REPORT ON THE RESEARCH WORKS

AT CITRUS AND VEGETABLE SEED RESEARCH CENTRE

UNDER BANGLADESH AGRICULTURAL RESEARCH INSTITUTE,

JOYDEBPUR, DACCA

August, 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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Report on the Citricultural Works

Jun. 28, 1978 to Jun. 27, 1981

SUBMITTED BY:

(YOSHIRO KODERA)
CITRUS EXPERT

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I N T R O D U C T I O N

Bangladesh stands between 20.5°N and 26.5°N latitude and has an average altitude of 150'ft. from the sea level. It is a reverine country having 87% of its area comprising of plain land and the remaining consisting of low hills at northeast and eastern region of the country stretching to the Bay of Bengal in the South. Although the topographical condition of the hilly regions of the eastern part of the country are more or less similar i.e. hillocks followed by compact blocks of plain land but there exist a sharp climatic difference between the northeast and the south eastern region. The climate in the northeast is towards sub-tropical characterized by heavy rainfall (more than 200") whereas that the South east is tropical.

In general the soil of Bangladesh is very fertile containing on the average 1% nitrogen, 1% P_2O_5, 1.03% K_2O, 1.16% calcium and 4.4% organic matter The annual monsoon replenishes its fertility through siltation.

The annual precipitation varies from 44.00 inches to 200.00 inches with an average of 81.75 inches. However this rainfall is predominantly concentrated during the months of May to October and no rainfall is encountered durin the months of November to April and a good crop yield become impossible without irrigation.

Bangladesh belongs to the humid tropical region. It has a very well defined winter season when temperature varies on the average 53°F to 80°F wherea the temperature normally varies from 75°F to 95°F during the summer season of the year.

There is no wide variation in day length during the whole year. The daily light period during November to March are shorter and it ranges from 10 ∿ 12 hours per day; whereas it is longest during the period of June to September which fluctuates from 14 hours to 12 hours.

It is evident from the fore going discussion that the soil and climate of Bangladesh is suitable for growing a good number of tropical and sub-tropical fruits including certain species of citrus fruits.

It is an established fact that warmer temperature (around 70°F) is most favourable for vegetative growth of all fruit plants including those of citru:

fruits. But plant responses to temperature in respect of flowering, fruit growth and ripening differ considerably from species to species. Some plants do not produce flowers and bear fruit unless they are subject to certain chilling temperature whereas others do not require vernalization. Citrus plants has also a certain range of temperature under which they grow well and bear fruits. The plant responses of different groups of citrus fruits vary considerably. Dr. Y. Nakagawa has analysed the temperatures of the major citrus growing countries of the world and found;

a) that satsuma mandarins can be grown in places where the accummulated yearly temperature varies from 2400° to 3000°C.

b) that Ponkan and Tankan mandarins grow well where heat units are more than 3400°C to 3500°C.

c) Sweet oranges particularly Washington Navel oranges grow well where heat units from April to September ranges 2500°C to 3000°C.

d) Fruits of lemon attain good quality where heat units very from 2100°C to 4500°C.

e) Grapefruits are produced in areas where heat units are more than 4200°C. The pummelo also follow the similar pattern.

It has been observed in the annual temperature of last five years that in 9 months (March to November), the accummulated temperature of Dacca, Ishurdi and Sylhet (Appendix - I) ranged from 4916°C to 4523°C. From these temperature record we can say that this amount of temperature is not suitable for mandarin and sweet oranges, but for lime lemon and pummelos, they are quite congenial.

However, if we plant some shade trees inside the citrus orchard and keep the accumulated temperature around 2000°C, it may be possible to grow mandarin and sweet oranges fruits in preferable way.

In view of this fact some plants were planted in our net house where 70% of the light intensity was cut as compared with the open field plantation; the photographes of those plants are presented in figure 1 and 2. From the initial observation it will be evident from the photographs that the plants growing under net house are much better than those growing under open field.

Before going into the details of our activities we want to mention some of the characteristics of citrus fruits, because people very often think that the fruits having sour taste belong to this group. Among the important characteristics that we may mention, (a) superior ovary, (b) pellucids dots in the leaves (c) aromatic oil in the leaves (d) leaves may be simple which may be winged occassionally compound (trifoliate orange), (e) fruits are hesperidium having 8-16 segment which contain juice vesicles and (f) the rind is divided into two parts albedo and flevedo.

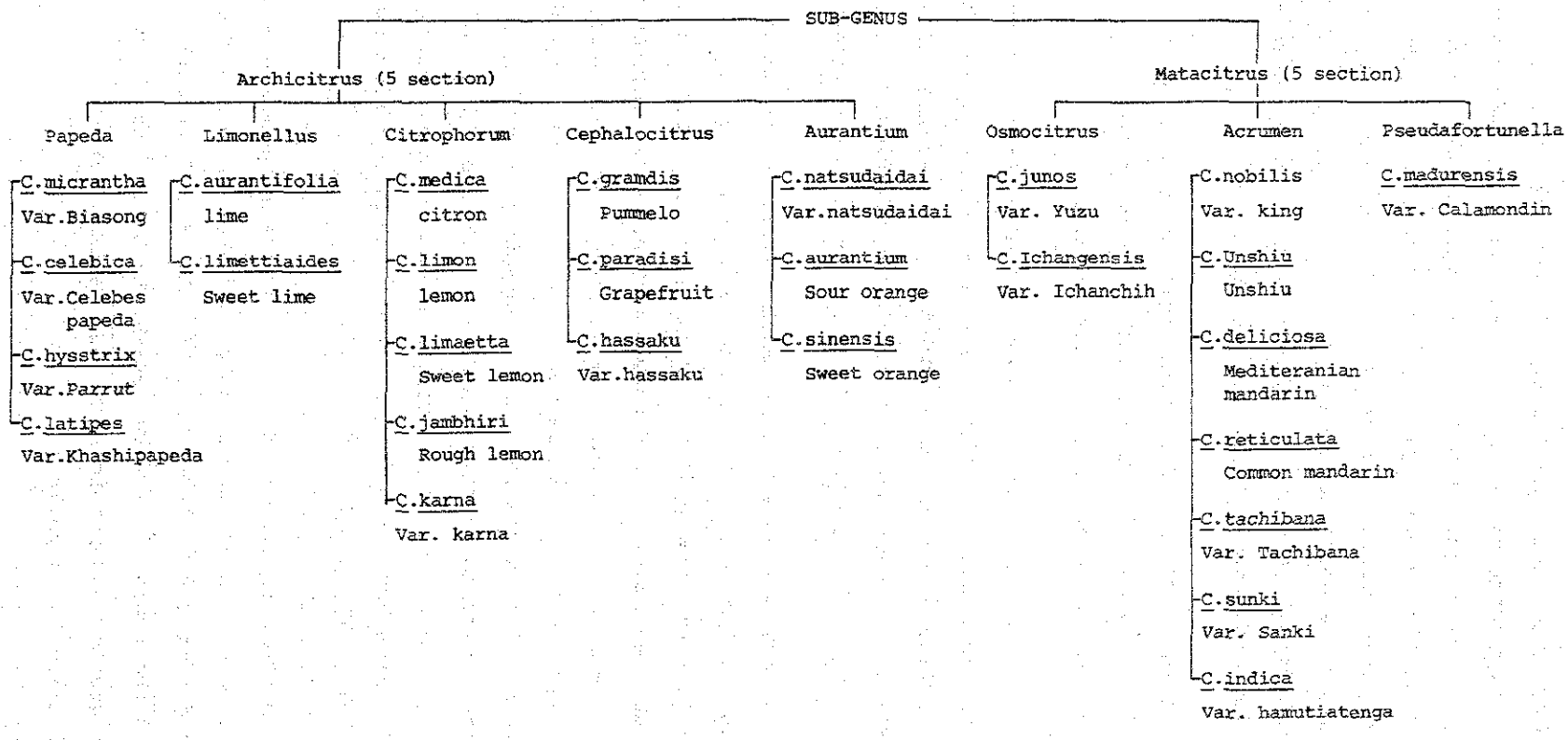
Again in the scientific arena there is lots of confusion in the classification of this group of fruits. There are two types of classification, one is botanical and the other one is horticultural.

In the botanical classification of citrus fruits there is also difference of opinion among the scientists. It is generally agreed that the genus "Citrus" belonges to the family Rutacae and sub-family Aurantioideae. Many scientists have classified this genus, out of which, the classifications put forward by Dr. Swingle and Dr. Tanaka have got wide acceptance.

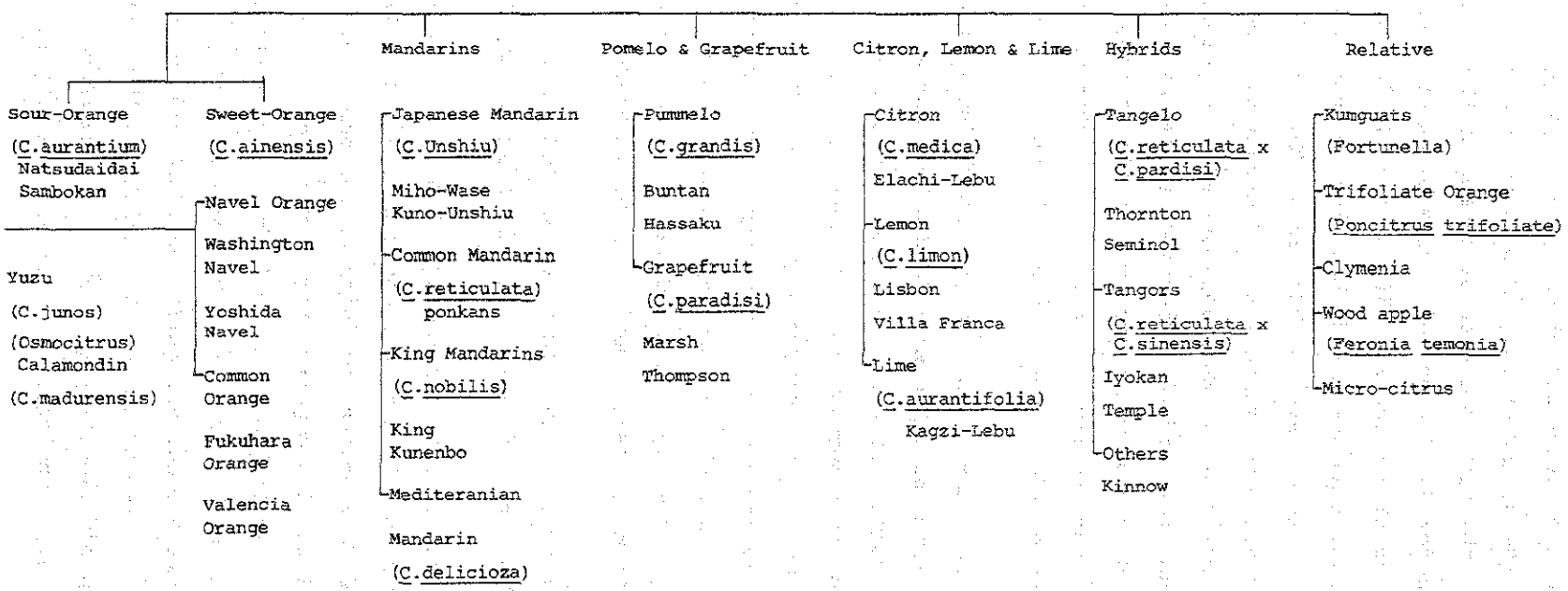
Dr. Swingle has mentioned 6 genus including the genus "Citrus", fruits of which exhibit the characteristics of true citrus fruit. He also mentioned 16 species under the genus citrus. Again Dr. Tanaka has sub-divided the genus citrus into two sub-genus and each sub-genus into a number of sections. He indicated that this genus may contain more chain 159 species. His argument for granting the status of species are sometimes criticized by other scientists. However a modified classification is suggested hereafter for use in this project citing examples of those varieties that are being cultivated in this project. Since the botanical classification is very much complicated, various horticulturists have grouped the citrus fruits depending mainly on the fruit quality, size, shape etc.

Again there is also lots of contradictions among various horticulturists. We have studied the horticultural classification in a number books and have rearranged them into simpler one. In this modified classification, we have mentioned the names of such varieties which are being cultivated in this project for greater understanding by our working scientists. The suggested classification is as follows:

MODIFIED BOTANICAL CLASSIFICATION OF THE GENUS CITRUS



MODIFIED HORTICULTURAL CLASSIFICATION OF CITRUS FRUIT



Now turning into the activities of the project we want to mention that we are very happy that the Record of Discussion have been extended for another three years because of the fact that most of period of the first three years, we did not get any fund for development of citrus block at Joydebpur. However, we had to work hard to develop this area with a very little fund available with the experts. For this, Bangladesh side had also no fund, but the BARI gave some materials like bricks to develop that area. This area is now almost fully covered with 104 different varieties of Citrus fruits belonging to all types and class of citrus fruits. When Japanese Experts joined this project in July 1978 there was no field and no irrigation facilities to conduct any research work. The present status was achieved with utmost endeavour of the experts and Bangladeshi counterparts and we feel proud that the project attained a stage in which some effective research work can be taken up.

During the last three years we are conducting fifteen research programme in co-operation with the sub-centres and other centres of BARI out of which a few are nearing completion and others are in progress. At Joydebpur (main centre) we could not undertake specific research work due to lack of aged citrus plants. Most of the citrus plants in Joydebpur is below three years age. We have only one Japanese citrus expert and one Bangladeshi counterpart for taking care of all the fifteen experiments. However the experiments number 12 ∿ 15 are related to insect and pest, so these experiments are being conducted by a Team of 5 Bangladeshi scientists headed Dr. Idris Ibnal Azim.

The other members of this team are Md. Abdul Mannan, S.S.O. Md. Nuzrul Islam, S.S.O. Mrs. Shahana Begum, S.O. and Miss Anowara Begum, S.O.

In respect of experiment number 7, this is being conducted by Dr. Shahidul Islam, P.S.O. who is helped by Md. Abdur Rouf and Mrs. Rezia Sultana, all belonging to the Soil Science Division of the BARI. Again the experiments numbering from 9 to 11 are pertaining to diseases. There is only one Bangladeshi counterpart is to look after all these experiments. Unless some Japanese Experts in the field of Entomology, Pathology and Soil Science frequently visit this project and guide the aforesaid experiments we may not attain our goal. Moreover it is not possible on the part of one citrus expert specialized on production side to look after the research works in all fields such as Entomology, Pathology, Soil Science and others.

With this background in view, the brief review of research work that have been done during the last three years are presented hereafter:

RESEARCH ACTIVITIES

Title No. 1. Survey of the present status of Citrus production in all its aspects.

Period : Date of initiation : June, 1980
Date of Completion : November, 1983

Researchers: (1) Mr. Y. Kodera, Japanese Citrus Expert
(2) Mr. A.M. Abdullah, P.S.O. (Citrus)
(3) Mr. Nazim Uddin, S.S.O. (")
(4) Mr. Jamiul Islam, S.S.O. (")

Location : All over Bangladesh.

Purpose : Survey is necessary to know the species, varieties and kinds of Citrus fruits that are grown in Bangladesh.

Progress: For this work we have developed a proforma (appendix-2) to be filled in while conducting survey. This has been distributed to all of our sub-centres and other centres of BARI to help us in this programme. However, we received some reports regarding this programme but it is not upto our satisfaction. It is also not possible on our part to devote ourself full time for this work which call for full time work of a number of scientists. Considering the importance and necessity of more number of full time worker, a separate scheme for this survey work has been prepared and submitted to the BARC which has been approved by the Technical Committee and now awaits approval of the Finance Committee. After the approval of Finance Committee it will come into operation under which we expect to get two more Scientific Officer, two Field Assistant exclusively for this work.

However, the reports that we have received indicates lime, lemon and pummelo grows well all over Bangladesh and sufficient quantities of fruits of these kinds are available in the local market during peak harvest period. However there are few main places of production of these fruits viz Chittagong (1300 acres), Sylhet (3000 acres), and other than these two districts the area under this ranges from 200 to 500 acres (appendix - 3). In case of Mandarin orange there has been a decrease in area and total production of this fruit.

During December to April there is lots of mandarin orange in the Dacca market out of which 90% comes from India. In early season, December and January we get khasi Orange comming from Assam and from February to April we get lots of Nagpuri Orange comming from the Indian State of Nagpur and its adjoining places.

As regards sweet orange, what we get in the market is entirely imported from India. The production of sweet orange is limited due to the fact that there is too much rain and poor drainage system compared to the other citrus producing areas of the world.

More-over most of the places in Bangladesh, we have clay soil which cause water logging. But the north easten part of Bangladesh i.e. Rajshahi Division has sandy loam soil and comparatively has less rainfall and as such this area may be suitable to some extent for the production of sweet orange.

Recommendations: As regards lime and lemon we can recommend the seedless variety of lemon and kagzi lebu, a variety of lime for general cultivation. They produce good yield and the fruit is also much accepted by the people. During peak harvest time they sale only 25 paisa each and even during lean period it does not cost more than one taka each. This means that they bear fruits all the year round. Only by improving the management practices we can increase their yield and get fruit throughout the whole year.

