levels of resistance of cultivated and wild mungbean to *C. chinensis* and *C. maculatus* occurring at Chainat FCRC are indicated in Table 1. Among the six strains examined, only TC 1966 showed a complete resistance to both, *C. chinensis* and *C. maculatus*. Although the number of eggs laid on the seed surface of TC 1966 was equivalent to that in the other wild accessions, no adults emerged and no seeds were damaged in the case of TC 1966. Two other wild accessions and three recommended cultivars were susceptible at various levels to both *C. chinensis* and *C. maculatus*.

Table 1. Levels of resistance of cultivated ('CN 60', 'KPS 1' and 'KPS 2') and wild (TC 1965, TC 1966 and TC 2207) mungbean varieties to *C. chinensis* and *C. maculatus*.

Bruchid species	Legume line	100 seed weight (g)	Eggs/rep. (No.)	Emergence (%)	Damaged seeds (%)	Developmental period (days)
C. chinensis	'CN 60'	7.1	38.0 a*	80.3 a	100.0 a	23.4 a
	'KPS 1'	7.3	22.0 ab	86.4 a	95.0 a	24.0 a
	'KPS 2'	7.3	29.0 ab	89.7 a	100.0 a	24.2 a
	TC 1965	1.0	12.0 b	66.7 a	89.5 a	26.7 a
	TC 1966	1.7	15.5 b	0.0 b	0.0 b	-
	TC 2207	1.4	15.0 b	70.0 a	90.0 a	25.9 a
C. maculatus	'CN 60'	7.1	50.0 a	60.0 ab	100.0 a	26.7 a
	'KPS 1'	7.3	30.0 abc	78.1 a	100.0 a	27.4 ab
	'KPS 2'	7.3	35.0 ab	75.7 a	100.0 a	27.3 ab
	TC 1965	1.0	19.0 bc	39.5 b	85.0 a	31.6 b
	TC 1966	1.7	9.0 c	0.0 c	0.0 b	-
	TC 2207	1.4	15.5 bc	45.2 b	70.0 a	28.8 ab

Average of two replicates, 10 seeds infested with two pairs of freshly emerged bruchid adults per replicate.

* : Mean separation within columns for each bruchid was performed using the least significant difference at 99% level.

Breeding procedure

'CN 60' could be easily crossed with TC 1966 and no abnormality was recognized in the F_1 and subsequent generations. Resistant seeds with a green seed coat were selected in the segregating generation (Fig. 2). Although bruchids laid many eggs on the surface of the resistant seeds, larvae that hatched did not reach the adult stage. Seed weight (100 seed weight) of TC 1966 was 1.7 g and that of 'CN 60' was 7.1 g. Hence, 100 seed weight was about 3.5 g in the F_2 generation. The seed weight increased gradually by the recurrent backcrossing and attained the minimum standard for recommended cultivars (5.5 g/100 seeds) in the BC_3F_1 generation (ca. 6.6 g/100 seeds).

Agronomic characters of the resistant BC_3F_2 population

Seed weight (100 seed weight) of the resistant BC_3F_2 population was significantly lower (ca. 6.3 g) than that of 'CN 60' (ca. 7.1 g) and 'KPS 1' (ca. 7.3 g), but was large enough to satisfy the standard (5.5 g) requested by the

Thai Government. Since the resistant BC_3F_2 population exhibited a larger number of pods per plant (ca. 23) than the check cultivars (ca. 17-18), seed yield per plant (ca. 13 g) was comparable to that of 'CN 60' (ca. 10 g) and 'KPS 1' (ca. 14 g). Stems of the plants from the resistant BC_3F_2 population were shorter in length (ca. 45 cm) than those of 'KPS 1' (ca. 68 cm) and comparable to those of 'CN 60' (ca. 51 cm). Average number of days to 50 % flowering in the resistant BC_3F_2 population was 30 days, as in the case of 'CN 60', and 5 days earlier than in 'KPS 1'. All the three entries matured (with color change in 80 % of the pods) 30 days after the occurrence 50 % flowering.

Discussion

It was revealed that the resistance of TC 1966 was also effective against the *C. chinensis* and *C. maculatus* species distributed in Thailand (Table 1). Genetic analysis indicated that the resistance was controlled by a single dominant gene. It was suggested that a water-soluble, high molecular weight, and heat-and protease-stable substance was responsible for the resistance of TC 1966. The substance responsible for the bruchid resistance should be further investigated in terms of toxicity to animals and human beings.

Since no reproductive barriers were recognized between 'CN 60' and TC 1966, it was possible to produce hybrids and to improve the agronomic characters of the hybrids by recurrent backcrossing (Fig. 1). Based on the field experiment, it was concluded that the agronomic characters of the resistant BC_3F_2 population reached the levels of the recommended cultivars. In the resistant BC_3F_2 population, the plant was short with many pods and early maturity habit. The agronomic characters of the breeding line should be examined also in other seasons and locations in Thailand.

V. radiata var. *sublobata*, which is distributed over a very wide area stretching from East Africa through Asia to North Australia, shows a wide genetic variation. Moreover, no genetic barriers were recognized between *V. radiata* and *V. radiata* var. *sublobata*. Thus, *V. radiata* var. *sublobata* can be considered as a very useful genetic source for mungbean breeding. However, few accessions of *V. radiata* var. *sublobata* are currently collected and preserved in the world's genebanks. Therefore, it is important to collect and preserve a larger number of different accessions of *V. radiata* var. *sublobata* occurring in wide geographical regions.

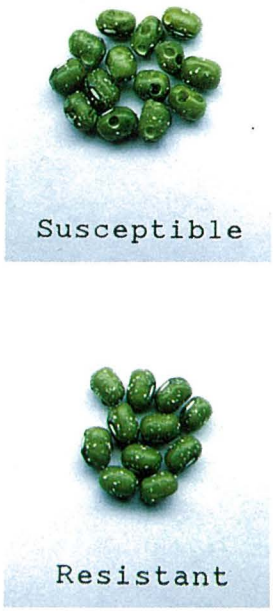

Fig. 2.
Resistant and susceptible seeds in the segregating generation (BC_2F_1) of 'CN 60' × TC 1966.