At present pummelo is grown mostly in home stead gardens. We have not seen any organized commercial pummelo garden in Bangladesh; although this fruit can be grown without much effort. We have some sweet pulp pummelo in our garden at Joydebpur which after necessary observation released to the farmer, they may get motivated and grow pummelo also in commercial scale.

Title No. 2. Collection and study of local Citrus varieties.

Period : Date of initiation : July, 1978
Date of Completion : November, 1983

Researchers: (1) Mr. Y. Kodera, Japanese Citrus Expert.
(2) Mr. A. M. Abdullah, P.S.O.
(3) Mr. Jamiul Islam, S.S.O.
(4) Mr. Nazium uddin, S.S.O.

Location : Joydebpur, Ishurdi, Jaintiapur and Pahartali (Ctg.)

Purpose : To collect good varieties as well as wild and unknown species of Citrus fruits.

Progress: We have so far, collected five varieties of mandarin orange, four varieties of lemon and one variety of lime, eight varieties of sweet orange, one variety of pomelo, and one variety of sour orange namely Ada zamir. They have been transplanted in the field at Joydebpur and is under observation.

Observation: We have previously mentioned that lime and lemon can be grown all over Bangladesh. But growing of seedless lemon in commercial scale will be very much profitable in this country. This is a special variety of lemon growing only in Bangladesh upto the present time. It seems that it is adapted only to the climatic condition of Bangladesh. We can even export seedless lemon fruit to the middle-eastern countries, if we become a bit aware about its cultivation and post harvest handlings.

As regards mandarin and sweet orange group of Citrus fruits our observation is that they prefer shading. In Sylhet region in tea gardens they grow some kind of leguminous trees as shade plants. It has many fold benefits like (a) it controls the air moisture (b) adds renutrition and (c) cutting of light intensity. We have found out the position of shade plants in mandarin orange garden at our Jaintiapur farm. It should cout 50 ∿ 70% of the light intensity for better preservation of photosynthetic material. If some one does not like to use shade plants, he should select northern and eastern side of the slope because the morning sunshine is not detrimentental to the plant growth and development but that of the afternoon seriously effect the plant. In the early stages of plantation we may use shade plants in the western side of the citrus plants in relatively closer spacing. As the citrus trees grow we may thin out the shade trees even up to 50%.

In Jaintiapur it is observed that the varieties namely Fuetrell's early or Musambi planted in the eastern slope are performing well in comparison with Khasia, Nagpuri and Satsuma orange planted along the southern slopes.

During hotest months in Joydebpur i.e. March and April there are lots of sun-burn, gummosis and die-back appear due to the direct heat of sunshine to the stem of citrus plants. More-over the soil moisture is completely dried

out during this time due to clay type of soil. So, it will be very difficult to produce mandarin and sweet oranges here without using shade trees. In Chittagong and Sylhet region where there is hilly areas and have sandy loam type of soil, the production of citrus fruits is more in those areas for these reasons.

Suggestion: In Joydebpur we are trying to change the soil organic condition by using maximum quantity of rice straw or cowdung and making sufficient number of drains. We also planted a good number of shade trees namely giant epil. Without these practices we can never expect good harvest.

Title No. 3. Introduction and adaptability trial of different exotic species of citrus and their relatives.

Researchers: (1) Mr. Y. Kodera, Japanese Citrus Expert
(2) Mr. A.M. Abdullah, P.S.O. (Citrus)
(3) Mr. Ashraf Khan, S.S.O.

Period : Date of initiation : July, 1978
Date of Completion : November, 1983

Location : Joydebpur, Jaintiapur, Ishurdi and Pahartoli.

Purpose : Selection of improved varieties adaptable under Bangladesh condition.

Result: We have already collected 30 mandarin orange varieties, three lemon varieties, 25 pummelo varieties, Seven rootstock varieties, 12 sweet orange varieties and 10 hybrids from Japan and other neighbouring countries (Table-1). Most of them come from Japan. But in Japan similar agro-ecological condition does not exist as in Bangladesh.

Table - 1(1)

List of collected Citrus Varieties of C.V.R.C.

		Local collection	Exotic source	Total
1.	Mandarins	5	30	35
2.	Lemon & Lime	4	3	7
3.	Pummelo	26	25	26
4.	Hybrid	0	10	20
5.	Sweet Orange	8	12	20
6.	Root Stock	1	7	8

Mandarins

1. Aoshima
2. Batangas
3. Dancy
4. Feutrell's early
5. Hashimoto-wase
6. Hayashi
7. Imazu Ponkan
8. Ishikawa
9. Jyuman
10. Kashi
11. King
12. Kinnow (Hybrid)
13. Kisyu-mikan
14. Kunenbo
15. Kuno
16. Matsuyama
17. Miho-wase
18. Miyakawa
19. Nagpuri
20. Tankan
21. Okitsu-wase
22. Ponkan
23. Ponkan F242
24. Shilver hill
25. Sugiyama
26. Tachibana
27. Tanikawa
28. Yamada
29. Yoshida-Ponkan
30. Yoneyama-U
31. Ihara-Ponkan
32. Iwamoto-U
33. Aoe-wase
34. Yoneyama-U
35. Koji

Table - 1(2)

Citron, Lemon & Lime

1. Villafranca lemon
2. Eureka lemon
3. Lisbon lemon
4. Elachi-lebu
5. Seedless lemon
6. Kagzi-lebu
7. Sarbuti

Pomelo, Grapefruit and Hassaku

1. Anseikan
2. Banoukan
3. Banpeiyu
4. Beni-hassaku
5. Daidai
6. Hassaku No. 55
7. Hirato-Buntan
8. Hyuga-natsu
9. Kaopan
10. Kawachi-Bankan
11. Kinkoji
12. Kobayashi-mikan
13. Marsh
14. Natsukan
15. Mato Buntan
16. Otachibana
17. Sambokan
18. Shinamanatsu
19. Red Blush
20. Suisyo-Buntan
21. Tachibana-Orange
22. Tanikawa-Buntan
23. Tosa-Buntan
24. Wase-Hassaku
25. Local pummelo
26. Amanatsukan

Hybrid

1. Allspice
2. Iyokan
3. Kalamadin
4. Miyauchi Iyokan
5. Okitsu No. 17
6. Okitsu No. 21
7. Seminol
8. Tankan
9. Temple
10. Thornton

Table - 1(3)

Sweet Orange

1.	Blood red	11.	Pineapple
2.	Decibre	12.	Ruby red
3.	Fukuhara-orange	13.	Shiroyanagi navel
4.	Hamlin-orange	14.	Suckery
5.	Jaffa	15.	Valencia-orange
6.	Kanton	16.	White gillette
7.	Kinkunenbo	17.	Washington navel
8.	Morita navel	18.	Yoshida navel
9.	Mosambi	19.	Fukurari navel
10.	Oumishima navel	20.	Trovita-orange

Root Stock

1.	Daidai (Kaiseita)	5.	Syuto (Kabusu)
2.	Korejime	6.	Trifoliate orange
3.	Rough Lemon	7.	Yuzu
4.	Sankitsu	8.	Adazamir

The introduced lemon varieties which are adaptable even under tropical condition may find a place in Bangladesh.

However, trifoliate orange and lemon varieties are more susceptible to die-back and canker during March to April. The trifoliate orange although recommended as number 1 rootstock in Japan, but here in Bangladesh the Yuzu and the local pummelo are exhibiting better performance as rootstock in the initial stage of growth. The Kaopan; a pummelo variety of Thailand; may perform well under the local condition of Bangladesh.

As regards mandarin oranges the literature reveals that Ponkan and Tankan varieties are more tolarent to heat and fruits can develop even under humid condition. So there are chances of getting some varieties belonging to Ponkan and Tankan group adaptable under Bangladesh condition.

Title No. 4. Development of appropriate nursery technique for raising and maintaining of rootstock seedlings.

Researchers: (1) Mr. Y. Kodera, Japanese Citrus Expert
(2) Mr. A.M. Abdullah, P.S.O.
(3) Mr. Ashraf Khan, S.S.O.

Period : Date of initiation : January, 1980
Date of Completion : November, 1983

Purpose : Improvement in the usual practices of raising rootstock seedlings.

Progress: There is no special technique for the collection of rootstock seeds. It is found from some observational trial that the viability of citrus rootstock seeds decreases with the increase in the no of days they are stored. It is better that we sow the seeds immediately after extraction. As regards spacing of rootstock seedlings in nursery bed for easy grafting and transplanting they should be planted in rows 2' apart and 10-12" in the row.

In the seed bed the young seedlings are subjected to the attack of leaf-minor and lemon butterfly which is effectively controlled by 5 ∿ 6 sprays with Sumithion or Melathion at 6 ∿ 7 days interval. For prevention of diseases we are using Bordeaux mixture which seem to be enough in our orchard.

Title No. 5. Comparative study of propagating lime, lemon and pummelo through budding and grafting against air layering and cutting.

Researchers: (1) Mr. Y. Kodera, Japanese Citrus Expert
(2) Mr. A.M. Abdullah, P.S.O.
(3) Mr. Ashraf Khan, S.S.O.

Period : Date of initiation : November, 1980
Date of completion : November, 1983

Location : Joydebpur, Dacca

Purpose : To find out the best way of multiplication of individual varieties of the aforesaid groups of Citrus fruits.

Progress: In Bangladesh air layering is not only the common method for the multiplication of lime, lemon and pumelo, but it is being practiced in many other tropical fruits like guava, litchi etc. Air layered plants produce fibrous root system and produced bushy plants. More-over it may be a reason

for shorter life in some of the plant species. It does not produce good trunk specially for lime and lemon and thus it has less fruiting area. On the other hand air layering take more manpower and also has specific season for air-layering i.e. June to July. The citrus plants at that time remain at blooming stage and some might have borne fruits in them which is detrimental for the plants. But cutting can be operated at any time of the year and easy to take care of the cutting in bed and it need only good water management. In our station initial study revealed that the success in cuttings is about 60 percent on the average depending on time and variety.

In respect of multiplication of rootstock varieties like Yuzu and trifoliate orange we do not have seeds here in Bangladesh. We are to import seeds from Japan. Moreover the seedlings raised from seeds produce uneven seedlings which is not desirable for use as rootstocks. Moreover we imported some two hundred Yuzu seedlings two years back, they have already produced good number of branches which we can use profitably for making cutting for use as rootstock.

Before 1978 in Bangladesh only budding was practiced on pummelo rootstocks for the propagation of mandarin and sweet oranges. After the starting of this project we collected two new rootstock species namely Yuzu and trifoliate orange for comparative study with local pummelo rootstocks. We can not expect the same result as it is obtained in Japan because of the differences in climatic condition, manpower and ignorance about the prevailing diseases, insects and their control measure. The results of some of the cutting experiments with different citrus species are presented in Table - 2.

Table - 2

Cutting Experiment with different Citrus Species

Date	No. of cutting made	No. of cutting survised	No. of cutting died	Percen-tage	Remarks
Local pumelo (C.grandis)					
2, Nov. 1980	56	36	20	64.29	
10, Jan. 1981	236	230	6	97.46	
2, Jan. 1981	54	53	1	98.15	
Total	346	319	27	86.63	
Yuzu (C.junos)					
February, 1980	105	56	49	53.33	
" "	91	37	54	40.66	
" "	98	36	62	36.73	
Total	194	129	165	43.57	
Trifoliate Orange (C.trifoliate)					
February, 1980	86	29	59	31.40	
"	155	44	11	28.39	
"	116	81	35	69.83	
"	124	58	66	46.77	
Total	481	212	171	44.09	
Seedless Lemon (C.limon)					
5, July 1980	70	65	5	92.86	
Sarbati (C.limettioides)					
5, July 1980	16	12	4	75.00	
Elachilebu (C.medica)					
5, July 1980	42	30	12	71.43	

The present practice of multiplying local pummelo, seedless lemon, Elachi lebu, Sarbati lebu is done through air layering. The problem is that airlayering can be done in certain period (June to August) of the year and also it is time consuming and costly. But the possibility of multiplying them through cutting was studied. It was observed that the success of cutting in case of

pummelo seedless lemon, elachi lebu, sarbati, Yuzu and tripoliate orange on the average were 86.63, 92.86, 71.43, 75.00, 43.57 and 29.89 percent respectively.

The performance of these plants at bearing stage are yet to be observed.

It is also necessary to compare these results with that of air layering which was not included in this study. It is expected this will be done in the next season. However, we have also tried in different season the success of side grafting, vinyl grafting and budding on different citrus species and have found that it can be done in all seasons if we can manage water requirement property. It produces better result during February and March. The result of some these study are presented perchafter in Tables 3, 4, 5, 6.

Table - 3

Data of side grafting on pummelo rootstocks with different Mandarin and pummelo varieties

Date of operation: 11, May 1980 Date of final observation: 12, Jan.'81

Name of varieties	No.of side grafting performed	No. of scion died	No.of scion survived	% of survival	Remarks
Mandarin Orange					
1) Miyagawa wase	48	2	46		
2) Mihowase	85	7	78		
	133	9	124	94%	
Pummelo					
1) Hirato buntan	32	5	27		
2) Banoukan	28	-	28		
3) Uwabuntan	23	-	23		
	83	5	78	94%	

Foot Note: Mean Maximum Temperature - 29.7°C
Mean Minimum Temperature - 25.3°C
Rainfall - 412 mm

Result: In this study two varieties of Mandarin orange and three varieties of pummelo were tried. It was observed that all of them could be propagated by side grafting, the success of which as observed here was 93% for mandarin orange and 94% for pummelo varieties. Moreover, the Bangladeshi counterparts and some other gardeners have already acquired skill of side grafting. So there will be no problem in future.

Table - 4

Data of vinyl graftings on pummelo rootstock with different Mandarin, pummelo, lime and lemon varieties

Date of operation: 11, May '80 Date of final observation: 12, Feb.'81

Name of varieties	No. of scion grafted	No. of scion died	No. of scion survived	% of survival
A. Mandarin group				
(a) Miyagawawase	36	15	21	
(b) Mihowase	19	8	11	
Total	55	28	32	58%
B. Pummelo group				
(a) Hirato-buntan	28	9	19	
(b) Uwa-buntan	15	6	9	
Total	43	15	28	65%
C. Lemon and Lime				
(a) Seedless lemon	59	16	43	73%
(b) Elachi lebu	18	2	16	88%
Total	77	18	59	76.50

Result: In this study two mandarin orange variety two pummelo variety and two lime and lemon varieties were tried as to whether they can be propagated through vinyl grafting. The success of vinyl grafting as observed here is 58% in case of mandarin orange, 65% in case of pummelo and 76.50% in case of lime and lemon. Since vinyl grafting needs more skill so we should repeat this study before making any recommendation.

Table - 5

Data of Budding Experiment at Joydebpur Main Centre

Date of operation: March, 1980. Date of final observation: 17, Feb.'81

Name of varieties	No. of scion grafted	No. of scion died	No. of scion survived	% of survival
A. Sweet Orange (C.sinensis)				
(1) Pineapple	40	37	3	8%
(2) Succari	40	31	9	23%
B. Pummelo (C.grandis)				
(1) Pummelo	40	29	11	28%
(2) Amanat sukan	40	35	5	13%
C. Sweet lime (C.limettliodes)	120	48	72	60%

Result: This trial was conducted to study the skill of the existing gardeners working at Jaintiapur. They were asked to do the above buddings. There was no supervision either from the Japanese Experts or from the Bangladeshi counterparts. The success as obtained here speak about their poor skill in budding. So they need to be trained further to acquire sufficient skill in this regard.

Table - 6

Data of Thailand pummelo grafted on Bangladesh pummelo and Yuzu rootstocks

Date of operation: 28, Dec. 1980 (Yuzu) Nov. 1980 (Pummelo) Date of final observation: 12, Aug. '81

No. of scion grafted	Vinyl grafting	Side grafting	No. of scion died (Veneer)	No. of scion died (side grafting)	No. of survival (vinyl grafting)	No. of survival	Total survival	%
(a) Yuzu								
52	45	7	44	4	1	3	4	8%
(b) Local pummelo								
54	40	14	22	6	18	8	26	48%

Summary of Result:

Scion of two varieties of Mandarin orange and three varieties of introduced pummelo were grafted (side grafting) on 11, May '80. It was observed from the experiment that the success of graft union was 93% in case of mandarin orange and while that of pummelo was 94% showing very high compatability.

In case of vinyl grafting, the success was less i.e. 58% and 65% for mandarin and pummelo scions respectively.

But the graft compatibility of Thailand pummelo (Kaopan) on Yuzu and local pummelo rootstocks were not encouraging. The percentage of success was less than 50% in all the cases. It will be also observed from these results that side grafting may be suitable for Bangladesh condition.

As for lime and lemon only vinyl grafting was done. The observed success was 73% and 88% respectively.

Title No. 6. Study to find out a suitable rootstocks for propagation of Citrus fruits under agro-ecological condition of Bangladesh.

Researchers: (1) Mr. Y. Kodera, Japanese Citrus Expert
(2) Mr. A.M. Abdullah, P.S.O.
(3) Mr. Ashraf Khan, S.S.O.

Period : Date of initiation : November, 1980
Date of Completion : November, 1983

Location : Joydebpur, Dacca.

Purpose : To select a good rootstock for the propagation of different kinds of citrus fruits under the soil and climatic condition of Bangladesh.

Observation: At this stage we are using pummelo, trifoliate orange, Yuzu and sour orange (Ada zamir) as rootstock. Initial study reveals that plants grafted on pummelo, Ada zamir and Yuzu is showing good growth while that on trifoliate orange is not showing encouraging growth. However this is a long and time consuming experiment which can not be completed within this short time. Moreover the results obtained in other countries do not hold good for this country specially the trifoliate orange during dry season it shade the

leaves because of the deciduous nature of the plants and the stem will be subjected to sun burn causing gummosis, canker and die-back. But Yuzu plants are quite resistant to the above diseases and exhibit good growth. Therefore we can not make any comment at this stage. We are yet to observe their affinity during stock and scion union, ultimate performance in fruiting and flowering and their resistance to different diseases. At this stage we may look for the work already done at the citrus research station Jaintiapur where they found pummelo to be the best rootstock for mandarin and sweet oranges. But the problem with pummelo is that it is mono-embryony and do not produce uniform seedlings. Therefore, we suggest that a very good plant be selected for taking cutting so that the grafting can be done on uniform cuttings so as to get the same influence of stock on scion variety as like that of polyembryony rootstock.

We also suggest to plant some cutting of the same plant in one plot so as to establish a garden having the same mother plant in order to obtain uniform cutting for future use as stock.

Title No. 7. Effect of chemical fertilizer and organic manure on the growth and fruit yield of lemon, lime and pummelo.

Researchers: (1) Mr. Y. Kodera, Japanese Citrus Expert.
(2) Mr. A.M. Abdullah, P.S.O.
(3) Dr. Shahidul Islam, P.S.O.
(4) Mr. Abdur Rouf, S.O.
(5) Mrs. Sultana Rezia, S.O.

Period : Date of initiation : July, 1980
Date of Completion : November, 1983 (to be continued)

Location : Joydebpur, Dacca and Jaintiapur, Sylhet.

Purpose : To determine suitable combination of N.P.K. for proper growth and fruit yield of lemon, lime and pummelo under optimum cultural practices.

Result: The experiments have been laid out in a factorial design with 8 treatments replicated 3 times.

The treatments are;

(1)	Control	(5)	NP
(2)	N	(6)	NK
(3)	P	(7)	PK
(4)	K	(8)	NPK

The planting has been done in July. Necessary care and observation are being taken regularly. Besides the above experiment the analysis of soil was conducted in our laboratory by ourself. Soil samples from 3 different depth (10cm, 20cm, and 30cm) were collected from our field No. 6 and net house where more than 20 varieties of different citrus fruits are being cultivated. Thus 60 samples were analysed in respect of nitrogen from NH_4 and NO_3, Phosphrous (P_2O_5), Potassium (K_2O), Magnesium, Manganese, Calcium, Iron (Ferric) and Aluminium. The analysis as done in our laboratory is presented here after in Table - 7. The soil of Jaintiapur has also been analysed by ourselves in our laboratory. The nutrient status of Jaintiapur farm is also reported in Table - 8.

Table - 7(1)

Inorganic Composition of Soil
Citrus No. 6 Plot and Net house

Date of sampling 23, Mar. '81

Mineral element in dried soil

	Soil in Citrus Field	NH_4-N (ppm)			NO_3-N (ppm)			P (ppm)			K (ppm)			PH		
		10cm	20	30	10cm	20	30	10cm	20	30	10cm	20	30	10cm	20	30
1.	Yoshida-navel	25	25	25	10	2.5	2.5	7.5	7.5	10.0	200	150	200	5.6	5.8	5.6
2.	Villafranca	100	10	50	50	2.5	2.5	2.5	5.0	7.5				5.6	5.6	5.8
3.	Rubi-red	70	25	25	10	5.0	2.5	1.0	1.0	0.1				5.8	6.0	5.8
4.	Ureka-lemon	50	25	25	30	5.0	10.0	1.0	2.5	5.0				5.6	5.6	5.6
5.	Lisbon-lemon	100	10	25	50	2.5	5.0	1.0	5.0	7.5				5.6	5.6	5.6
6.	Kawachibankan	10	10	25	30	2.5	2.5	1.0	5.0	10.0				5.4	5.8	5.6
7.	Mihowase	25	10	50	10	20.0	5.0	2.5	5.0	10.0	200	50	200	5.6	5.6	6.6
8.	Mosambi	50	25	25	30	2.5	2.5	2.5	0.1	0.1				5.6	5.6	5.6
9.	Sampokan	50	25	25	20	2.5	2.5	10.5	0.1	0.1				5.4	5.6	5.6
10.	Washington-navel	25	25	25	30	2.5	2.5	2.5	5.0	5.0				6.0	5.8	5.8
11.	Okitsu wase	150	25	50	5	1.0	2.5	0.1	7.5	5.0				5.8	5.6	5.8
12.	Miyagawa wase	50	10	25	30	1.0	5.0	2.5	5.0	10.0				5.8	5.6	6.0
13.	Benni hassaku	10	10	25	5	2.5	2.5	2.5	5.0	7.5				6.0	5.4	5.6
14.	Amanatsukan	10	10	25	5	2.5	2.5	1.0	7.5	5.0				5.8	5.6	5.8
15.	Feutrell's early	25	25	25	30	20.0	5.0	2.5	2.5	0.1				5.6	5.6	5.8
16.	Hyaganatsu	70	25	50	20	2.5	5.0	5.0	2.5	2.5	200	150	200	5.8	6.0	5.8
17.	Jaffa	70	25	50	20	2.5	2.5	2.5	1.0	0.1				6.0	6.0	5.8
18.	Iyokan	10	25	25	30	5.0	2.5	5.0	1.0	1.0				5.8	6.0	6.0
19.	Suckery	50	10	70	30	10.0	2.5	2.5	2.5	0.1				5.8	5.8	5.8
20.	Net House	10	10	50	5	2.5	10.0	5.0	7.5	2.5	200	50	200	5.8	6.0	5.6
	Optimum range	50	to	100	10	to	20	7.5	to	10.0		50				

1. NH_4-N, K, Ca, Mg and Mn were extracted by 0.05 N Kcl solution
2. P and Fe were extracted by 0.05 N Hcl acid solution.

Table - 7(2)

Inorganic Composition of Soil
Citrus No. 6 Plot and Net house

Date of sampling 23, Mar. '81

Mineral element in dried soil

	Soil in Citrus Field	Mg (ppm)			Mn (ppm)			Ca%			Fe^{++} (ppm)			Al (ppm)		
		10cm	20	30	10cm	20	30	10cm	20	30	10cm	20	30	10cm	20	30
1.	Yoshida-nave	40			2.5	1.0	2.5	2.5	1.0	1.0	250	100	250	25	25	50
2.	Villafranca	40			1.0	0.5	0.5	1.0	1.0	0.5	500	500	500	25	25	25
3.	Rubi-red	40			5.0	2.5	2.5	1.5	1.0	0.5	250	250	100	25	25	150
4.	Ureka-lemon	40			1.0	0.5	0.5	1.0	1.0	1.0	1000	750	500	25	25	50
5.	Lisbon-lemon	40			2.5	0.5	0.5	1.0	1.0	0.5	750	250	500	25	25	50
6.	Kawachibankan	40			1.0	0.5	1.0	1.5	1.5	1.0	1000	750	500	25	25	25
7.	Mihowase	60			2.5	0.5	1.0	1.0	1.0	1.0	1000	500	250	25	25	50
8.	Mosambi	40			10.0	5.0	5.0	0.5	0.5		250	100	100	25	150	100
9.	Sampokan	40			5.0	2.5	5.0	0.5	1.0		750	100	100	25	50	50
10.	Washington-navel	40			2.5	1.0	2.5	1.0	1.0		1000	250	250	25	25	50
11.	Okitsu wase	10			1.0	5.0	0.5	1.0	0.5		750	500	750	0	25	50
12.	Miyagawa wase	20			5.0	0.5	1.0	1.0	0.5		1000	750	500	25	25	50
13.	Benni hassaku	20			0.5	0.5	0.5	0.5	1.0		250	500	250	0	25	50
14.	Amanatsukan	20			2.5	0.5	0.5	1.0	1.0		500	250	750	25	25	50
15.	Feutrell's early	20			5.0	2.5	2.5	1.0	1.0		500	500	100	25	25	50
16.	Hyuganatsu	20			2.5	2.5	2.5	1.5	2.0		250	100	250	25	50	25
17.	Jaffa	20			2.5	2.5	5.0	1.0	0.5		500	100	100	25	50	100
18.	Iyokan	20			0.5	1.0	0.5	1.0	0.5		1000	250	250	0	50	25
19.	Suckery	10			2.5	1.0	2.5	0.5	0.5		500	100	100	25	50	50
20.	Net House	20			0.5	2.5	5.0	1.0	1.0		500	250	250	25	25	150
	Optimum range	50	to	60		5		0.3	to	0.8	700	to	1,100	less	than	25

Table - 8(1)

Inorganic Composition of soil at C.V.R.C.
Jaintiapur sub-centre, Sylhet

Date of sampling December, 1980

Mineral element in dried soil

Soil in Citrus Field	P.H		NO_3-N		NH_4-N		P		K		Ca		Mg	
	10cm	20cm	10	20	10	20	10	20	10	20	10	20	10	20
Japanese Mandarin area	5.5	5.5	1.0	1.0	0.4	0.4	1.0	1.0	3	8	0.09	0.09	5	5
Nagpuri Kinnow area	5.5	5.5	2.5	2.5	0.1	0.1	2.5	0.1	3	3	0.09	0.09	10	6
Sweet orange area	5.5		1.0		0.1		1.0		3		0.09		5	
Optimum range			10.0		5.0		5.0 - 7.5		8 - 15		0.1 - 0.15		20	

Table - 8(2)

Nutrient analysis of soil of Jaintiapur

Date of sampling 28, July '80

Variety	P PPM	Fe ppm	Ca%	Mg ppm	Mn%	K
Elachi lebu (Rai)	5	250	1.0	20	2.5	150
Malta (Rai)	5	100	1.0	80	5.0	100
Satsuma	12.5	100	1.0	10	5.0	50
Mosambi	5	100	1.0	10	1.0	50
Jaffa	5	250	1.0	20	1.0	50
Khasia	5	100	1.0	20	5.0	50
Bloodred	5	100	1.0	10	5.0	50
Rubi red	5	100	1.0	20	1.0	50
Kinnow	5	100	1.0	10	2.5	50
Nagpuri	5	100	1.0	10	2.5	100
Pineapple	5	100	1.0	20	2.5	50
Washington navel	5	100	1.0	10	2.5	50
Elachi lebu	5	100	1.0	20	1.0	50
Sarbati (Raikhali)	12.5	250	1.0	10	2.5	100
	7.5-10.0	60-150	3.0-55	50-60	25-100	1.2-1.7

When this results are compared with the standard range as shown under those tables it can be seen that these soil samples are deficient in NH_4-N, NO_3-N, P, Mg and Mn. The K, and PH, Ca content are more or less sufficient. Again Aluminium content of these samples are too high which is not good for growth and development of citrus fruits.

We also got co-operation from Dr. H. Sakai, an expert in Soil Science working at CERDI. He analysed some of our soil samples which are appended below in Table 9 also confirm our findings.

Table - 9

Soil Analysis of Citrus field No. 1 and No. 2 taken by Dr. H. Sakai

Date of sampling 9, Jan. '81

	Soil	PH	1-N %	NO_3 Available P_2O_5 p%m mg/100g soil		SO_4-S ppm	m,e/100 soil CEC	Ex-Ca	Ex-Mg	Ex-K	Saturation %		Zn	cu	ppm hot water
No.1 F.	1.	65	0.128	494	37.6	17.3	14.67	12.18	4.45	629	100	1.	26.17	0.15	0.472
	2.	5.15	0.079	1.24	4.6	13.8	12.93	5.76	1.82	0.26	60.6	2.	1.19	0.87	0.180
No.2 F.	3.	6.3	0.064	Trace	Trace	0.45	14.55	9.82	2.01	0.183	82.5	3.	0.36	0.62	0.147
	4.	8.0	0.080	"	"	0.11	9.43	7.83	1.68	0.086	100 over	4.	0.37	0.85	0.234
	5.	7.35	0.089	"	"	1.47	14.02	9.35	2.34	0.188	84.7	5.	0.29	0.46	0.245

Remark No. 1. Upper part of soil
2. Lower part of soil
1. Surface to 10cm
2. 10-30cm
3. 3 more than 30cm

Remark No. 2. No. 1 to 2 is our field number 1
No. 3-5 is our field number 2

Title No. 8. Leaf analysis

Period : Date of initiation : November, 1980
Date of Completion : November, 1983

Researchers: (1) Mr. Y. Kodera, Japanese Citrus Expert
(2) Mr. A.M. Abdullah, P.S.O.
(3) Mr. Ashraf Khan, S.S.O.
(4) Mr. R.Sakaguchi, Junior Expert

Location : Joydebpur and Jaintiapur

Purpose: Leaf analysis has been found to be more effective in detecting the up take of nutrients than the soil analysis. So, to develop a standard to determine fertilizer requirement for citrus varieties, this study has been under-taken.

This study is also aimed at to detect the unidentified diseases or nutritional deficiences that is being observed in the citrus plants growing at Jaintiapur. Some of the plants growing at Joydebpur have also exhibited similar symptoms. So to identify whether these symptoms have developed due to the deficiency of any of the mineral nutrients or due to some unidentified diseases.

Progress: Leaf samples of 40 different varieties of citrus plants belonging to mandarin orange, sweet orange, lemon, and lime groups were collected from Jaintiapur farm (15 varieties) and Joydebpur (25 varieties) during March, 1981. The results obtained are presented below in 3 different tables numbering 10, 11, and 12. The optimum range of minerals that a leaf should contain is also mentioned below these tables.

Table - 10

Inorganic Composition of Leave of Citrus
No. 5 Plot and Net house

Date of sampling 12, Mar. '81

Variety of Citrus	P (ppm)	K (ppm)	Ca %	Mg (ppm)	Fe (ppm)	Mn (ppm)	B (pm)
Mihowase	trace	2.0	1.0	0.1	25	10	30
Amanatsukan	"	1.5	1.0	0.05	50	50	40
Okitsuwase	"	2.0	0.5	0.05	10	10	30
Mosambi	"	2.0	1.0	0.15	5	10	20
Nagpuri	0.025	1.5	1.0	0.1	10	5	30
Decibre	"	2.0	0.5	0.1	5	5	40
Jaffa	"	2.0	1.0	0.15	10	25	30
Kawachibankan	"	1.5	0.5	0.05	25	25	20
Yoshida navel	"	2.0	1.0	0.1	25	25	30
Miyag wase	0.025	1.5	1.0	0.05	25	25	40
Feutrell's early	0.025	1.5	1.5		5	25	
Suckery	trace	2.0	1.5		5	25	30
Hyuganatsu	0.025	2.0	1.0		25	50	40
Rubired	0.025	2.0	0.5		0	10	30
Benihassaku	0.025	2.0	0.5		25	10	20
Villafranca lemon	0.025	0.5			5	10	30
Pineapple	0.025	2.0	0.5		0	5	40
Iyokan	0.025	2.0	1.0		10	50	20
Samboukan	0.025	1.5	0.5		0	10	30
Ureka lemon	0.025	0.5	1.0		0	25	20
Optimum range	0.1 to 0.15	1.0-1.5	1.0-2.0	0.2-0.4	50-100	50	30 to 40

Table - 11

Inorganic Composition of Leave of Citrus No. 6 Plot

Date of sampling 12, Mar. '81

Variety of Citrus and condition	P (ppm)	K (ppm)	Ca%	Mg (ppm)	Fe (ppm)	Mn (ppm)	B (ppm)
1. Lisbon-lemon (Healthy)	0.02	2.0	1.5	0.05	5	5	40
2. Pineapple (Diseased)	0.02	1.0	1.0	0.05	5	10	20
3. Nagpuri (Diseased)	0.02	1.5	1.0	0.05	5	5	20
4. Mosambi (Diseased)	0.02	1.0	1.0	0.05	5	5	30
5. Washington navel (Healthy)	10.02	2.0	1.0	0.05	10	10	30
Optimum range	0.1-0.15	1.0-1.5	1.0-2.0	0.2-0.4	50-100	2.5-100	30-40

Table - 12

Leaf Analysis of Defferent Citrus plants of Jaintiapur

Variety	P%	K%	Ca%	Mg%	B%	Fe%	Mn%
1	2	3	4	5	6	7	8
Malta (Mosambi)	0.025	1.0	1.5	0.15	30	5	10
Elachi lebu	0.025	0.5	1.5	0.15	30	5	5
Sarbati	0.025	1.0	1.5	0.10	10	5	10
Jaffa	0.025	1.0	1.0	0.15	10	5	5
Kagaji lebu	0.025	1.0	1.5	0.15	20	5	5
Nagpuri	0.025	1.5	1.0	0.15	20	5	10
Kinnow	0.025	1.0	1.5	0.15	10	5	5
Elachi lebu	0.025	1.0	1.0	0.15	20	5	10
Feutrell's	0.025	1.5	1.5	0.10	20	10	5
early Seedless lemon	0.025	1.0	1.0	0.15	20	5	5
Pineapple	0.025	1.0	1.5	0.10	10	10	5
Blood red	0.025	1.0	1.5	0.10	10	5	5
Rubi red	0.025	0.5	1.0	0.15	20	5	5
Satsuma (Pakistan)	0.025	1.0	1.5	0.2	10	5	10
Khasia	0.025	0.5	1.0	0.15	10	5	10
Optimum range	0.13	0.71	4.70	0.3	50	1.00	50

From the table it is observed that the leaves are deficient in phosphorus, magnesium, iron and manganese. The rest of the elements were found in moderate quantities.