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In Vitro Conservation of Pineapple Genetic Resources

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Research Period : 1985-90
Research Site : Tropical Agriculture Research Center, Okinawa Branch

Genetic resources of pineapple are generally conserved in fields by planting of crowns, suckers and slips which are obtained from original plants usually one or two years after the planting. In this way, one can easily detect genetic variations of the resources by naked eye observation. However, this practice requires field space and manpower. In addition, valuable genetic resources may be lost when natural disasters such as typhoons or severe drought occur, which limits the number of genetic resources of pineapple that can be preserved in the field.

In this study, we attempted to develop techniques for long term *in vitro* conservation by adopting the improved method of meristem culture applied to higher plants.

Key words : pineapple, germplasm, long term conservation

Materials and methods

Materials : We used four kinds of pineapple clones, as follows : Hawaii (Cayenne Group), Yellow Mauritius (Queen Group), *Abacaxi branco* (Amarero Group), *Ananas ananasoides* (wild species).

We used axillary buds derived from young crowns as explants in this experiment, instead of axillary buds derived from suckers in our previous experiments.

Sterilization : We separated axillary buds from crowns with a sharp knife and sterilized them through the following procedures. After washing in tap water, we rinsed them with 70 % ethanol for 5 seconds, and stirred them in 2 % chloride antiformin for 5 minutes (for 20 minutes in the previous experiments) on a magnetic stirrer. Finally we rinsed them three times in sterilized water.

Media ; We used two kinds of agar media and various kinds of liquid media as follows ;

MS Ⅰ ;	3 % sucrose, 1 % agar,	pH 5. 8.
MS Ⅱ ;	1. 5 % glucose, 1 % agar,	pH 5. 8.
MS Ⅲ ;	3,5,7, % sucrose,	pH 5. 8
MS Ⅳ ;	3 % sucrose, 2, 4-D and NAA,	pH 5. 8.

Media Ⅲ and Ⅳ were used for the roller tube culture.

Culture ; We used a sufficient amount of medium in each

Culture ; We used a sufficient amount of medium in each test tube. Tubes for the liquid roller tube culture were larger than those for the agar culture. Then we inoculated the buds on the agar media or in liquid media and cultured them at the temperature of 26°C under room light illumination for growth of buds.

Culture for long term conservation ; After a few leaves developed and a small plant emerged from the bud, we transferred the plants in tubes at lower temperatures ranging from 16°C to 20°C for long term conservation.

Results and Discussion

In the bud culture of pineapple, it is difficult for the buds to maintain a high viability due to the high frequency of fungal and bacterial infection in the culture.

In this experiment, we were able to reduce the frequency of fungal and bacterial infection compared to our previous experiments (Table 1). Among the four varieties used in this experiment, the ratio of infected buds to all inoculated buds was the highest in Yellow Mauritius (47 %) and the lowest in Hawaii (18 %).

Furthermore we improved the germination rate of the buds compared with the previous experiments (Table 1). The ratio of germinated buds to all uninfected buds was the highest in Yellow Mauritius (100 %) and the lowest in *A. ananasoides* (36 %).

Table 1.
Rate of contamination and germination in the current experiment and in previous experiments.

	Hawaii		Y. Mauritius		A. branco		A. ananasoides		Mean	
	R. I.[1]	R. G.[2]	R. I.	R. G.	R. I.	R. G.	R. I.	R. G.	R. I.	R. G.
Current Experiment	18 %	50 %	47 %	100 %	24 %	58 %	34 %	25 %	31 %	58 %
Previous Exp. 1.[3]	82									
2.	11	22	22	58	44	0	66	0	36	20

1) R. I. ; Ratio of buds with fungal and bacterial infection to all inoculated buds in the experiment.
2) R. G. ; Ratio of germinated buds to uninfected buds.
3) Both in Exp. 1 (1988) and Exp. 2 (1989) the axillary buds were derived from suckers. Then they were rinsed in 70 % ethanol and were stirred for 20 minutes in 2 % chloride antiformin.

Also the germination rate of the buds varied depending on the media ; it was higher in the case of roller tube culture (average 79 %) than in the case of agar culture (average 58 %). The germination rate of the buds was higher in the medium containing 1. 5 % glucose (average 63 %) than in the medium with 3 % sucrose (average 53 %) (Table 2).

In the first step of the culture, small plants emerging from the buds grew fast, particularly in the liquid media.

However, the plants in the liquid media for the roller tube culture grew too fast to remain fresh for a long period of time in test tubes or flasks. There were no significant differences in the growth rate among the agar media. For long term conservation the agar culture was more suitable than the roller tube culture because subcultures were not necessary.

Table 2.
Growth of four varieties in various media (50 days after inoculation).

Medium[1]	Hawaii		Y. Mauritius		A. branco		A. ananasoides		Mean	
	R. G.[2]	N. L.[3]	R. G.	N. L.	R. G.	N. L.	R. G.	N. L.	R. G.	N. L.
MS Agar Medium Ⅰ	50%	3.0	100%	6.7	66%	1.8	0%	—	53%	3.3
MS Agar Medium Ⅱ	50	4.0	100	4.8	50	1.3	50	4.0	63	3.5
MS Liquid Media Ⅲ	80	4.7	100	10.5	75	4.7	66	4.5	79	6.1
Mean	62	4.1	100	6.5	63	2.5	36	4.3	64	4.4

1) Medium ; The medium is described in Materials and Methods (Media ;).
2) R. G. ; Ratio of germinated buds to uninfected buds.
3) N. L. ; Number of leaves. Average number of leaves on a small plant.

We often observed abnormalities or callus-like tissues in several plants when we cultured the buds in media containing auxin (2, 4-D and NAA).

In the second step of culture, after we transferred the plants in tubes at a lower temperature, the growth rate decreased rapidly. In addition, we observed that small plants were well preserved and appeared normal and healthy even under lower temperature conditions (Fig. 1, 2).

On the basis of the results obtained, we consider that the procedures listed below are required for long term conservation of pineapple genetic resources.

1) Obtaining axillary buds from young crowns.

2) Rinsing the buds in 70% ethanol for 5 seconds and stirring them for 5 minutes in 2% chloride antiformin. Finally washing them three times in sterilized water.

3) Inoculating the buds on the MS agar media with an adequate concentration of glucose (1.5%) at the temperature of 26° C for growth in the first step.

4) Transferring the plants in tubes to an environment at lower temperature after small plants appear from the buds, for long term conservation.

Genetic resources can be adequately preserved through these procedures for more than four years without any subculture, if a large quantity of medium is put in each tube or flask.

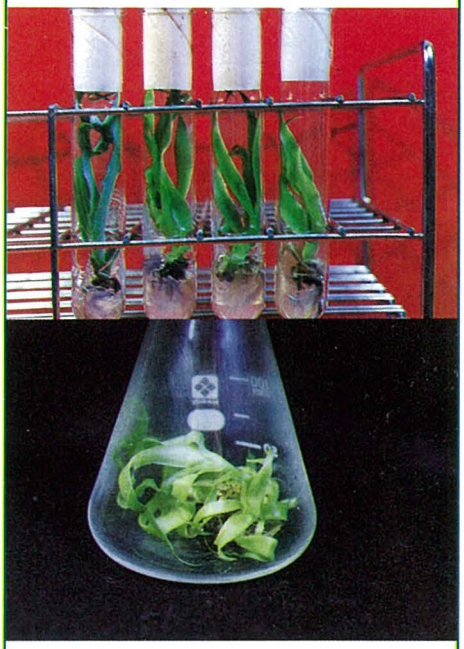

Fig. 1.
Genetic resources of pineapple preserved in test tubes (upper) and flasks (lower).

Research Period : 1988-90
Research Site : Malaysian Agricultural Research and Development Institute (MARDI), Alor Seter, Malaysia

Rice Planthoppers and Their Natural Enemies in the Paddy Fields of the Muda Area, West Malaysia

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The Muda irrigation scheme is the largest rice granary of Malaysia. It comprises 96, 000 ha of paddy fields and accounts for about 50 % of the national rice production. Double cropping was initiated in 1970 and direct-seeding culture has been widely adopted by the Muda farmers. After the initiation of double cropping, the insect pest composition of rice paddies changed with the changes in the agronomic and cultural practices. The occurrence of the rice planthoppers, both the brown planthopper *Nilaparvata lugens* and the white-backed planthopper *Sogatella furcifera*, has increased and they have become a new threat to rice production. The objective of this study was to analyze the mechanism of population growth of the planthoppers and to determine the factors which regulate the planthopper populations.

Key words : *Nilaparvata lugens*, *Sogatella furcifera*, natural enemies, rice, Malaysia

Materials and Methods

Periodical population surveys of the planthoppers and their predators were conducted in direct-seeded paddy fields during four crop seasons. A suction machine with a portable petroleum engine was used for the surveys. Arthropods collected were kept in 70 % ethanol and identified under a binocular microscope. The planthoppers collected were checked for parasitism. For checking egg parasitoids, the rice plants in which planthoppers had previously laid eggs were placed in a paddy field and were exposed to the attack of parasitoids. Four days later, the eggs in the rice plants were taken out in a petri dish for observation of parasitism. The generations of the planthopper were tentatively identified on the basis of heat accumulation of one generation of the respective planthoppers.

Results and Discussion

The population growth pattern of both the brown planthopper and the white-backed planthopper in Muda was generally characterized by 1) a low immigrant density at

the early stage of rice growth, 2) the presence of two larval generations and optional third generation after the invasion of immigrants, 3) high population growth rates up to the 2nd generation and 4) low population growth rates from the 2nd to the 3rd generations (Table 1). Since the population suppression in the later generation was usually very strong, no hopperburn occurred in ordinary paddies. In most cases serious outbreaks of the planthopper were observed in the paddies where biotic communities were considerably disturbed, for example, by the application of insecticides at the early stage of rice growth.

Table 1.
Average pattern of population growth of rice planthoppers in the Muda area.

Species	Maximum density of immigrants/m^2	Mean density of 3-5 instar larvae/m^2			Population growth rate*		
		1st	2nd	3rd generation	r_1	r_2	r_3
White-backed planthopper	3.7	32	288	129	22.6	12.3	0.4
Brown planthopper	17.9	40	187	67	21.1	10.9	0.4

* r_1, r_2, r_3 ; population growth rate from immigrants to the first generation, from the 1st to the 2nd and from the 2nd to the 3rd generations, respectively, based on the numbers of adults for r_1 and on the 3rd to 5th instar larvae for r_2 and r_3.

The presence of a great diversity was another important characteristic of the planthopper population growth in Muda. For example, the population growth rates of the brown planthopper from immigrants to the first generation and from the 1st to the 2nd generations ranged from 0.6 to 42 and from 0.3 to 18, respectively. These values indicated that the population peak of the planthoppers occurred some time at the time of immigration or in the 1st generation, instead of the 2nd generation, which was the most common in Muda.

The interaction between planthoppers and their natural enemies seemed to be the major factor controlling the population growth pattern. The amount of immigrants at the early stage of rice growth was the most important factor that influenced the subsequent population size in temperate paddy fields. In the tropical paddies of the Muda area however, there was almost no relation between the amount of immigrants and the peak density. Since the population growth rates tended to be low in the fields where the relative density of natural enemies to the planthoppers was high, it is considered that the natural enemies played an important role in the regulation of the planthopper population.

Fig. 1.
Egg parasitoid, *Oligosita* (top), parasitized eggs (middle) and normal eggs (bottom) of the brown planthopper.

Egg parasitoids seemed to be the most important natural enemies among the parasitoids of the planthoppers. The predominant egg parasitoids consisted of two genera of tiny wasps, *Anagrus* and *Oligosita* (Fig. 1). The percentage of planthopper eggs parasitized by either genera ranged from 10-70 % depending on the fields and periods. In general, parasitism by these wasps increased with the progression of rice growth, and reached usually a value of more than 50 % in the later stage. (Fig. 2). Parasitism by drinid wasps and twisted-winged parasitoids, elenchids which attack nymphs and adults of the planthoppers was also common in the Muda area. The net proportion of planthoppers parasitized by these nymphal parasitoids, however, was usually less than 20 %. These nymphal parasitoids were less effective for the control of the planthopper population.