One specialized type of analysis was done to compare whether deficiency or excess quantity of some elements are responsible for the unidentified disease (Table - II). The leaf samples from both healthy and diseased plants were collected and analysed. It will be revealed from the table that the leaf sample contain almost equal quantities of phosphorus, K_2O, calcium, magnesium, iron, manganese and boron. Thus it can be said that the disease symptom produced in these plants are not due to deficiency of any minerals but it is due to some virus.

At this moment we do not have any Japanese Citrus pathologist who can take up this work. So an expert may be despatched immediately to take up this work.

Title No. 9. (1) Studies on the causes and control of die-back and citrus canker diseases.

Period : Date of initiation : October, 1980
Date of Completion : November, 1983

Researchers: (1) Mr. Y. Kodera
(2) Mr. Abu Taher
(3) Mr. Ashraf Khan
(4) Mr. Abdul Hoque

Location : Joydebpur and Jaintiapur

Purpose : To identify the real cause or causes of the diseases and to formulate their control measures.

Progress:

(1) Die-back: This is a complex disease and various pathogenic organisums and physiological disorder have been reported to cause this disease. Some unidentified fungi have been isolated from the diseased part of die-back infected plants. They are being identified and the pathogenicity test are yet to be made.

(2) Citrus canker: The pathological test conducted in the laboratory reveals that this disease is caused by a bacteria Xanthomonas citri. It was observed that lime and lemon varieties are much susecptible to this disease than other citrus groups. In order to formulate certain spray schedule, an observational trial was undertaken at Jaintiapur Citrus Research Sub-centre on four different varieties of lime and lemons, namely Rangpuri lime, Elachi lebu, seedless lemon and Kagzi lebu, Five plants from each of the varieties were sprayed with (4:4:50) Bordeanx mixture in every month starting from October 1980 to April 1981. In each variety there was also one un-treated control plant. From the result presented in Table 13 below may be seen that on control i.e. untreated plants of each variety showed higher percentage of infection than treated plants. It was also revealed that the percentage of infection was gradually decreased on treated plants. So, we can say that the application of Bordeaux mixture was effective in minimizing the disease.

Table - 13

Data showing the percentage of infection of different lime and lemon varieties after spraying of Bordeaux mixture

Variety	Treatment	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Average
	1	23.7 %	22.1 %	9.8 %	7.8 %	0 %	15.4 %	13.1 %
	2	53.8	30.8	9.0	28.6	2.6	0	20.8
Rangpur lime	3	51.1	29.3	19.3	11.1	5.3	8.8	20.2
	4	14.5	30.6	17.7	16.9	10.3	4.3	15.7
	5	25.4		19.0	41.0	19.4	14.6	23.9
	Control	23.8	46.7	20.3	20.0	25.4	10.1	24.4
	1	23.1	23.3	15.9	13.6	15.8	12.5	19.3
	2	20.9	14.0	29.7	12.3	15.4	20.9	15.9
Elachi lebu	3	26.2	24.5	9.6	24.5	26.9	35.1	21.1
	4	33.3	14.0	13.6	10.9	25.0	16.3	18.9
	5	12.3	22.6	12.3	5.5	11.9	12.8	12.9
	Control	25.9	26.0	20.9	21.0	47.5	20.5	26.9
	1	24.5	29.0	16.3	21.0	5.8	10.7	17.9
	2	28.8	15.0	19.9	41.0	40.3	3.6	21.1
Seedless lebu	3	16.3	24.2	19.8	25.5	0	14.0	16.6
	4	18.1	23.1	12.7	25.5	4.2	0	14.0
	5	22.0	24.5	32.4	29.4	4.2	3.0	20.4
	Control	43.8	38.1	29.0	29.3	19.4	18.1	29.6
	1	46.2	27.7	24.5	13.0	9.4	17.5	23.1
	2	25.5	29.0	26.4	10.3	0	12.2	17.2
	3	42.3	12.9	22.4	14.5	7.9	22.2	20.4
	4	18.6	26.7	17.1	4.5	32.2	6.0	16.0
	5	30.9	26.9	12.9	8.5	0	11.5	15.1
	Control	30.3	50.0	25.4	9.5	21.1	13.3	24.9

Title No. 12. Survey of common diseases of citrus in Bangladesh.

Period : Date of initiation : March, 1980
Date of Completion : November, 1983

Researchers: (1) Mr. Y. Kodera
(2) Mr. A.M. Abdullah
(3) Mr. Abu Taher
(4) Mr. Ashraf Khan

Location : Joydebpur

Purpose : To find out the types of citrus diseases prevalent in Bangladesh and also record their seasonal abundances.

Progress: This study was started on March 1980, when Dr. H. Daito, was assigned by the JICA to look after the disease problem in Bangladesh. Dr. H. Daito and his counter-part Mr. Ashraf Khan, S.S.O (Plant pathology) worked on this for about three months. They made a list of seven different citrus diseases and made a prelimenary survey of their seasonal abundance, but they could not give a complete picture of seasonal abundance of various diseases and also their varietal susceptibility. After the departure of Dr. H. Daito we continued the work and obtained a clear cut idea about the various diseases and their seasonal abundances. Data on the prevalence of various diseases are being recorded on the first week of every month at Joydebpur citrus collection plot No. 5. Now it is observed from the tabulation of one year's data that three diseases are found as major such as die-back, citrus canker and gummosis. The rest four i.e. scab, wind burn, sooty mold and melanose are considered as minor.

Another important diseases "greening" has been found at Joydebpur and Jaintiapur which may be due to mycoplasma like organism. But this could not ascertain as yet through artificial inoculation. Dr. S. Ieki, a Japanese Citrus pathologist, who visited Jaintiapur in December 1979, also of the view that this may be greening disease.

Seasonal abundance of die-back:

The peak period of this disease is from September to November in almost all the varieties of citrus except on Yuzu. However, about the varietial

susceptibility lime, lemon, and pomelo are highly susceptible than mandarin and sweet oranges. One of our main rootstock (trifoliate orange) is also highly susceptible to this disease. It was observed from the data that during winter season (December to March) the appearence of this disease is less and if we control the diseases during this period, then we can minimize it on peak period.

Citrus Canker:

This disease also occurs almost all the varieties of citrus fruits and the peak period of this diseases is during rainy season (May to November), while lime and lemon varieties are attached by this disease throughout the year.

Gummosis:

This disease attacks mainly lime and lemon varieties and its appearance was high during rainy season (July to October). The cause of this disease is related with high light intensity i.e. sun burn. The disease may occur due to excessive light intensity which cracks the barks and help the entrance of the causal organism. In the citrus plots of Joydebpur the intensity of this disease was high previously, but recently we could control this disease by using shade plants. Another factor for the decrease of this disease is that the citrus plants at Joydebpur are now growing vigorously and having many leaves on them which some what shade the barks and protect from sunburn.

Minor diseases:

Citrus scab, wind burn, sooty mold and melanose attack almost all the varieties throughout the year except few varieties. The loss due to this diseases are less and can be controlled much easily than other citrus diseases.

General observation is that the appearance of major diseases are high during rainy season. We generally use Bordeanx mixture and Difar to control diseases like Die-back, citrus canker, gummosis etc. For effective control of such diseases we can start a programme to control the diseases through various chemical spray during rainy season.

Suggestion: All the facilities that are needed to identify various diseases through pathogenecity test is not available at this moment. Moreover the

services of an Japanese expert on citrus pathology is felt necessary to adopt more sophiticated way to identify them.

However, a list of seven identified diseases with their causal organism and seasonal abundance is presented in Table - 14 and the raw data in respect of season abundance of diseases are presented in appendix-4.

Table - 14

List of diseases, their causal organism, verietal susceptibility and seasonal abundances

Name of the disease	Causal organism	Varietal susceptibility	Seasonal abundance
(Major) 1. Die-back	(a) Fusarium sp. (b) Colletotrichurm sp. (c) Diaporthe sp.	All the species of Citrus.	September to November
2. Citrus Canker	Xanthomonas Citri	Lime, lemon and trifoliate orange but mandarin and sweet oranges are less susceptable	May to November
3. Gummosis	Phytophthora Parasitica	All the species of citrus	July to November
(Minor) 4. Citrus scab	Elsinoe Fawcettii	All the species of citrus	July to November
5. Wind burn	Physical	All the species of citrus	All the year round
6. Sooty mold	Capnodium Citri	All the species of citrus	Except winter season
7. Melanose	Diaporthe Citri	Lime, lemon and mandarin orange	All the year round
8. Greening	Mycoplasma	-	-

Title No. 11. Screening of exotic as well as indigenous cultivars of citrus against the existing important diseases.

Period : Date of initiation : January, 1981
Date of Completion : November, 1983

Location : Joydebpur

Researchers: (1) Mr. Y. Kodera
(2) Mr. Abu Taher
(3) Mr. Ashraf Khan
(4) Mr. A.M. Abdullah

Purpose : To observe the incidence of various diseases on the exotic and indigenous citrus varieties.

Progress: This is a very important work which needs almost attention because of the fact that some minor disease may be a major disease for a new variety under changed agro-climatic condition. But in Bangladesh there is not much facilities and technically trained man power for conducting such work on fruit plants particularly in citrus. So, to complete this study a long term Japanese expert on citrus diseases should be assigned to this project. Another problem was that there is no seperate area to conduct such research work.

Title No. 12. Studies on the incidence and seasonal abundance of different pests on promising varieties of citrus plants.

Period : Date of initiation : November, 1979
Date of Completion : November, 1983

Researchers: (1) Dr. Idris Ibnal Azium, P.S.O.
(2) Mrs. Sahana Begum, S.O.
(3) Mr. Y. Kodera, Citrus Expert
(4) Mr. A.M. Abdullah, P.S.O.

Location : Joydebpur, Dacca

Purpose: (1) To record insect pests, parasites that attack Citrus plants in Bangladesh and their predators.

(2) To study the season abundance and population fluctuation of various insect pests and predators.

Progress: This work was undertaken at the existing plantation of CVRC project during the winter season of 1978 and 1980. Reading was obtained in every week from the selected plants where insecticidal spray was prohibited. For the purpose of this trial all the citrus plants were grouped into 4 major groups namely sweet orange, mandarin orange, pummelo, lime and lemons.

During this period of investigation 12 types of insects were fround to attack citrus plants at Joydebpur, a list of which appended below (Table - 15) wherein they have been classified into major and minor according to the severity of damage. But previously Dr. M. Alam recorded 19 different types of insects attacking citrus plant from various regions of Bangladesh which is given in appendix No. - 5. Previous Researcher working in our Jaintiapur Citrus Research Station reported about orange bug and orange fruit fly. The latter on is responsible for the pre-harvest fruit drop.

Table - 15

List of citrus pests

Sl. No.	Common name	Scientific name	Order	Family	Status
1.	Leaf miner	Phyllocnistis citrella	Lepidoptera	Plyllocnistidae	Major
2.	Lemon Butterfly	(a) Papilio demoleus (b) Papilio polytes	"	Papelionidae	"
3.	Florida red scale insect	Chrysomphalus aonidum	Homoptera	Coocidae	"
4.	Yellow scale insect	Aonidiella citrina	"	"	Minor
5.	Red scale insect	Aonidiella aurantii	"	"	"
6.	Psyllid Bug	Diaphorina citri	"	Aphalaridae	"
7.	Citrus while fly	Aleurocemthus woglumi	"	Aleyrodidae	Major
8.	Citrus while fly	A spiniferus	"	"	"
9.	Citrus long lailed mealy bug	Pseudococcus virgatus	"	Psuedocoocidae	Minor
10.	Citrus mealy bug	Pseudococcus sp.	"	"	"
11.	Citrus Aphis	Toxoptera aurantii	"	Aphididae	"
12.	Citrus mealy scale	Coccus hesperidium	"	Pseudococidae	"

The population study with respect to leaf minor, it was observed that its population flutuated several times during the whole year. However, its population rose to the peak in October in case of Mandarin orange, pummelo and sweet orange varieties while for lime and lemon group its population rose to the peak in November.

The papilio demolens did not cause much damage to the plantation at Joydebpur although it is a major pest of citrus in other part of Bangladesh. No infestation of any kind of scale insects were also encountered during the period of this study.

Title No. 13. Studies on the biology and seasonal abundance of Florida red scale insect on lemon and oranges.

Period : Date of initiation : June, 1979
Date of Completion : June, 1981

Researchers: (1) Mr. Abdul Mannan, S.S.O.
(2) Mr. Shahana Begum, S.O.
(3) Mr. Y. Kodera, Citrus Expert.
(4) Mr. A.M. Abdullah, P.S.O.

Purpose : To evaluate vulnerable points of life cycle of the insect, its nature and extent of damage, parasites and preadators.

The biology of Chrysomphalus aonidum (L) (Coccidae, Homoptera), a serious pest of citrus was studied in the field as well as in the laboratory. Insect population was maintained in a number potted citrus plants, through inoculation with batches of newly hatched crawlers. The eggs were lemon-yellow in colour, oval in shape measuring .076mm and .043mm in length and breadth respectively. The incubation period was 24 hrs. Average percentage of hatching was almost 98.02% during the month of August and September.

Upon settling the development of the first instar nymph started. The first instar nymph moulted in 9 ∿ 12 days with an average of 10.9 day in the month of August and September. There was no difference between male and female until first molt was completed. In 2nd instar female moulted on an average of 10.9 days. Total period required to attain from egg to adult stage in case of female was 22.8 days. After the first moult and at 14th or 15th

day the red brown male became elongated spindle shaped and eyes became visible. The male then passed through prepupal, and pupal stage and then emerged as adult. The total period for the development from egg to adult male was on an average 23 days. The period from the completion of 2nd moult to the first egg deposition was 38 to 45 days. While the oviposition period varied from 4 weeks to 7 weeks.

Regarding the behaviour, it can be noted that the crawler spent some time under the mother scale. Then moved restlesly until they got a suitable place to settle. Except for few cases more than 60% of male scale were found on the dorsal side of the leaf while most female were found on the ventral side of the leaf.

July to September was the peak period of infestation and maximum adult population was found in the field at that time. The population of the insect rapidly falls down in winter months. Until now Menochilus sexmacalatus has been recorded as one of the predator of Chryromphalus aonidum.

Problems: The research on entomological problems were restricted due to lack of isolated area congenial for such work. Moreover this work was conducted at the main centre which may not hold good for citrus growing areas like Sylhet and Chittagong. In future such type of work should be done at Jaintiapur and Chittagong areas.

Title No. 14: Studies on the population fluctuation of leaf hopper and its control.

Period : Date of initiation : November, 1980
Date of Completion : November, 1983

Researchers: (1) Mr. Y. Kodera
(2) Mr. A.M. Abdullah

Location : Joydebpur, Jaintiapur and Ishurdi

Purpose : To find out population fluctuation of the insect on lemon and lime varieties and also to develop effective control measures for this insect.

Progress: This type of work has not been taken up as yet in collaboration with the entomolgy Division. So far we observed we did not find any such insect. However hoppers are found in mango and some other tropical fruits.

Title No. 15. Field trial of insecticides for the effective control of lemon butterfly and citrus leaf minor on seedless lemon, mandarin orange and sweet orange.

Period : Date of initiation : November, 1980
Date of Completion : November, 1983

Researchers: (1) Mr. Y. Kodera
(2) Mr. A.M. Abdullah
(3) Mr. M.A. Mannan
(4) Mr. Nurul Islam

Location : Joydebpur, Jaintiapur and Ishurdi

Purpose : To select effective insecticides for the control of lemon butterfly and citrus leaf minor on citrus plants.

Progress: We have been using mainly sumithion and Melathion for the control of different insects. Until now they are giving good results. But the insects may develop some resistance if we continue to control the insect with the same insecticide for a long time. It is expected that we will be able to control the insects by using a number of insecticides in combination. It is also intended that we may find better insecticide for controlling them.

Appendix - 1

Mean monthly maximum and minimum temperatures rainful
for last five years

Station	Item	Temperature (°C)											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
	Max	25.8	27.6	30.5	32.0	32.2	31.0	30.5	30.3	31.1	30.7	29.1	26.3
Chittagong	Min	13.8	15.9	20.3	23.6	24.9	25.2	24.9	24.8	25.0	23.7	18.9	15.4
	rainful	0.2	0.7	0.8	5.6	17.7	28.0	20.6	17.7	12.2	5.7	2.8	0.4
	Max.	25.3	28.3	32.8	34.4	33.5	31.5	30.1	30.9	31.3	30.7	28.7	25.9
Dacca	Min.	11.9	14.1	19.3	23.3	25.1	25.8	26.1	26.2	25.8	23.6	17.7	12.8
	rainful	4.0	3.2	2.1	6.3	14.8	16.1	13.7	12.6	9.8	7.1	0.3	0.6
	Max	25.7	28.3	33.4	36.3	35.1	33.2	31.8	31.8	32.8	31.9	29.3	26.6
Ishurdi	Min	11.5	13.7	18.2	22.6	24.6	25.6	25.9	26.2	25.9	23.3	17.4	12.8
	rainful	0.3	1.0	0.8	3.4	10.2	20.5	15.3	13.3	8.7	4.6	0.3	0.5
	Max	24.5	27.2	31.7	34.5	32.9	32.0	31.9	32.0	32.1	30.9	28.4	25.7
Rangpur	Min	10.2	11.9	15.4	20.9	22.8	24.7	25.6	26.4	25.7	22.2	16.4	12.1
	rainful	0.0	0.6	0.4	3.6	9.4	17.1	16.2	16.2	9.2	3.9	0.3	0.5
	Max	24.9	27.2	30.6	31.6	30.8	30.1	30.9	31.0	31.0	30.2	28.5	26.2
Sylhet	Min	12.2	14.1	17.7	21.2	22.8	24.4	25.1	25.0	24.7	22.2	17.4	13.8
	rainful	0.5	1.3	3.5	8.9	17.2	20.4	13.4	13.4	11.0	7.6	1.7	0.0

Appendix - 1(2)

Comparative daily solar Radiation (Cal/cm^2) under different light intensity

Place / Date	Open space	Net House	Weather of daily
16.3.81	859	339	Cloudy Sky for some hours
17.3.81	332	136	Cloudy and Rainy
18.3.81	489	199	Clean Sky
19.3.81	420	143	- do -
20.3.81	492	192	- do -
21.3.81	406	154	Cloudy morning
22.3.81	-	-	- do -
23.3.81	750	209	- do -
24.3.81	346	137	Rain accompanied with hail storm from 3-0 p.m. to 4-0 p.m. on 23.3.81.
25.3.81	340	153	
26.3.81	-	-	Cloudy for sometime
27.3.81	299	124	Clean Sky
28.3.81	400	169	- do -
29.3.81	-	-	
30.3.81	887	335	Cloudy morning
31.3.81	352	154	Almost cloudy
Total	6392	2534	

Appendix - 1(2)

Comparative daily solar Radiation (Cal/cm^2) under different light intensity

Place / Date	Open space	Net House	Weather of daily
1.4.81	183	57	Cloudy and Rainy
2.4.81	456	170	- do -
3.4.81	379	140	Cloudy
4.4.81	470	169	Cloudy and Rainy
5.4.81	-	-	
6.4.81	501	183	Cloudy and Rainy
7.4.81	525	226	Clean Sky
8.4.81	494	223	Foggy morning, Clean Sky
9.4.81	522	237	Clean Sky
10.4.81	521	233	- do -
11.4.81	492	225	Clean Sky, Cloudy for sometime
12.4.81	-	-	Cloudy and Rainy
13.4.81	450	357	- do -
14.4.81	-	-	Cloudy for sometime
15.4.81	921	451	Cloudy and Rainy
16.4.81	418	181	- do -
17.4.81	408	177	- do -
18.4.81	405	182	Cloudy
19.4.81	-	-	Cloudy and Rainy
20.4.81	232	90	Cloudy
21.4.81	512	231	
22.4.81	600	259	
23.4.81	455	201	Rainy morning
24.4.81	128	61	- do -
25.4.81	357	164	Clean Sky
26.4.81	-	-	- do -
27.4.81	1137	485	- do -
28.4.81	512	299	- do -
29.4.81	484	219	Rainy afternoon
30.4.81	277	122	Cloudy morning

Appendix - 2(1)

Proforma of the Survey on Citrus species
and Varieties of Bangladesh

A. Basic Information:

1. Name of farmer
2. Address of farmer
3. Habitat (a) Topography and soil type
   (b) Light situation
   (c) Drainage condition

B. Plant Characters:

1. Kind of Citrus: Mandarin/Sweet/Lemon/Lime/Pummelo/Unidentified/Wild.
2. Local name, if any.
3. Origin, if known.
4. Propagated by: Seed/cutting/layering/grafting/budding.
5. Age of plant
6. Base birth
7. Height
8. Canopy shape and size: Prominent trunk/bushy/spealing, etc.
9. Thorniness: Thorny all over/only in young twigs.
10. Flowering: Once a year/twice a year/more than twice a year
11. Time of flowering and fruit ripening
12. No. of fruits produced/per year (an estimate)

C. Leaf Characters (Short description):

1. Shape of leaf	Length Width
2. Winged or wingless	
3. Colour	Deep green Light green
4. Thickness	Thick Moderately thick Less thick
5. Length of Petiole	

D. Fruit Characters:

1. Colour
2. Number of petals
3. Solitary

E. Fruit Characters:

1. Shape, size and colour (ripe and unripe)
2. Fruit surface, smooth/rough/very rough
3. Skin: adherent/loose
4. Colour of juice vesicles
5. Thickness of skin
6. No. of seeds per fruit
7. Weight of fruit juice
8. No. of seeds per fruit
9. Juice quality: Very sour/sour/sour with bitter taste/slightly sour/sweet.

F. Seed Characters:

1. Size — Big / Medium / Small
2. Number of embryo
3. Colour of embryo — White / Green

D. Diseases:

1. Symptoms of any diseases or abnormalities.
2. Remarks.

Appendix - 3(1)

Estimates of Pomelo, 1972-73 to 1978-79

Name of the district	1972-73		1973-74		1974-75		1975-76	
	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)
Dacca	40	79	45	81	45	55	45	50
Kishoregonj	40	82	40	100	60	130	55	150
Mymensingh	130	153	135	198	130	190	130	185
Tangail	15	29	15	37	20	44	30	65
Faridpur	235	276	245	288	240	280	215	230
Chittagong	180	350	180	258	190	210	205	240
Chittagong H.T.	30	40	35	42	50	70	55	80
Noakhali	75	143	80	156	100	190	105	205
Comilla	40	72	36	65	35	65	35	55
Sylhet	435	1,070	435	927	440	935	475	1,010
Rajshahi	145	362	150	369	165	400	155	375
Dinajpur	95	84	110	105	90	90	110	115
Rangpur	115	93	115	93	125	100	125	110
Bogra	60	108	60	97	65	110	55	100
Pabna	55	113	60	123	65	130	75	140
Khulna	75	77	130	148	130	150	135	150
Bakerganj	25	35	30	43	35	50	40	60
Patuakhali	5	7	5	6	10	10	10	10
Jessore	35	64	35	63	50	70	40	65
Kushtia	75	80	75	69	95	95	90	100
Bangladesh:	1,905	3,317	2,016	3,269	2,140	3,374	2,185	3,495

Source: The year book of Agricultural Statistics of Bangladesh (1978-79)

Appendix - 3(2)

Name of the district	1976-77		1977-78		1978-79	
	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)
Dacca	45	46	40	38	45	43
Kishoregonj	65	84	95	119	105	120
Mymensingh	125	170	125	161	125	170
Tangail	40	88	45	93	45	83
Faridpur	220	226	215	229	220	215
Chittagong	205	173	215	182	225	190
Chittagong H.T.	55	81	60	79	70	90
Noakhali	105	224	110	238	125	253
Comilla	45	69	55	91	60	97
Sylhet	460	980	465	957	475	1,134
Rajshahi	160	394	165	382	150	336
Dinajpur	120	128	145	160	155	165
Rangpur	130	119	115	106	110	101
Bogra	60	99	70	118	60	108
Pabna	100	184	120	278	130	306
Khulna	155	165	155	165	165	176
Bakerganj	55	63	65	96	80	123
Patuakhali	10	11	10	11	10	12
Jessore	40	66	50	77	70	108
Kushtia	110	121	130	129	140	149
Bangladesh:	2,305	3,491	2,450	3,709	2,565	4,015

Appendix - 3(3)

Estimates of Mandarin, 1969-70 to 1978-79

Name of the district	1969-70		1970-71		1971-72		1972-73	
	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)
Dacca	-	-	-	-	-	-	-	-
Kishoregonj	-	-	-	-	-	-	-	-
Mymensingh	-	-	-	-	-	-	-	-
Tangail	-	-	-	-	-	-	-	-
Faridpur	-	-	-	-	-	-	-	-
Chittagong	-	-	-	-	-	-	-	-
Chittagong H.T.	410	360	101	75	135	90	140	88
Noakhali	-	-	-	-	-	-	-	-
Comilla	-	-	-	-	-	-	-	-
Sylhet	1,510	3,885	1,497	3,795	1,943	3,465	1,931	3,460
Rajshahi	-	-	-	-	-	-	-	-
Dinajpur	-	-	-	-	-	-	-	-
Rangpur	-	-	-	-	-	-	-	-
Bogra	-	-	-	-	-	-	-	-
Pabna	-	-	-	-	-	-	-	-
Khulna	-	-	-	-	-	-	-	-
Bakerganj	-	-	-	-	-	-	-	-
Patuakhali	-	-	-	-	-	-	-	-
Jessore	-	-	-	-	-	-	-	-
Kushtia	-	-	-	-	-	-	-	-
Bangladesh:	1,920	4,245	1,598	3,870	2,078	3,555	2,071	3,548

Appendix - 3(4)

Name of the district	1973-74		1974-75		1975-76	
	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)
Dacca	-	-	-	-	-	-
Kishoregonj	-	-	-	-	-	-
Mymensingh	-	-	-	-	-	-
Tangail	-	-	-	-	-	-
Faridpur	-	-	-	-	-	-
Chittagong	-	-	-	-	-	-
Chittagong H.T.	230	175	209	181	195	149
Noakhali	-	-	-	-	-	-
Comilla	-	-	-	-	-	-
Sylhet	2,030	3,442	2,091	3,341	2,100	3,374
Rajshahi	-	-	-	-	-	-
Dinajpur	-	-	-	-	-	-
Rangpur	-	-	-	-	-	-
Bogra	-	-	-	-	-	-
Pabna	-	-	-	-	-	-
Khulna	-	-	-	-	-	-
Bakerganj	-	-	-	-	-	-
Patuakhali	-	-	-	-	-	-
Jessore	-	-	-	-	-	-
Kushtia	-	-	-	-	-	-
Bangladesh:	2,260	3,617	2,300	3,522	2,295	3,523

Appendix - 3(5)

Name of the district	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)
Dacca	-	-	-	-	-	-
Kishoregonj	-	-	-	-	-	-
Mymensingh	-	-	-	-	-	-
Tangail	-	-	-	-	-	-
Faridpur	-	-	-	-	-	-
Chittagong	-	-	-	-	-	-
Chittagong H.T.	185	139	190	138	190	152
Noakhali	-	-	-	-	-	-
Comilla	-	-	-	-	-	-
Sylhet	2,100	3,361	1,700	2,222	1,740	2,232
Rajshahi	-	-	-	-	-	-
Dinajpur	-	-	-	-	-	-
Rangpur	-	-	-	-	-	-
Bogra	-	-	-	-	-	-
Pabna	-	-	-	-	-	-
Khulna	-	-	-	-	-	-
Bakerganj	-	-	-	-	-	-
Patuakhali	-	-	-	-	-	-
Jessore	-	-	-	-	-	-
Kushtia	-	-	-	-	-	-
Bangladesh:	2,285	3,500	1,890	2,360	1,930	2,384

Appendix - 3(6)

Estimates of Lime and Lemon, 1972-73 to 1978-79

Name of the district	1972-73		1973-74		1974-75		1975-76	
	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)
Dacca	105	143	105	154	100	110	105	95
Kishoregonj	52	67	55	61	50	33	55	35
Mymensingh	120	70	135	74	100	55	105	50
Tangail	35	59	35	58	45	66	50	75
Faridpur	395	450	395	435	350	231	300	210
Chittagong	225	322	225	322	230	270	240	280
Chittagong H.T.	130	96	160	129	215	174	230	205
Noakhali	110	137	115	144	120	159	125	160
Comilla	40	60	35	53	35	50	50	65
Sylhet	1,195	1,360	1,195	1,140	1,210	1,155	1,280	1,315
Rajshahi	135	228	140	226	155	245	185	285
Dinajpur	185	150	200	162	150	149	210	175
Rangpur	140	221	140	221	145	160	160	175
Bogra	100	55	100	62	105	65	80	45
Pabna	105	93	120	106	115	101	110	95
Khulna	135	40	135	45	135	64	140	70
Bakerganj	30	35	35	42	35	69	50	60
Patuakhali	5	4	6	5	10	8	10	8
Jessore	90	40	100	44	100	44	100	44
Kushtia	239	330	290	298	315	324	340	375
Bangladesh:	3,622	3,960	3,721	3,781	3,740	3,532	3,925	3,822

Appendix - 3(7)

Name of the district	1976-77		1977-78		1978-79	
	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)	Area (acres)	Prod. (tons)
Dacca	100	81	100	77	105	85
Kishoregonj	40	24	60	31	70	39
Mymensingh	105	46	105	42	110	48
Tangail	60	79	65	91	65	81
Faridpur	305	202	285	199	305	213
Chittagong	230	279	240	229	245	234
Chittagong H.T.	230	203	245	234	265	243
Noakhali	135	159	140	175	150	182
Comilla	60	82	70	95	75	102
Sylhet	875	771	690	608	710	678
Rajshahi	190	293	200	309	205	324
Dinajpur	220	194	245	225	265	234
Rangpur	180	98	300	253	285	230
Bogra	90	50	90	45	95	52
Pabna	100	88	105	104	120	128
Khulna	140	87	155	97	160	118
Bakerganj	70	82	75	91	90	112
Patuakhali	10	8	15	12	20	16
Jessore	110	48	120	48	140	57
Kushtia	370	421	280	309	270	298
Bangladesh:	3,620	3,395	3,585	3,272	3,750	3,474

Appendix - 4(1)

Monthly data on the incidence of the disease dieback

Variety	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
(Mandarin) Mino wase	L	L	M	L	L	L	L	N	L	L	L	
Oktsu wase	L	L	L	M	M	L	L	L	N	N	L	
Miyagawase	L	L	L	L	L	M	L	L	N	L	N	
Iyokan	N	L	M	L	L	N	-	-	-	-	L	
Feutrell's early	L	L	N	M	M	L	L	L	L	L	L	
Nagpuri	L	N	M	N	L	L	L	L	L	L	L	
Satsuma	L	L	M	M	M	L	L	N	L	L	L	
Kinnow	L	M	H	H	H	L	L	L	L	L	L	
Khasia (Sweet Orange)	M	M	M	H	VH	L	N	N	M	L	M	
Washington navel	H	H	H	M	M	L	L	L	M	L	L	
Pineapple	L	L	M	L	L	L	L	L	M	L	H	
Mosambi	L	L	L	M	M	L	L	L	M	L	L	
Rubi red	L	M	M	M	M	L	L	N	L	L	L	
Blood red	N	N	N	N	N	L	M	L	N	L	L	
Suckery	L	L	M	M	M	L	L	N	M	M	L	
Decibre	N	N	M	M	L	L	L	L	L	L	L	
Jaffa	L	L	L	L	L	M	M	L	N	L	L	
Diacy (Lime & Lemon)	L	M	M	M	M	L	-	-	-	-	L	
Villa franca	M	M	M	M	L	L	L	L	L	L	L	
Ureka	L	M	L	M	M	L	L	N	N	N	L	
Lisbon	N	N	N	M	L	L	L	L	L	L	L	
Seedless	H	H	H	VH	VH	L	L	N	L	L	L	
Elachi	VH	VH	VH	VH	H	L	N	N	L	L	L	
Kagzi (Pummelo)	VH	VH	H	VH	VH	N	L	L	L	L	L	
Kawachi barka	L	L	L	M	L	L	L	N	L	L	L	
Amanathsukan	M	H	H	L	L	L	L	L	N	L	L	
Beni hassaku	N	N	N	H	H	L	L	L	L	L	L	
Hyganathsu	L	L	L	H	H	M	M	L	M	M	L	
Sampokan	L	L	L	M	M	L	L	L	L	L	L	

N = Normal, L = Light infection, M = Medium infection, H = High infection, VH = Very high degree of infection.