Spiders and the small water bug, *Microvelia* (Fig. 3) were the predominant polyphagous predators in the paddies. The density of these predators increased with the progression of the rice stages and reached a maximum value after the flowering of rice (usually a few or sometimes several hundred/m^2, respectively). It is difficult to evaluate the role of polyphagous predators as natural enemies of the planthoppers because we do not know how many planthoppers were killed by the predators. We de-

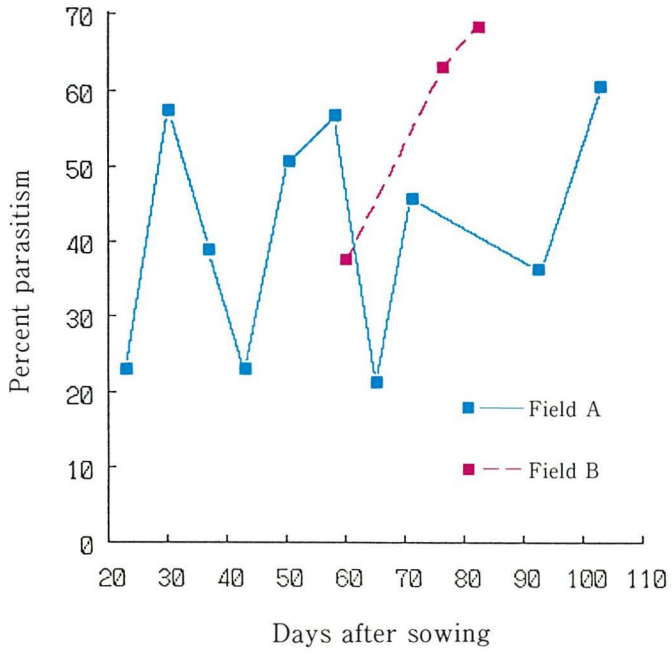

Fig. 2.
Example of changes in the parasitism of the eggs of the brown planthopper (1989, 2nd crop).

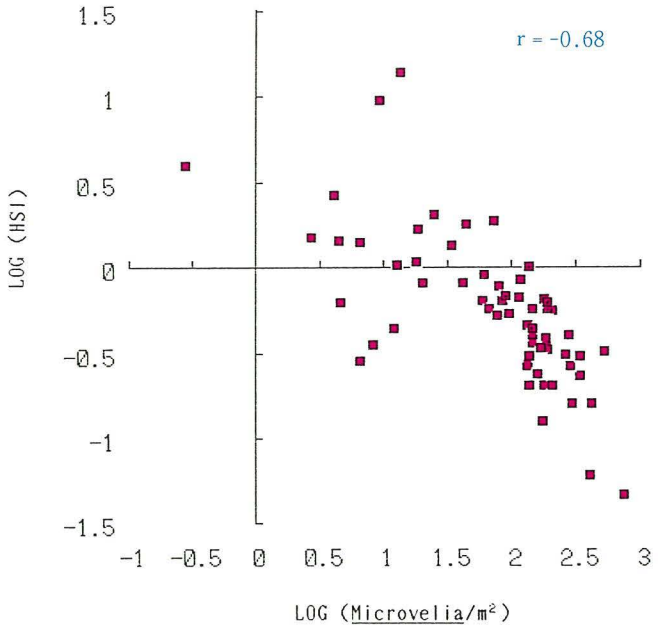

Fig. 3.
Relationship between the density of *Microvelia* and the hopper survival index (HSI).
HSI = total number of 4th and 5th instar larvae / total number of 1st, 2nd and 3rd instar larvae in the previous survey.

veloped an index (HSI) to estimate the survivorship of small nymphs of planthoppers, using age-specific planthopper population data obtained periodically in various fields. The results revealed clearly that the survivorship of the small planthoppers decreased when the density of spiders or *Microvelia* increased (Fig. 4). These results suggest that spiders and *Microvelia* contributed to the suppression of the planthopper population.

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Fig. 4.
Adult of *Microvelia*.

Research Period : 1988-90
Research Site : Xinjiang Institute of Biology and Desert Research, Peoples' Republic of China

Role of Windbreaks in the Alleviation of the Effect of Adverse Climatic Conditions and Prevention of Wind Erosion

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Meteorological observations relating to the alleviation of the effect of adverse climatic conditions in arid land were carried out at the Turfan Desert Research Station, Xinjiang Institute of Biology, Pedology and Desert Research, Chinese Academy of Sciences located in the northwestern part of China from 1990 to 1991.

It was demonstrated that the use of windbreaks alleviated the adverse effects of wind speed and air temperature, improved the surface soil temperature and relative humidity, and prevented wind erosion.

Dry lands account for one third of the total surface area of the world. The process of desertification has been accelerated recently by excessive cultivation, deforestation, and over-grazing. In the marginal agricultural areas of the dry lands, land erosion and sand accumulation due to dry wind are being promoted by the scarcity of water, and agrometeorological disasters are likely to occur frequently. We demonstrated that under very dry conditions, wind erosion could be prevented and adverse meteorological conditions could be alleviated by the use of a tamarisk windbreak forest in July, 1990, and by the construction of windbreak nets in October, 1990.

Key words : windbreak forest and net, arid land, climatic improvement, wind erosion

Materials and Methods

The meteorological parameters were measured by using several instruments on the windward and leeward sides of a windbreak forest and two windbreak nets*.

The windbreak forest consisted of tamarisk trees (*Tamarix* L.) with a mean height of 4.6 m, width of 11 m and length of 1 km. The density** of the windbreak forest was 85 % (50 % in the upper layer and 100 % in the middle and lower layers).