Appendix - 4(2)

Monthly record of incidence of the disease citrus Canker

Variety	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
(Mandarin) Mino wase	L	L	L	L	L	L	L	L	N	L	N	
Oktsu wase	L	L	L	M	L	L	L	L	L	L	L	
Miyagawase	L	M	M	M	M	L	L	M	N	N	L	
Iyokan	L	L	L	M	L	L	-	-	-	-	M	
Feutrell's early	M	M	L	L	L	M	L	L	N	M	H	
Nagpuri	M	M	M	L	N	L	N	N	N	M	L	
Satsuma	L	L	N	L	L	L	N	L	N	M	L	
Kinnow	M	M	M	M	M	M	M	M	L	M	H	
Khasia (Sweet Orange)	L	L	L	M	M	L	N	N	L	L	N	
Washington navel	L	L	M	M	L	L	L	L	L	L	N	
Pineapple	M	M	M	L	L	L	L	L	N	M	M	
Mosambi	N	L	L	M	M	L	L	L	N	M	M	
Rubi red	L	L	M	L	L	L	M	L	N	M	H	
Blood red	L	L	L	L	L	M	L	N	N	L	M	
Suckery	L	L	L	N	N	L	L	L	N	L	H	
Decibre	L	L	M	M	M	M	L	L	N	L	H	
Jaffa	L	L	L	M	L	L	L	N	L	L	VH	
Diacy (Lime & Lemon)	L	L	N	L	L	L	-	-	-	-	M	
Villa franca	N	L	L	L	L	M	L	L	L	L	L	
Ureka	N	L	M	M	M	L	M	L	L	L	VH	
Lisbon	L	L	L	L	L	M	L	M	M	M	H	
Seedless	H	M	VH	VH	VH	M	M	M	M	M	VH	
Elachi	H	VH	VH	VH	VH	M	L	L	L	M	H	
Kagzi (Pummelo)	VH	VH	VH	VH	VH	H	L	L	M	H	M	
Kawachi barka	L	L	M	M	L	L	L	N	N	L	N	
Amanathsukan	M	M	L	M	L	M	M	L	N	M	M	
Beni hassaku	N	L	L	M	M	L	L	L	M	M	H	
Hyganathsu	N	L	L	M	M	L	L	M	N	M	N	
Sampokan	L	L	L	L	L	M	L	L	L	L	N	

Appendix - 4(3)

Monthly record of the incidence of the disease gummosis

Variety	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
(Mandarin) Mino wase	L	N	N	L	N	N	N	N	N	N	N	
Oktsu wase	L	N	M	M	N	N	N	N	N	N	N	
Miyagawase	L	N	N	N	N	N	N	N	N	N	N	
Iyokan	M	M	L	L	L	L	-	-	-	-	L	
Feutrell's early	N	N	M	N	N	N	N	N	N	N	N	
Nagpuri	L	L	N	N	N	N	N	N	N	N	N	
Satsuma	N	N	N	L	L	N	N	N	N	N	N	
Kinnow	L	L	L	L	L	N	N	N	N	N	N	
Khasia (Sweet Orange)												
Washington navel	N	N	N	N	N	N	N	N	N	N	N	
Pineapple	M	L	L	L	L	N	N	N	N	N	N	
Mosambi	N	N	N	L	L	N	N	N	N	N	N	
Rubi red	L	L	L	N	N	N	N	N	N	N	N	
Blood red	N	N	N	N	N	N	N	N	N	N	N	
Suckery	N	N	L	N	N	N	N	N	N	N	N	
Decibre	L	L	L	N	N	N	N	N	N	N	N	
Jaffa	L	L	L	L	L	N	N	N	N	N	N	
Diacy (Lime & Lemon)	L	L	L	L	L	N	-	-	-	-	N	
Villa franca	L	L	N	N	L	N	N	N	N	N	N	
Ureka	L	L	L	L	L	N	N	N	N	N	N	
Lisbon	N	N	N	N	N	N	N	N	N	N	N	
Seedless	VH	N	M	M	M	N	N	N	L	L	L	
Elachi	M	M	M	M	M	N	N	N	N	N	L	
Kagzi (Pummelo)	M	M	M	M	M	N	N	N	N	N	L	
Kawachi barka	N	N	N	M	M	N	N	N	N	N	N	
Amanathsukan	L	L	L	N	N	N	N	N	N	N	N	
Beni hassaku	L	L	L	N	N	N	N	N	N	N	N	
Hyganathsu	N	N	N	N	N	N	N	N	N	N	N	
Sampokan	N	N	N	N	N	N	N	N	N	N	N	

Appendix - 4(4)

Monthly record of incidence of the disease scab

Variety	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
(Mandarin) Mino wase	N	N	N	L	L	N	N	N	N	N	N	
Oktsu wase	N	N	N	N	N	N	N	N	N	N	N	
Miyagawase	N	N	N	N	N	N	N	N	N	N	N	
Iyokan	N	N	N	L	L	N	-	-	-	-	N	
Feutrell's early	N	N	N	N	N	L	N	N	N	N	N	
Nagpuri	N	N	N	L	L	N	N	N	N	N	N	
Satsuma	N	N	N	N	N	N	N	N	N	N	N	
Kinnow	L	L	L	N	N	N	N	N	N	N	L	
Khasia (Sweet Orange)	N	N	N	N	N	N	N	N	N	N	N	
Washington navel	N	N	N	N	N	N	N	N	N	N	N	
Pineapple	N	N	N	N	L	N	N	N	N	N	L	
Mosambi	N	N	N	L	L	N	N	N	N	N	N	
Rubi red	N	N	N	N	N	L	N	N	N	N	L	
Blood red	N	N	N	L	L	N	N	N	N	N	N	
Suckery	N	N	N	N	N	N	N	N	N	N	N	
Decibre	N	N	N	N	N	N	N	N	N	N	N	
Jaffa	N	N	N	N	N	N	N	N	N	N	N	
Diacy (Lime & Lemon)	N	N	N	N	N	N	-	-	-	-	N	
Villa franca	N	N	N	N	N	N	N	N	N	N	L	
Ureka	N	N	N	N	N	N	N	L	L	N	N	
Lisbon	N	N	N	N	N	L	L	N	N	N	L	
Seedless	N	N	L	L	N	N	N	N	L	L	M	
Elachi	N	N	L	M	N	N	N	N	L	L	L	
Kagzi (Pummelo)	N	N	N	L	L	N	N	N	L	N	L	
Kawachi barka	N	N	N	N	N	N	N	L	N	N	N	
Amanathsukan	N	N	N	N	N	N	N	N	N	N	N	
Beni hassaku	N	N	N	N	N	N	L	L	N	N	N	
Hyganathsu	N	N	N	N	N	N	N	N	N	N	N	
Sampokan	N	N	N	N	N	N	N	N	N	N	N	

Appendix - 4(5)

Monthly record of incidence of the deseases Wind burse

Variety	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
(Mandarin) Mino wase	N	N	N	N	N	N	N	N	N	N	N	
Oktsu wase	N	N	N	N	N	N	N	N	N	N	N	
Miyagawase	N	N	N	N	N	N	N	N	N	N	N	
Iyokan	N	N	N	N	N	N	N	N	N	N	N	
Feutrell's early	N	N	N	N	N	N	N	N	N	N	N	
Nagpuri	N	N	N	N	N	N	N	N	N	N	N	
Satsuma	N	N	N	N	N	N	N	N	N	N	N	
Kinnow	N	N	N	N	N	N	N	N	N	N	N	
Khasia (Sweet Orange)	N	N	N	N	N	N	N	N	N	N	N	
Washington navel	L	N	N	N	N	N	N	N	N	N	N	
Pineapple	L	L	L	N	N	N	N	N	N	N	N	
Mosambi	N	N	N	N	N	N	N	N	N	N	N	
Rubi red	N	N	N	N	N	N	N	N	N	N	N	
Blood red	N	N	N	N	N	N	N	N	N	N	N	
Suckery	N	N	N	L	L	N	L	N	N	N	N	
Decibre	N	N	N	N	N	N	N	N	N	N	N	
Jaffa	N	N	N	N	N	N	N	N	N	N	N	
Diacy (Lime & Lemon)	N	N	N	N	N	N	N	N	N	N	N	
Villa franca	N	N	N	N	N	N	N	N	L	L	N	
Ureka	N	N	N	N	N	N	N	N	L	L	N	
Lisbon	N	N	N	N	N	N	N	N	L	L	N	
Seedless	N	N	N	N	N	N	N	N	L	L	L	
Elachi												
Kagzi (Pummelo)	N	N	N	N	N	N	N	N	L	L	N	
Kawachi barka	L	L	N	N	N	N	N	N	N	N	N	
Amanathsukan	N	N	N	N	N	N	N	N	N	N	N	
Beni hassaku	N	N	N	N	N	N	N	N	N	N	N	
Hyganathsu	N	L	N	N	N	N	N	N	N	N	N	
Sampokan	N	N	N	N	N	N	N	N	N	N	N	

Appendix - 4(6)

Monthly record of incidence of the disease Sooty mold

Variety	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
(Mandarin) Mino wase	N	N	N	N	N	N	N	N	N	N	N	
Oktsu wase	N	N	N	N	L	N	N	N	N	N	N	
Miyagawase	N	N	N	L	N	N	N	N	N	N	N	
Iyokan	N	N	N	N	N	N	N	N	N	N	N	
Feutrell's early	L	N	N	N	N	N	N	N	L	L	N	
Nagpuri	N	N	L	N	N	N	N	N	N	N	N	
Satsuma	N	N	N	N	N	N	N	N	N	N	N	
Kinnow	N	L	N	N	N	N	N	N	N	N	N	
Khasia (Sweet Orange)	N	N	N	N	N	N	N	N	N	N	N	
Washington navel	N	N	N	N	N	N	N	N	N	N	N	
Pineapple	N	N	N	N	N	N	N	N	N	N	N	
Mosambi	N	N	N	N	N	N	N	N	N	N	N	
Rubi red	N	N	N	N	N	N	N	N	N	N	N	
Blood red	N	N	N	N	N	N	N	N	N	N	N	
Suckery	N	N	N	N	N	N	N	N	N	N	N	
Decibre	N	N	N	N	N	N	N	N	N	N	N	
Jaffa	L	L	N	N	N	N	N	N	N	N	N	
Diacy (Lime & Lemon)	N	N	N	N	N	N	N	N	N	N	N	
Villa franca	N	N	N	N	N	N	N	N	N	N	N	
Ureka	N	N	N	N	L	N	N	N	N	N	N	
Lisbon	L	L	N	N	N	N	N	N	N	N	N	
Seedless	N	N	N	L	N	N	N	N	N	N	N	
Elachi	L	N	L	L	N	N	N	N	N	N	N	
Kagzi (Pummelo)	N	N	L	L	L	N	N	N	N	N	N	
Kawachi barka	N	N	L	N	N	N	N	N	L	L	L	
Amanathsukan	N	N	N	N	N	N	N	N	N	N	N	
Beni hassaku	N	N	N	L	L	N	N	N	N	N	N	
Hyganathsu	N	N	N	N	N	N	N	N	N	N	N	
Sampokan	N	N	N	N	N	N	N	N	N	N	L	

Appendix - 4 (7)

Monthly record of incidence of the degrees melanose

Variety	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
(Mandarin) Mino wase	N	N	N	N	N	N	N	N	N	N	N	
Oktsu wase	N	N	L	N	N	N	N	N	N	N	N	
Miyagawase	N	N	N	N	N	N	N	N	N	N	N	
Iyokan	N	N	N	N	N	N	N	N	N	N	N	
Feutrell's early	N	N	N	L	L	N	N	N	N	N	N	
Nagpuri	N	N	N	N	N	N	N	N	N	N	N	
Satsuma	N	N	N	N	N	N	N	N	N	N	N	
Kinnow	N	N	N	N	L	N	N	N	N	N	N	
Khasia (Sweet Orange)	N	N	N	N	N	N	N	N	N	N	N	
Washington navel	N	N	N	N	N	N	N	N	N	N	N	
Pineapple	N	N	N	N	N	N	N	N	N	N	N	
Mosambi	N	N	N	N	N	N	N	N	N	N	N	
Rubi red	N	N	N	N	N	N	N	N	N	N	N	
Blood red	N	N	N	N	N	N	N	N	N	N	N	
Suckery	N	N	N	N	N	N	N	N	N	N	N	
Decibre	N	N	N	N	N	N	N	N	N	N	N	
Jaffa	N	N	N	N	L	N	N	N	N	N	N	
Diacy (Lime & Lemon)	N	N	N	N	L	N	N	N	N	N	N	
Villa franca	N	N	N	N	N	N	N	N	N	N	N	
Ureka	N	N	N	L	N	N	N	N	N	N	N	
Lisbon	N	N	N	L	L	N	N	N	N	N	L	
Seedless	N	N	N	N	N	N	N	N	N	N	N	
Elachi	N	N	N	N	N	N	N	N	N	N	N	
Kagzi (Pummelo)	N	N	N	N	N	N	N	N	N	N	N	
Kawachi barka	N	N	N	N	N	N	N	N	N	N	N	
Amanathsukan	N	N	N	N	N	N	N	N	N	N	N	
Beni hassaku	N	N	N	N	N	N	N	N	N	N	N	
Hyganathsu	N	N	N	N	N	N	N	N	N	N	N	
Sampokan	N	N	N	N	N	N	N	N	N	N	N	

Appendix - 5

A LIST OF INSECT AND MITE PESTS OF CITRUS IN BANGLADESH

Sl. No.	Common name	Scientific name	Family	Order	Status
		(A) Insects Attacking Fruit			
1.	The Orange bug	Phynchocoris humeralis Th.	Pentatomidae	Hemiptera	Major
2.	The Orange fruit fly		Trypetidae	Diptera	-do-
		(B) Insects Attacking Stem and Shoot			
3.	The Orange tree borer	Monohammus versteegi Rits.	Cerambycidae	Coleoptera	-do-
4.	The Orange trunk borer	Chloridolum aicemence Thoms.	-do-	-do-	-do-
5.	The Citrus stem borer	Chelidonium cinctum G.	-do-	-do-	-do-
6.	The Orange shoot borer	Arbela tetraonis M.	Arbelidae	Lepidoptera	-do-
		(C) Insects and Mite Attacking Leaf			
7.	The Lemon butterfly	Papilio demoleus L.	Papilionidae	Lepidoptera	-do-
8.	-ditto-	Papilio polytes L.	-do-	-do-	-do-
9.	The Citrus aphjs	Toxoptera ourantii B.	Aphididae	Hemiptera	-do-
10.	The Citrus psyllid bug	Euphalerus citrii Kuw.	Paylidae	-do-	-do-
11.	The Citrus whitefly	Aleurocantnus weghmi A.	Aleyrodidae	Hemiptera	Major
12.	-ditto-	Aleurocanthus spiniferus Q.	-do-	-do-	-do-
13.	The Citrus yellow scale	Aonidiella citrina Coq.	Coccidae	-do-	-do-
14.	The Citrus red scale	Aonidiella aurantii M.	-do-	-do-	-do-
15.	The Citrus leaf miner	Phyllocnistis citrella St.	Phyllocnistidae	Lepidoptera	-do-
16.	The Citrus long-tailed mealy bug	Pseudococcus virgatus Ckll.	Coccidae	Hemiptera	-do-
17.	The Citrus mealy bug	Pseudococcus sp.	-do-	-do-	-do-
18.	The Citrus mite	Schizetranychus Hindustanicus Hirst.	Tetranychidae	Acarina	-do-
		(D) Insect Attacking Flower			
19.	The Citrus flower	Frankliniella sp.	Thripidae	Thysanoptera	-do-

* Identified by Dr. M. Zahurul Alam (B.A.R.I)

PROBLEMS/SUGGESTIONS

(1) There is considerable environmental and cultural difference between Bangladesh and Japan. So the number of experts willing to come to Bangladesh is very limited. Therefore, to attract Japanese experts to work in Bangladesh and that they do not feel isolated; it is necessary that the Bangladesh Counterparts be more co-operative and help them to overcome these difficulties and feel interested to work here. Such type of bottlenecks on the part of the Japanese experts are not good for the development of Bangladesh and more particularly for this project. There should exist very cordial relation between the Japanese experts and Bangladeshi scientists to achieve the desired goal of the project.

(2) It is stipulted in the Record of Discussion that the project be implemented through a committee constituted by the representative of both governments which is popularly known as Joint Committee. This Committee meets at least once a year. But the suggestions made or resolution adapted by this Committee are not always implemented by the government of Bangladesh. The government of Bangladesh should look for some other means for smooth implementation of the project.

(3) The term of the existing scheme expired on November 3, 1980. The technical co-operation between the government of Bangladesh and the government of Japan has already been extended for a perido of another 3 years. The government of Bangladesh has prepared a revised scheme covering the Second Five Year Plan to match with the extended Record of Discussion. The scheme has not yet been approved finally by the ECNEC. As a result the Bangladesh side is unable to utilize the aid facilities provided by the government of Japan. It is a general feeling that the Bangladesh side is not trying sufficiently to get the scheme approved.