The windbreak nets were made of two kinds of polyethylene Russell nets with a height of 1.85 m and lenght of 30 m. The original net densities set a 30 % for the A net and 40 % for the B net, were (A) 50 % and (B)

45 % during the observation period, due to the deposition of plant seeds and soil particles. The meteorological parameters measured included the wind speed, wind direction, air temperature, surface soil temperature and relative humidity. In addition, the accumulation of sand was monitored. Observation points on the windward side were located at-20, -10, -7, -5, -2, -1, -0 H and on the leeward side at 0, 1, 2, 5, 7, 10, 15, 20, 25, 30 H for both windbreaks, and also in the center of the windbreak forest. The numerical of H indicates the distance that is represented by the multiple of the height (H) of the windbreak forest or net, the negative sign corresponds to the windward side and positive to the leeward side.

The observation periods ranged from July 1 to 2 for the windbreak forest and October 10 to 13, 1990 for the windbreak net.

* Details on the instruments used are included in the references (1) and (2).

** Density = 100 % - porosity.

Results and Discussion

(1) As shown in Fig. 1 A (6:00 July 2), the relative wind speed decreased from-10 H and returned to the original value at 30 H. The values (percentage)* ranged from 10 to 20 % from the center of the windbreak forest to 5 H and the wind speed increased gradually after 5 H. The wind from 0 to 5 H blew in the opposite direction and made eddies. Surface soil and air temperatures decreased in the range from -1 to -2 H by radiation cooling and increased significantly at 0 H by sunshine. Relative humidity increased from -2 to 25 H, particularly at 0 to 2 H due to the evapo-transpiration from tree leaves, reflecting the beneficial effect of the windbreak on the alleviation of adverse climatic conditions in arid land.

(2) As shown in Fig. 1 B (12:00 July 2), the wind speed decreased from -10 to 15 H, but the decreasing area was smaller than that at 6:00 because the wind direction formed on acute angle with the windbreak although the values of minimum wind speed (10 to 20 %) did not change. The surface soil temperature which was very high and ranged from 70° to 80°C in and around the windbreak forest, decreased to 20° to 25°C, indicating the effect of the windbreak on the alleviation of adverse climatic conditions.

This beneficial effect was also observed in the case of the relative humidity which increased considerably in the center of the windbreak and slightly near the leeward side. The increase of the air temperature by 2 to 3°C from -2 to

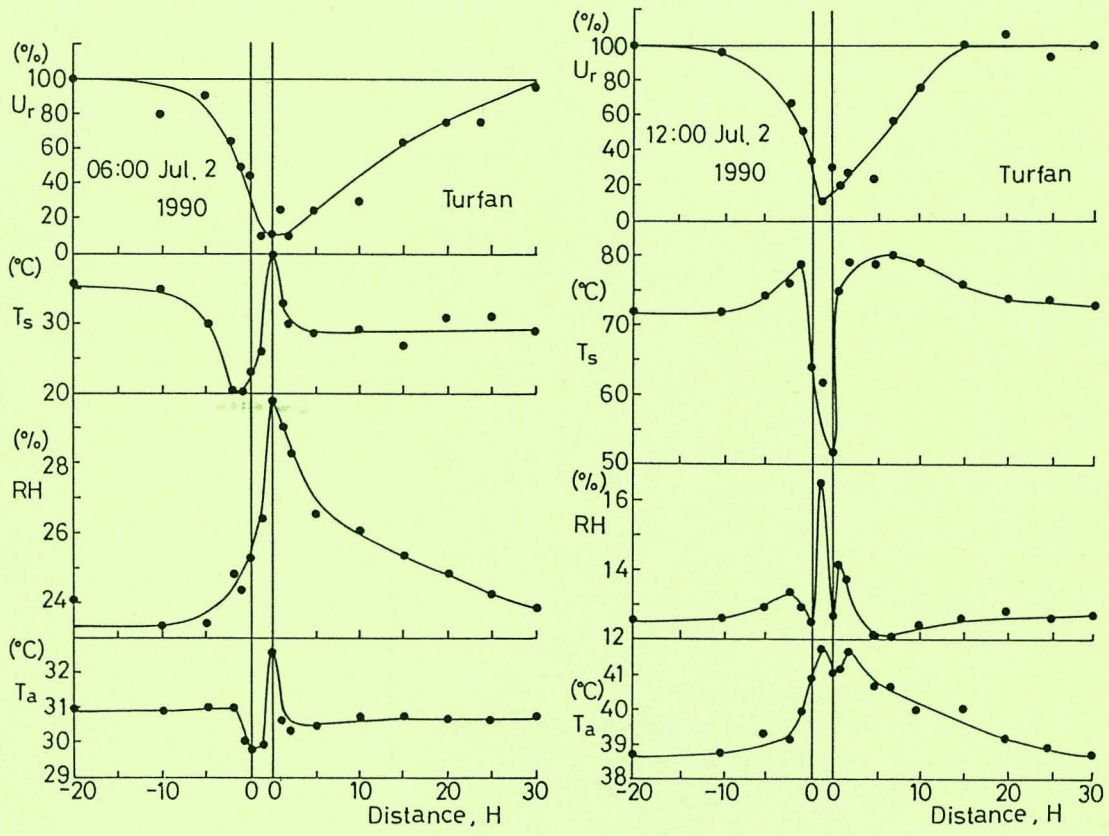

Fig. 1.
Changes in the meteorological parameters in the day time and at night associated with a tamarisk windbreak forest under dry and high temperature conditions in Turfan (Northwest China, (A) 6:00 July 2, and (B), 12:00 July 2, 1990).

U_r : Relative wind speed, T_s : Surface soil temperature, RH : Relative humidity, T_a : Air temperature.

20 H and the decrease of the relative humidity from 5 to 15 H were not beneficial for crop cultivation in arid land in summer.

(3) The remarkable decrease of the wind speed associated with the wide effective area of the windbreak forest (30 H at 6:00) was due to the fact that the direction of the wind formed a 90° angle with the windbreak forest. On the other hand the effective area was not wide (15 H at 12:00) when the direction of the wind formed a 45° angle with the windbreak forest.

Although the air temperature increased inside the windbreak forest on the leeward side in the daytime, at night it decreased on both the windward and leeward sides, and increased in the early morning on the windward side by sunshine.

The relative humidity was high inside and near the windbreak forest due to the evapo-transpiration from tree leaves of the windbreak forest.

The changes in the surface soil temperature were similar to those of the air temperature. However the tempera-

ture inside the windbreak forest was 25°C lower compared with the temperature outside the forest due to the shadow of the trees.

Wind erosion was negligible for values ranging from -5 H on the windward side to 10 H on the leeward side, and sand accumulation was present at values from -5 to 5 H, in particular on the windward and leeward sides from -2 to 2 H.

It is necessary to plant a windbreak forest that is resistant to strong wind, as well as dry, high-low temperature and salinity conditions in the dry land of Northwest China. As the use of tamarisk trees can alleviate the adverse effect of the meteorological conditions and prevent wind erosion, due to their resistance to adverse conditions, such trees are suitable for a windbreak forest.

(4) As shown in Fig. 2 (10:30 October 13), the wind speed decreased from -10 to 15 H and the minimum value was 20 % for the A net and 40 % for the B net. The surface soil temperature and air temperature increased, but the relative humidity decreased from 5 to 10 H due to the effect of the net. The surface temperature near the leeward side decreased due to the shadow of the nets.

(5) Minimum relative wind speed decreased to 25 % and 35 % by nets at densities of 50 % and 45 %, respectively.

The air temperature increased in the range from -5 to 10 H, the relative humidity decreased in the range from 5 to

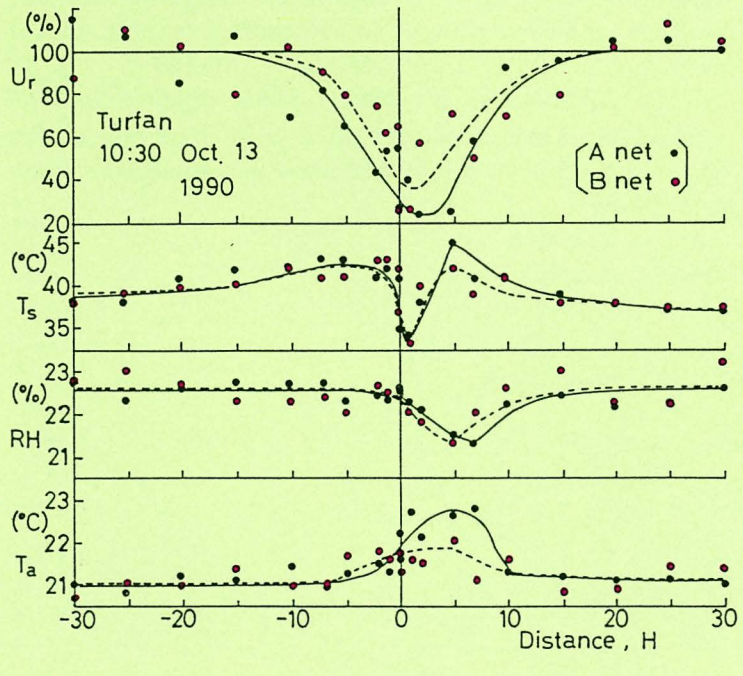

Fig. 2.
Changes in the meteorological parameters in the day time and at night associated with windbreak nets under dry and high temperature conditions in Turfan (Northwest China, 10:30, Oct. 13, 1990).
U_r : Relative wind speed, T_s : Surface soil temperature, RH : Relative humidity, T_a : Air temperature.

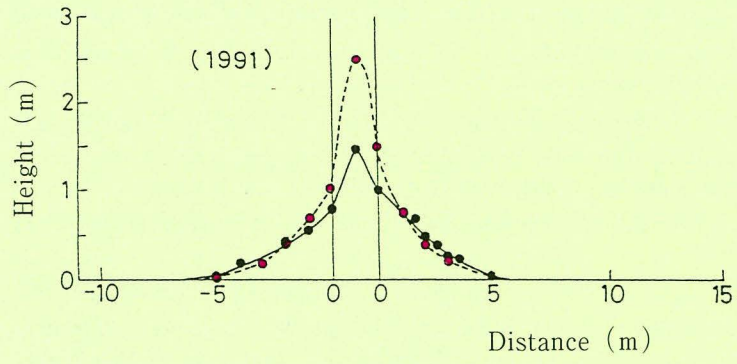

Fig. 3.
Changes in the amount of sand accumulated due to the presence of a tamarisk windbreak forest
● ; high accumulation area,
● ; medium accumulation area.

Photo. 1.
Tamarisk windbreak forest (upper) and windbreak net (lower).

7 H. The surface soil temperature decreased in the range from 1 to 2 H due to the shadow of the nets and increased near 5 H by sunshine for both windbreak nets.

(6) As shown in Fig. 3, the accumulation of sand was high in the center of the windbreak forest (1.5 m and 2.5 m for the medium and high accumulation areas, respectively). The accumulation area increased from -5 to 5 H, due to the prevailing NW wind. Sand accumulated near the windward and leeward sides due to the decrease of the wind speed in these areas.

* The relative wind speed is expressed in percentage by taking U_r at 1.5 m height at -20 H as 100 %.

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Growth of Trees Planted in Degraded Forest Land

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1) Forestry and Forest Products Research Institute, 2) College of Forestry, University of the Philippines

Research Period : 1990
Research Site : College of Forestry, University of the Philippines, the Philippines

There are many areas of degraded land caused by shifting cultivation and overgrazing in the tropics. One of the methods to improve the land productivity in such lands is the implementation of re/afforestation. Since tree growth is an important index of land productivity, we analysed the tree growth in a man-made forest composed of long rotation tree species in the experimental forest of the University of the Philippines as well as the growth of fast-growing tree species planted in a markedly degraded area, in Carranglan, central Luzon island, the Philippines. This research was implemented under the Tropical Agriculture Research Program of TARC.