(4) The fund provided by the government of Bangladesh to meet different expenditures like custom duties and sale tax, and other recurring expenditure under this project is very limited; resulting delay in clearning of materials from Chittagong port and to bear such other expenses like the wages of labourers, purchase of oil and fuel for farm machineries. Thus we are facing hardship in doing day to day work. The fund provided by the JICA to each expert is at present utilized to meet some of the ex-

penditures of the project like wages of labourers, purchase of oil and fuel and maintainance of machineries. If this situation continues, it is apprehended that the activities of the project will come to standstill after the departure of the Japanese experts.

(5) The machineries and vehicles of this project are very often used by BARI. They return them without cleaning and servicing. Some times they even ask to bear the cost of oil and fuel either from the limited fund of this project or from the experts. This practice is not at all a healthy symptom and should be stopped immediately.

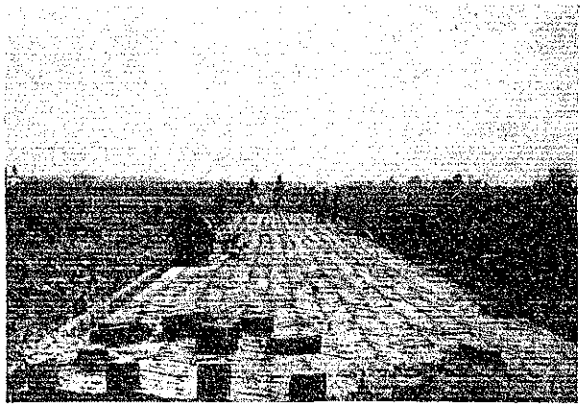
(6) Here in the Citrus and Vegetable Seed Research Centre, the Japanese experts work as a Team. There is no doubt that there is some sort of gap of communication from Japanese side. But it is observed sometimes that when an expert ask for some staff he is being interrupted from Bangladesh side without consulting the concerned expert and without considering the importance of work. Moreover, some time two orders are given to one person from two sides which creates misunderstanding and dislocate important works

(7) There is very often delay in matters relating to works involving experts in the Ministry of Agriculture and Forests, ERD and sometimes even in the BARI. For this delay in official matter sometimes the Bangladeshi Counterparts try to escape by saying that "This is Bangladesh" which is very much disappointing on the part of Japanese Experts. There should be special provision or system in the Ministry of Agriculture and Forest, ERD and BARI for dealing with the matters relating to the experts.

(8) Two JOCV (Junior Experts) have already been assigned under this project. It is expected that two more junior experts will be assigned each at Chittagong and Ishurdi for the development of sub centre. We all agree that Joydebpur will never be a citrus growing area and I personnally feel that the sub-centres be developed for conducting research work in future, that might be adaptable to the growers of the citrus growing areas. With this point in view, the Japanese side is trying much to develop the sub-centres even under the present agreement. The Ministry of Foreign affairs of the government of Japan is also showing keen interest in this matter. But the government of Bangladesh failed to fillup even the posts of all researchers of the approved scheme; the tenure of which has already been

expired after a period of 4 years. So, naturally there is apprehension on the part of Japanese side that Bangladesh will not be able to provide efficient officer for the development of sub-centres. Moreover until the works like development of land, sinking of deep tubewell, construction of laboratory etc. are completed, no full time expert can stay at Akbarpur which the Bangladesh side is gong to develop as a Regional Station for Citrus and Vegetables.

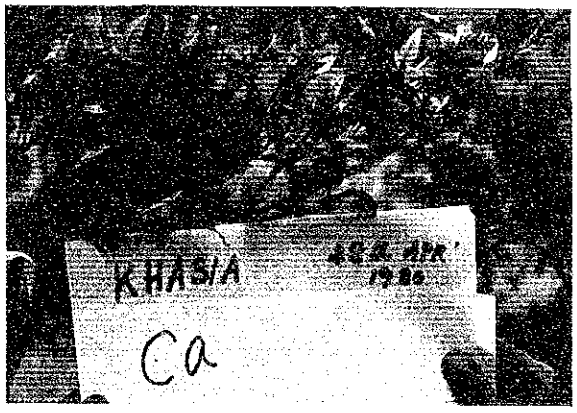
At the end I want to extend my heart felt thanks to all the working scientists of the Citrus and Vegetable Seed Research Centre, BARI and all officers of the Ministry of Agriculture and Forests for their Co-operation and valuable help extended to me during my three years stay in Bangladesh. It is expected that my successor Dr. H. Daito who is a famous researchers in Japan will be able to achieve more success in the field research and contribute to the development of Citrus Industry in Bangladesh.



No. 1 Brick-work are being done in the approach road.

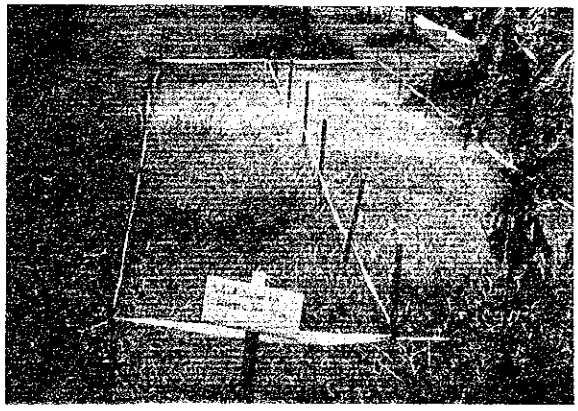
No. 4 Planting of citrus plants in the citrus block of field No. 2.

No. 2 Preparation of beds for planting of citrus plants in the citrus block of field No. 2.

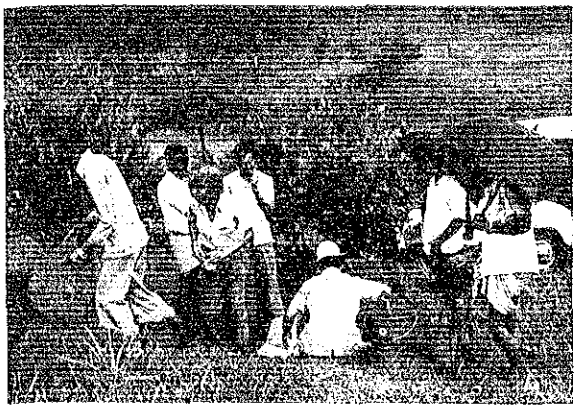


No. 5 Identification of nutrient deficiency in citrus leaves.

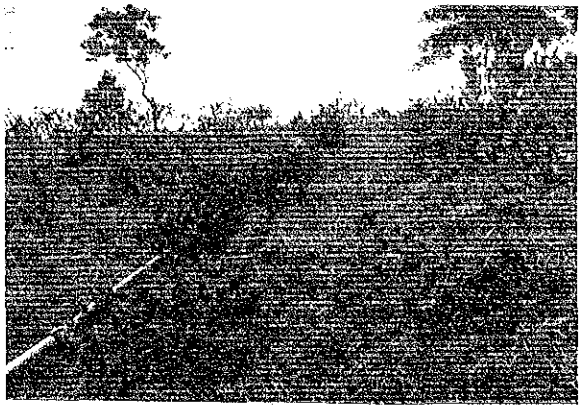
No. 3 Planting of citrus plants in the citrus block of field No. 2.



No. 6 .Controlling weeds by appling weedicide.



No. 7 Nutritional experiment at Jaintiapur.



No. 10 Kagzi lebu garden at Jaintiapur.

No. 8 Cutting experiment of Yuzu and Trifoliate orange.

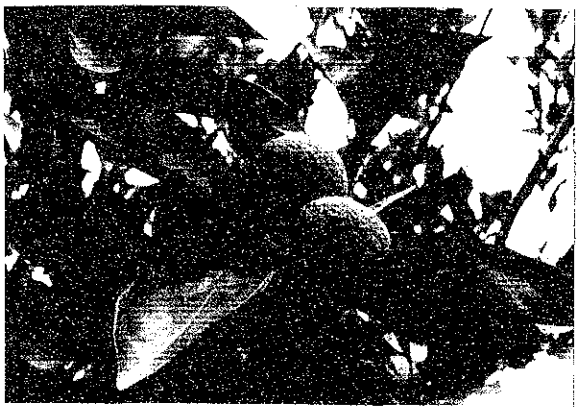
No. 11 Root stock trial at Jaintiapur.

No. 9 Fertilizers experiment on Pummelo.

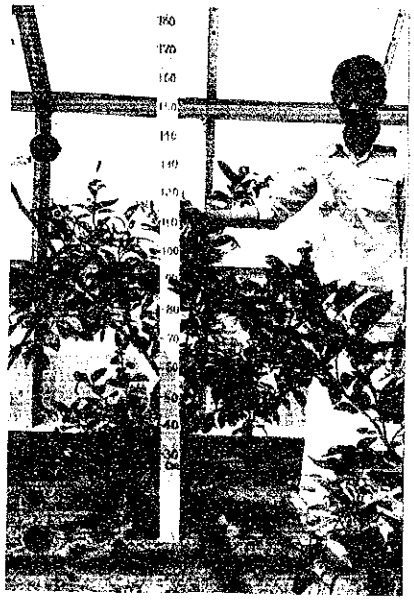
No. 12 Grafting experiment on trifoliate orange root stock.

No. 13 Sweet orange garden at Jaintiapur.

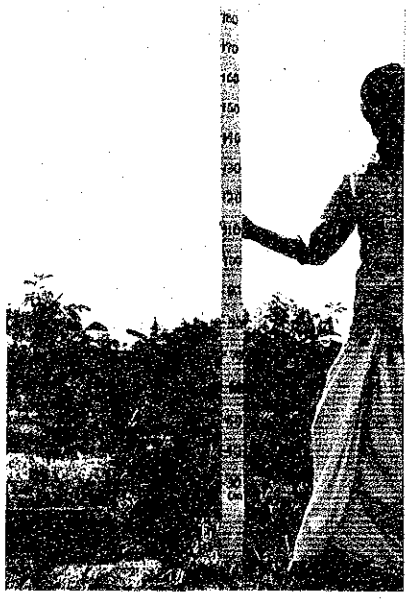
No. 16 Newly introduced exotic varieties.



No. 14 Fruits of Washington Navel variety at Jaintiapur.



No. 15 Side grafting experiment on pummelo root stock.



No. 17 Comparative study of growth under different light intensity.

Report on the Vegetable Pathological Works

Feb. 15 to Apr. 12, 1981

submitted by

M. Umekawa

(MANABU UMEKAWA)

CONTENTS

I N T R O D U C T I O N

At the request of Japan International Cooperation Agency (JICA), I visited Bangladesh as a short term expert of plant pathology and stayed here from 15th February to 12th April, 1981.

During my stay for 57 days I worked at Citrus and Vegetable Seed Research Centre (CVRC). And carried out two main works. These were;
(1) to estimate resistance of watermelon varieties to Fusarium wilt, and
(2) to collect the specimens of other series diseases of vegetable and isolate the causal fungi or bacteria.

During my work Mr. Md. Abu Taher, Senior Scientific Officer (Virology) and Mr. A. Ahad Miah, Senior Scientific Officer (Vegetable) were also with me and I taught them all the procedures I used.

A trip was arranged from Citrus and Vegetable Seed Research Centre for collecting the specimens of Fusarium wilt of watermelon. I visited Ishurdi, Natore and Rajshahi with Mr. A. Ahad Miah and observed the vegetable fields of the farmers in this country.

At the beginning of my report I wish to express my sincere gratitude to Japanese team leader Mr. S. Aihara, Vegetable expert Mr. S. Tasaki and other Japanese experts for kindly supporting my work in Citrus and Vegetable Seed Research Centre.

I am also very much grateful to Mr. Abu Taher and Mr. A. Ahad Miah for their kind help during my stay in Bangladesh.

1. Screening of Watermelon Varieties for Fusarium Wilt Resistance

In Bangladesh watermelon is a very popular fruit in the beginning of Kharif season. But every year Fusarium wilt disease causes heavy loss to watermelon production. The disease is very severe and common in watermelon growing areas of the country. But there has been no breeding work in this regard so far to screen out the resistant varieties from local and exotic materials. The object of this experiment was to find out the resistant varieties of watermelon to Fusarium wilt and to find out a suitable member of Cucurbitaceae family resistant to Fusarium wilt which may eventually be used as root-stock plant for graft cultivation.

(1) Isolation of causal fungus Fusarium oxysporum Schlechtendahl f. niveum (E.F. Smith) Snyder et Hansen

(a) Collection of infected plants

On 18th and 23rd February, and on 5th and 6th March, 1981, Plants which seemed to infected with Fusarium wilt were collected from the fields at Kashimpur, Chittagong, Jessore and Natore respectively.

Infected plants were collected on the basis of disease symptoms as follows - When very yound seedlings are invaded, they may damp-off and die or be stunted seriously and cotyledon wilted. Older plants show a true wilting at first or, when some what resistant may only be dwarfed. Inside of the wilting stem discoloration of the water ducts may show plainly or not at all. In advanced stages of the disease the roots begin to decompose and finally are killed.

(b) Preparation of media

In order to isolate the causal fungus from the infected plants, we used Potato Dextrose Agar (PDA) or Potato Sccharose Agar (PSA).

Procedure of preparing PDA or PSA is as follows:-
Two hundred gramme of peeled potatoes are cut into small pieces and boiled in 1,1 of distilled water for about 30 minutes. After boiling, 20g of dextrose or saccarose and 15g of agar powder are mixed to the potato extract, and dissolved by heating. The media should be sterilized with the autoclave for 15 minutes at a temperature of 120°C.

(c) Isolation of the causal fungus

The infected stems were cut into several pieces at a length of 0.5-1 cm. Among the several pieces fresh and top portion with disease symptoms were chosen and sterilized first by 70% ethanol for few seconds and then by 0.1% solution of mercurrie chiloride for few minutes. These sterilized pieces were washed by sterilized water and then put on the plate of PDA or PSA. Then the petridishes were incubated at 25°C. whole procedure of isolation was done in clean bench to avoid any contamination. Streptomycin was added to the media at the concentration of 500-1000ppm before pouring it in petridishes to exclude the bacterial contamination.

After 2-3 days of incubation fungal mycelium were found to grow from the pieces on the media, pure cultures of the causal fungus were made by transferring the mycelial tip.

(d) Maintainance of the isolates

Selected isolates from each location will be maintained in the test tubes containing the medium for future use. After every two months the isolates should be transferred to new test tubes.

(2) Screening of watermelon varieties for Fusarium wilt resistance

(a) Materials and Methods

Fourteen varieties of watermelon were used in our experiment. The names and origins of these varieties were shown in Table 1. Seeds were first germinated in the incubator and then sown in 9 cm polyethylene pots filled with sterilized soil. In this experiment Kashimpur isolate was used.

For inoculation of causal fungi, root dipping method was used. The seedlings were uprooted carefully so as to minimize the damage of roots. Then the roots of each seedlings were dipped in the spore suspension for 3-5 minutes and replanted in the same pots. Concentration of the suspension was about 100 spores/viewing area of microscope at the magnification of 200 fold.

Inoculated seedlings were placed on the table in glass house. For two days after inoculation, high soil-moisture conditions in the pots were maintained.

Observations on the disease development were done 6, 9 and 12 days after inoculation, and the degrees of the disease development of each varieties were expressed by using disease index and percentage of infected seedlings. Disease index was calculated by the following formula.

$$\text{Disease index (D.I.)} = \frac{1 \times n_1 + 2 \times n_2 + 3 \times n_3}{n_0 + n_1 + n_3 + n_4}$$

Symptom class	0	no symptom
	1	slightly wilting
	2	rather wilting
	3	severely wilting or dead

(b) Results and Discussion

The result of the screening test was shown in Table 1. Symptoms began to appear 4 days after inoculation. Among the tested varieties, three Japanese varieties namely Shin Kanro, Glory and Otome seemed to be resistant to Fusarium wilt. And Diamond Florida Giant, Kaho, Charleston Grey 133-2 and Patenga were very weak to Fusarium wilt. Among the local varieties, Goalandha was rather resistant.

Resistant varieties such as shin Kanro, Glory and Otome should be tested also under the field condition. If these varieties are found resistant in the field test, they may be used as breeding materials to make the resistant varieties.

(3) Inoculation test of causal fungi to Cucurbitaceous plants

Kashimpur, Chittagong and Jessore isolates were inoculated to watermelon, cucumber, sweet gourd and bottle gourd by poring method and needle prick method. Because of post inoculation environmental conditions, no symptom appeared in any of the inoculated plants. But as the stems of watermelon seedlings were cut, discoloration of vascular bundle was observed. In case of cucumber, sweet gourd or bottle gourd, we could not observe the same type of discoloration.

So, it was suggested that these fungi could attack watermelon only, and not other cucurbitaceous plants. From these results, it may be clear that Fusarium wilt of watermelon can be controlled by grafting cultivation even if the cultivated varieties were susceptible.