Key words : rehabilitation, degraded land, afforestation, the Philippines

Growth of long rotation tree species in relatively good stand

Before the University of the Philippines at Los Banos (UPLB) was established in 1908, the foot of Mt. Maquiling (1090 m above sea level) was widely cultivated by shifting cultivators and the vegetation of the abandoned area was replaced with cogon grass (*Imperata cylindrica*). There are various levels of land exploitation for agriculture/agroforestry at the foot of the mountain including sloping land. The Maquiling Botanical Garden (MBG) and the experimental forest are located behind the University. Afforestation around the area started after this period. The outline of four man-made forests in the MBG and experimental forest is shown in Table 1. Two mahogany (*Swietenia macrophylla*) stands formed almost pure forests. The ratio of the stem volume of the dominant trees to the whole volume ranged from 80 to 85%. In the mixed forest of bagtikan (*Parashorea malaanonan*) and palosapis (*Anisoptera thurifera*), the value of the ratio was 70%. Though the value of the ratio was lower than that of the mahogany stands, since the size of the lower layer trees was relatively larger, the total stem volume was almost the same as that of the mahogany stand. Based on the records of UPLB, the age of these forests is estimated at approximately 80 years old. Assuming that the age is 70 years old, the average yearly increment of the stem volume is likely to range from 11.5 to 13 $m^3 ha^{-1}$. Since the volume of the standing crop

Table 1. General description of man-made forest in and around MBG.

Stand	Average		Per hectare			
	DDH (cm)	Height (m)	No.	B. A. (sq. m)	Volume (cu. m)	Total stem volume(cu. m)
Swietenia	43.4	29.1	281	44.6	636[1)]	795[2)]
macrophylla I	18.5	16.8	521	16.1	158[1)]	
Swietenia	52.3	31.7	224	52.0	764	897
macrophylla II	18.2	17.1	181	5.7	56	
Parashorea	44.8	30.1	188	31.0	444	800
malaanonan	23.3	18.9	200	9.2	94	
Anisoptera	46.8	30.4	50	9.1	131	
thurifera	20.0	17.3	131	4.9	50	
Parashorea	42.9	28.7	81	13.9	200	440
malaanonan	18.5	15.9	30	1.1	11	
Dipterocarpus	26.9	23.8	200	12.2	153	
grandiflorus	13.4	14.2	390	6.6	58	

1) Upper rows indicate dominant trees and lower rows indicate suppressed trees.
2) Stem volume was estimated based on Akita-sugi stem volume table.

of sugi (*Cryptomeria japonica*), one of the important silvicultural tree species showing adequate growth in Japan is 879 $m^3 ha^{-1}$ (1st grade stand in the prediction table of Kanto-Abukuma district) and the average stem volume increment is 12. 6 $m^3 ha^{-1}$, it is assumed that the value recorded in the man-made forests around UPLB is almost equivalent to that of a fine sugi stand.

In the mixed forests of bagtikan and apitong (*Dipterocarpus grandiflorus*), younger and small apitong trees are planted among sparse large bagtikan trees. As the apitong trees are small, the total stem volume is small. Assuming that the age of the bagtikan trees is 70 and that of the apitong trees 30 years old, respectively, the annual increment of the stem volume would be about 10 $m^3 ha^{-1}$, a value smaller than that recorded in the other stands. However a large amount of trees has already been harvested, in particular, in the bagtikan and apitong mixed stand, a large amount of bagtikan trees has been harvested to plant apitong trees. Therefore, it is assumed that these forests display a high productivity and are good timber plantations. These observations suggest that good tree plantations can be established in cogon grasslands covering degraded land.

Growth of trees planted in degraded forest land

Afforestation attempts in Carranglan were initiated in 1977 under a joint project between Japan and the Philippines sponsored by the Japan International Cooperation Agency (JICA). Many seedlings died and repeated die back occurred year by year due to drought and soil compaction. Various attempts to improve the physical soil properties enabled *Acacia auriculiformis* and *Gmelina arborea* (yemane) trees to become adapted to the environment. The values of various parameters recorded during our survey are shown in Table 2.

Growth of *Acacia* trees in the stand established in 1980 was satisfactory and the canopy has already closed. The average annual increment of volume is about 10 m^3 which is by no means inferior to the values recorded in forests in Japan. The growth of young *Acacia* trees in the stand established in 1984, on the other hand, was not satisfactory. Since the site conditions of both stands were very similar, it is suggested that the productivity in the former *Acacia* stand may have been improved by the growth of the legume

Fig. 1.
Palosapis planted under *A. auriculiformis*.

Table 2. General description of stands surveyed in Carranglan.

Stand	Planting (year)	Average DDH (cm)	Average Height (m)	Per hectare No.	Per hectare B. A. (sq. m)	Per hectare Volume (cu. m)	Per hectare Total stem volume(cu. m)
Acacia 1	1984	5.6	5.8	1,507	4.0	16.0	17.2
		4.1	4.3	289	0.4	1.2	
Acacia 2	1980	10.3	12.1	1,235	10.7	73.7	86.4
		5.9	8.5	795	2.4	12.6	
Teak	1977	7.2	6.4	1,938	8.4	34.7	38.4
		6.3	5.8	250	0.9	3.6	
Yemane	1984	7.3	5.9	1,555	6.8	25.4	26.8
		5.7	5.2	151	0.4	1.4	
Kesiya	1977	12.2	6.3	1,590	19.7	70.3	70.9
pine		10.9	6.1	48	0.5	1.6	
Pine	1977	12.4	6.8	258	3.2	12.1	101.7
and		9.6	5.8	1,220	3.6	35.0	
Yemane, etc.		16.1	10.6	390	8.7	52.4	
mixed stand		6.8	7.4	130	0.5	2.2	

Legend : See Table 1.

tree species.

Teak (*Tectona grandis*), an important tree species for agroforestry, exhibited repeated dieback year by year, so that, it was considered not to be suitable for the area. However, since the stem biomass amounts to 38 m^3 presently and this species is tolerant to fire, it is anticipated that the growth conditions will be favorable in future.

Kesiya pine (*Pinus kesiya*), planted in 1977 did not grow adequately. The growth of yemane and other hard wood species mixed in the pine plantation was far better compared with that of trees in pure yemane stands, presumably due to the rapid closure of pine crowns or species mixture. It is thus suggested that agroforestry activities may exert a favorable effect on afforestation in degraded land.

Growth of planted trees under Acacia *as a nurse tree*

It is generally considered that once a tropical forest is destroyed, the restoration of the forest is very difficult. Since the rehabilitation of indigenous vegetation is important, the growth of two dipterocarp species, palosapis (*Anisoptera thurifera*) and guijo (*Shorea guiso*), planted under *Acacia* trees in 1984, was analysed (Table 3).

The average annual height increment of those dipterocarps ranged from 30 to 40 cm. Although they were planted in the shade and in a markedly degraded site, growth steadily improved year by year and the height of some trees exceeded 4 m. If such a growth can be maintained, it is anticipated that an artificially regenerated dipterocarp forest could be established in Carranglan. To achieve this objective, it is essential to develop silvicultural techniques including thinning level for light control, determination of optimum time to remove the nurse trees, promotion of species diversity, density control, etc.

Table 3.
Growth of Dipterocarpaceae tree species planted under other trees.

Stand[1]	Planted trees	Height (cm)	Diameter[2] (cm)	Number of trees examined
Acacia 3	Palosapis	197(408)[3]	2.1(4.0)[3]	58
	Guijo	139(215)	1.4(2.2)	29
Acacia 4	Palosapis	178(385)	1.8(4.6)	29
Acacia 5	Palosapis	181(296)	1.9(3.1)	24

1) Acacia 3 ~ Acacia 5 are located in the same stand.
2) Diameter at 30 cm above ground level.
3) The numbers in parenthesis indicate the largest heightsor diameters of trees.

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Establishment of Tropical Agriculture Research Slide Database System (TROSIS)

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Research Site : Tropical Agriculture Research Center

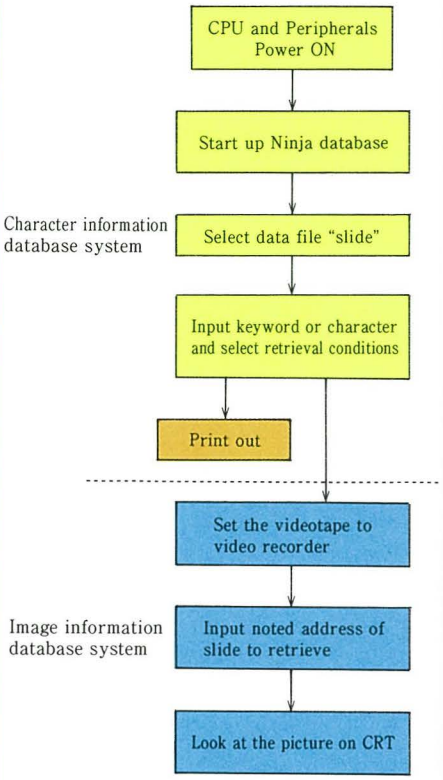

Fig. 1.
Flow chart of retrieval system.

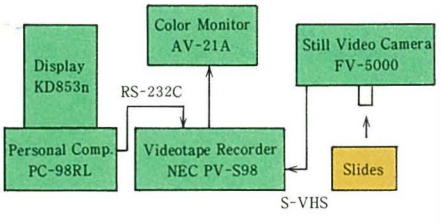

Fig. 2.
Combination of machines in slide database system.

Picture slides are a form of record of various research activities in which TARC scientists have been engaged, including laboratory work or field experiments, as well as surveys in various countries.

TARC aimed at constructing a slide library to meet the needs of its own staff and other users. The information available from it should be comprehensive covering all areas of tropical agriculture, helpful for situation analysis in program planning, for the preparation of public relation documents, as well as for meeting various needs for visual information.

The library was constructed so that users could retrieve needed slides readily following a simple procedure. TARC scientists contributed selected frames from their slide files. They were classified according to countries, regions, disciplines. Each frame was made retrievable electronically by keywords contained in a short verbal description of the scene.

The database was designated as TROSIS (Tropical Agriculture Slide Information System).

Key words : slide database, video system

Machines and Operating Environment

1. Hardware

The system was composed of the following hardware.

1) Personal computer : PC-9801 RL (Nippon Electric Co., Ltd.)
2) Digital videotape recorder : PV-S 98 (Nippon Electric Co., Ltd.)
3) Still-video camera system : FV-5000 (Fuji Photo-film Co., Ltd.)
4) Color monitor : AV-21 A (Japan Victor Co., Ltd.)

2. Software

1) DBMS : Ninja, a commercial database system produced by Something-Good Co., Ltd. in Japan, was used as the database management system for personal computer, PC-9801.
2) Video system controller : The program for video system control was developed by the author.

3. Operating System

Japanese MS-DOS system was used as the computer operating system.

Results and Discussion

1. The main system is composed of two sub-systems. The one(A), using a personal computer, is a text type database sub-system, which deals with the slide record number, photographer name, year, purpose of overseas duty, country name, place, keyword, outline of slide content and so on. Users are able to retrieve the slides easily from these items. Commercial software, Ninja was selected as the database management system, due to convenient handling like a manual-less system, capability of accommodating a flexible system configuration, and its versatility in the conversion of records to other database management systems.

The other sub-system(B) is a digitized image database system, that can locate particular slides recorded in a videotape with a videotape recorder and personal computer.

2. Operation

The retrieval procedure works as follows:

1) Turn on the computer and peripherals.
2) Drive MS-DOS system and start up the Ninja system.
3) Select the data file name, "slide".
4) Input the keyword or characters for retrieval and select retrieval conditions
5) Note the record address of videotape.
6) Set videotape to videotape recorder.
7) Start up the video control software.
8) Input noted address.
9) Turn the videotape and stop if the address corresponds to the set address.
10) You can see the slide with a color monitor.

Closer inspection of the slide is possible by using a projector. Slides are stored in air-conditioned cabinets.

About 900 slides can be recorded in a cassette of 60 min-videotape. About 2, 300 slides have been collected and systemized in this database.

3. Because of its simple operation and low cost, this slide database system is expected to be used widely for global applications.

Fig 3.
A view of the hardware.

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