2. Observation on the Occurrence of Vegetable Diseases and Isolation of Causal Fungi

During my stay in Bangladesh, I surveyed the occurrence of vegetable diseases at Joydebpur (field of CVRC), Kashimpur (field of ADE), Ishurdi (field of sub-centre), Natore (farmer's field) and Rajshahi (farmer's field).

Names of the diseases those were confirmed to occur were shown in Table 2. The survey should be done throughout every season. Causal fungi of several diseases were isolated from the infected plants by single spore isolation method using PSA medium containing streptomycin. These isolates should be maintained as the standard cultures for the future experiments. I discussed sufficiently with Mr. Taher about the importance of the standard culture.

Table 1.

Name of Variety		6 days after inoculation						9 days after inoculation						12 days after inoculation					
		0[a]	1[a]	2[a]	3[a]	D.I.	P.I.[b]	0[a]	1[a]	2[a]	3[a]	D.I.	P.I.[b]	0[a]	1[a]	2[a]	3[a]	D.I.	P.I.[b]
Patenga	Local	16	0	1	3	0.55	20	13	0	1	6	1.00	35	12	0	0	8	1.20	40
Goalanda	ditto	20	0	0	0	0	0	19	0	1	0	0.10	5	18	0	0	2	0.30	10
Sugar Baby-6	Japan	19	0	0	1	0.15	5	15	1	2	2	0.55	25	14	0	0	6	0.90	30
Yamato Cream	ditto	18	0	1	1	0.25	10	17	0	0	3	0.45	15	17	0	0	3	0.45	15
Shin-mikasa	ditto	20	0	0	0	0	0	19	0	1	0	0.10	5	18	0	1	1	0.25	10
Gin-Yamato	ditto	19	0	0	1	0.15	5	18	0	0	2	0.30	10	18	0	0	2	0.30	10
Kaho	ditto	15	1	0	4	0.65	25	11	0	1	8	1.30	45	9	1	0	10	1.55	55
Shin Kanro	ditto	20	0	0	0	0	0	20	0	0	0	0	0	20	0	0	0	0	0
Glory	ditto	20	0	0	0	0	0	20	0	0	0	0	0	19	0	0	1	0.15	5
Otome	ditto	20	0	0	0	0	0	20	0	0	0	0	0	19	0	0	1	0.15	5
Diamong/Florida Giant	USA	18	0	1	1	0.25	10	10	1	3	6	1.25	50	6	0	2	12	2.00	70
Sugar Baby-3	ditto	19	0	0	1	0.15	5	17	1	1	1	0.30	15	17	0	0	3	0.45	15
Charleston Grey 133-1	ditto	19	0	1	0	0.10	5	16	0	2	2	0.50	20	15	0	0	5	0.17	25
Charleston Grey 133-2	ditto	20	0	0	0	0	0	13	4	0	3	0.65	35	11	1	2	6	1.15	45

a : Symptom class

b : Percentage of infected seedlings.

Table 2. List of vegetable diseases observed in Bangladesh

Host	Name of disease	Causal parasite
Tomato	Mosaic	TMV or CMV
	Bacterial wilt	*Pseudomonas solanaceaum*
	Early blight	*Alternaria solani*
Potato	Early blight	*Alternaria solani*
Melon	Fusarium wilt	*Fusarium oxysporum* fs. *melonis*
	Gummy stem blight	*Mycosphaerella melonis*
	Downy mildew	*Pseudoperonospora cubensis*
Watermelon	Mosaic	Watermelon mosaic virus
	Fusarium wilt	*Fusarium oxysporum* fs. *niveum*
Cabbage	Alternaria leaf spot	*Alternaria brassicae*
Carrot	Motley dwarf	Carrot motley dwarf virus
	Leaf blight	*Alternaria danci*
Welsh onion	Downy mildew	*Peronospora destructor*

Report on the Vegetable Cultivation Works

Dec. 15, 1981 to Mar. 12, 1982

submitted by

Mr. Yoshihiro Iwanaga

CONTENTS

1. Introduction

I was assigned by the JICA to see the problems of vegetable cultivation research in Bangladesh and I came here on December 15th 1981 and stayed up to March 12th, 1982. During my 88 days'stay, I had three main duties, these are (1) collection and screening of local and exotic germplasm of cucumber for future breeding programme, and (2) to transfer grafting techniques of cucurbitaceous vegetables for avoidance from fusarium wilt and for maintenance of growth vigor, and (3) to transfer knowledge of chemical control for fruit setting of eggplant. By this time we set some experiments and taught the procedures to our local researchers, Mr. A. Ahad Miah (S.S.O. Vegetable), Mr. M.A. Taher (S.S.O. Virology), Mr. A. Rashid (S.O. Vegetable) and Mr. Sareh (S.O. Vegetable) in order to make progress in their research fields.

I would like to express my sincere gratitude to Japanese team leader Mr. S. Aihara, Vegetable expert Mr. S. Tasaki and other Japanese experts for helping me to complete my work and to Dr. Kazi Badruddoza, Director, BARI and Dr. A.K.M. Amzad Hossain, P.S.O., Citrus and Vegetable Seed Research Center for their helpful cooperation. Lastly, I express my gratitude to Mr. A. Ahad Miah, S.S.O. (Vegetable) and other staffs of Citrus and Vegetable Seed Research Center for their help during my stay in Bangladesh.

2. Studies on The Grafting Affinity of Watermelon with Cucurbita SPS. and Lagenaria leucantha

OBJECTIVE:

In Bangladesh watermelon is a important vegetable.

But the productivity is remained low level because many plants of watermelon are infected by fusarium wilt and moreover growth habit is fallen with another causes for example, soil moisture, manuring practice, temperature etc. in latter growth period. It has been considered that the pathogen of fusarium wilt of watermelon in Bangladesh could attack watermelon only, and not other cucurbitaceous plants.

It was identificated to be Fusarium oxysporum f. niveum. If watermelon is grafted with pumpkin or bottle gourd which is resistant against this pathogen and moreover have stronger root system, it is expected that productivity of watermelon cultivation is raised.

However, many kinds of physiological disorders are found in accordance with combination between scion and stock.

The purpose of this experiment are to find the combination between scion and stocks having higher grafting compatibility and to master the technique for grafting.

Materials and Methods:

(A) Characteristics for stock of cucurbitaceous vegetables and varieties used

(1) Lagenaria leucantha

The operation of grafting is easy.

It has deep root, low temperature elongation and best compatibility. The inferior change of texture and fruit shape isn't found.

However, since Fusarium oxysporum f. lagenariae which can attack bottle gourd had been recorded already in Japan, it must be attend to infection moreover, leaf blotch originated graft incompatibility and anthracnose are found at times.

(2) Cucurbita moschata

The stock varieties of medium or weak class for growth habit are used, as growth habit is rather too strong. They are namely 'Shirokikuza' 'No.8' 'Shinkho', 'Kongho', 'Benkei'.

The compatibility is different among the strain.

The inferior change of texture and fruit shape are found often.

(3) Cucurbita hybrida

The application amount of fertilizer must be decreased as the over growth of stem and leaves is arised because the growth habit is too strong.

The difference of compatibility is found among the strains.

The inferior change of texture and fruit shape are often found.

There are 'Tetsukabuto' 'Shintosa'

(4) Cucurbita pepo

The grafting compatibility is highest in cucurbita sps. but it is sensitive to severe change of moisture in soil. The ability of elongation in low temperature is high.

(5) Benincasa hispida

The grafting compatibility is high and fruit quality is good but the growth in the first stage is low and the delay of harvest time is found.

(6) Free stock

The watermelon varieties which is resistant against fusarium wilt and is superior to growth habit were used for stock.

(B) Method and kind of grafting

Three kinds of grafting are known on watermelon.

(1) Clip method

The upper portion on hypocotyl of scion grown at stage of first foliage leaf are cut diagnally only half of stem from bottom to top.

On the other hand, the upper portion on hypocotyl of stock which just start development of 1st foliage leaf are cut down diagnally in half of stem.

The section of both seedlings are combined and fixed with grafting clip.

(2) Cutting methods

The both side on hypocotyl of scion which start development of cotyledon are shaved thinly about 1 cm in length.

The growing point of stock which start development of first foliage leaf are removed, in same place are made a holl of 5 mm in depth with spatula.

The scion is put into the hole.

This is a suitable method for bottle gourd.

(3) Cleft grafting

The seedling age for grafting is the same in case of cutting method on bottle gourd.

The stock of pumpkin is used when first foliage leaf start appearance.

The stock is removed growing point and cut a gap of 1.5 ∿ 2.0 cm in length on one side of upper portion of stem.

The scion is cut 1.5 cm long and shaved thinly on both side of stem.

The scion is put into the gap of stock, and the section of both seedlings are combined and fixed with grafting clip.

(C) Relation of seeding time of scion and stock

In order to prepare stock and scion which is suited to grafting in seedling age, seeding time of both seedling must be controlled. According to difference of temperature of raising of seedling, it isn't constant but the relation is roughly shown in the Table 1.

Table 1. Period of raising of seedling for grafting

Method of grafting	Scion or stock	Period of incubation before grafting	Temperature of germination
Clip	Watermelon	17 ∿ 19 days	25 ∿ 30 °C
	Bottle gourd	13 ∿ 14	26 ∿ 27
	Pumpkin	10 ∿ 11	26 ∿ 27
Cutting	Watermelon	7 ∿ 8	25 ∿ 30
	Bottle gourd	12 ∿ 13	26 ∿ 27
	Pumpkin	-	-
Cleft	Watermelon	7 ∿ 8	25 ∿ 30
	Bottle gourd	12 ∿ 13	26 ∿ 27
	Pumpkin	10 ∿ 11	26 ∿ 27

(D) Control after grafting

In order to obtain high rates of taking root, the sufficient control must be carried out after grafting.

(1) In case of clip grafting

The control after grafting can be done easily.

It is desirable that humidity in air is kept on about 100%.

The grafted plants must be covered shading with black colored cheesecloth when light intensity is too strong.

The stem of scion are cut off in 11 ∿ 17 days after grafting. When scion wither, half of stem is cut off and remained half is cut off after 2 ∿ 3 days.

(2) In case of cutting and cleft grafting

No taking root is expected when severe control is not done for temperature is kept at 25 ∿ 27 °C and the humidity is kept on 100% in a week.

(E) Judgement of grafting affinity

The grafting affinity is distinguished to two kinds, they are in a narrow sense and in a wide sense. In a narrow sense, grafting in compatibility is

expressed such as a decline in rate of taking root and in rate of an increase of plant height and number of leaf. The grafting incompatibility this type can be detected in an early stage of growing period.

This is more clear when the cotyledon of stock is cut off.

On the other hand, grafting in compatibility in a wide sense is appeared by aggravation of physiological condition after fruiting, and is expressed such as decline of growth, wilting, deterioration of fruit quality.

The detection of incompatibility of this type is impossible in an early stage.

The method is possible only by cultivation in the field.

1. Expt. No. 1: Screening of suitable stock varieties to superior scion watermelon variety 'Sugar Baby'.

(1) OBJECTIVE

This experiment was conducted to select desirable stock varieties against 'Sugar Baby' variety which has been recognized superiority on performance and early maturing in Bangladesh.

(2) MATERIALS AND METHODS

The species and variety of stock used were shown in Table 2.

The grafting was done by clip method on February 12 ∿ 13, 1982 when pumpkin and bottle gourd of stock and scion were respectively 9 ∿ 10, 11 ∿ 12, 16 ∿ 17 days old.

The plants were grown under vinyl tunnel after grafting for keeping humidity.

(3) RESULTS AND DISCUSSION

The result of survinal rate was shown in Table 2. Difference among species of survinal rate was observed only a little and higher tendency was shown in bottle gourd.

Difference of survinal rate was also observed among varieties in same species. In cucurbita sps. 'Shinkho' showed highest rate while 'local No.3' was lowest in rate.

In Lagenaria leucantha, many varieties except 'Yashu No.2' showed comparatively higher rate.

The result on grafting affinity was shown in Table 3. All varieties of Lagenaria leucantha showed high compatibility while in cucurbita sps. only 'No.8' showed comparatively higher compatibility. Degeneration of growing point and growth of lateral bud were observed in some scion varieties of cucurbita sps. which the compatibility is low.

'Local No.3' could not be used for stock.

Table 2. Survival rates of Suger Baby grafted different stock

Species & varieties of stock	No. of plants grafted	Successful No. of plant	Graft %	No. of unsuccessful graft
A. Cucurbita moschata				
1. Shinkho	15	12	80.0	1
2. No. 8	15	9	60.0	1
3. Local No. 3	10	3	30.0	1
B. Cucurbita hybrida				
1. Tetsukabuto	15	11	73.3	1
C. Lagenaria leucantha				
1. FR-Aioi	15	13	86.7	1
2. Taibyo FR-7	15	11	73.3	1
3. Kyoryokuchoju	15	13	86.7	2
4. Yashu No. 2	5	3	60.0	1
5. Taiwanchochutai	15	13	86.7	0
6. Taiwantangyutai	15	12	80.0	0

Table 3. Effect of different stock varieties on growth of scion variety 'Sugar Baby'

Species & varieties of stock	Cutting off of cotyledon	Plant height days after grafting 16	21	Length increased between 16 and 21		No.of leaf days after grafting 16	21	Leaves No. increased between 16 and 21	
A. Cucurbita moschata		cm	cm	cm	(%)				(%)
1. Shinkho	+	4.9	6.8	1.9	(38.8)	3.3	5.2	1.9	(57.6)
	-	5.2	6.9	1.7	(32.7)	3.6	5.1	1.5	(41.7)
2. No. 8	+	6.3	10.0	3.7	(58.7)	3.7	5.6	1.9	(51.4)
	-	5.8	8.3	2.5	(43.1)	3.5	4.3	0.8	(22.9)
3. Local No. 3	+	-	-	-	-	-	-	-	-
	-	3.3	4.3	1.0	(30.3)	2.3	4.0	1.7	(73.9)
B. C.hybrida									
1. Tetsukabuto	+	4.6	7.7	3.1	(67.4)	3.2	4.9	1.7	(53.1)
	-	4.5	6.6	2.1	(46.7)	3.0	4.6	1.6	(53.3)
C. Lagenaria leucantha									
1. FR-Aioi	+	8.4	13.8	5.4	(64.3)	4.3	5.6	1.3	(30.2)
	-	8.7	14.5	5.5	(63.2)	4.3	5.8	1.5	(34.9)
2. Taibyo FR-7	+	7.9	11.9	4.0	(50.6)	4.1	6.1	2.0	(48.8)
	-	7.1	12.3	5.2	(73.2)	3.9	5.8	1.9	(48.7)
3. Kyoryoku choju	+	10.8	15.9	5.1	(47.2)	4.3	5.9	1.6	(37.2)
	-	11.2	20.2	9.0	(80.4)	4.5	6.4	1.9	(42.2)
4. Yashu No. 2	+	-	-	-	-	-	-	-	-
	-	7.5	11.0	3.5	(46.7)	4.3	6.0	1.7	(39.5)
5. Taiwan chochutai	+	8.9	13.8	4.9	(55.1)	4.1	5.6	1.5	(36.6)
	-	8.8	14.4	6.0	(68.2)	4.2	6.4	2.2	(52.4)
6. Taiwan tangyutai	+	6.3	9.8	3.5	(55.6)	4.2	6.0	1.8	(42.9)
	-	6.9	11.6	4.7	(68.1)	4.1	6.2	2.1	(51.2)

2. Expt. No. 2: Grafting response on different combination of scion and stock

(1) OBJECTIVE:

This experiment was planed to select the stock variety which showed higher grafting compatibility when 3 scion varieties of different origin were grafted with 6 stock varieties in two species.

(2) MATERIALS AND METHODS:

The species and varieties used were shown in Table 4.

The grafting was done by clip method on February 17, 1982 when the seedling of pumpkin, bottle gourd and watermelon were respectively 9, 11 and 16 days old. The number of scion was insufficient as the germination of watermelon didn't be uniform.

(3) RESULTS AND DISCUSSION:

The survival rates were shown in Table 4.

As the number of grafting per combination was insufficient the result couldn't reach conclusion.

However some low rate was observed in 'Local No.3' against 'Sugar Baby', 'Yashu No.2' against 'Kaho' and 'No.8' against 'Patenga'.

The result on grafting affinity was shown in Table 5.

It was also observed in this experiment that many varieties of Lagenaria leucantha were superior stock for watermelon.

However the observation at this stage only mean compatibility in narrow sense. The grafted plants must be planted in the field spreaded of fusarium wilt and after this compatibility in wide sense and effect of resistant variety against Fusarium oxysporum f. niveum can be concluded.

Table 4. Survival rates of grafted plants at different combination

Name of scion variety	Species & varieties of stock	No. of plants grafted	Successful No. of plant	Graft %	No. of unsuccessful graft
1. Sugar Baby	A. Cucurbita sps.				
	1. No. 8	5	4	80.0	1
	2. Tetsukabuto	5	4	80.0	1
	3. Local No. 3	5	3	60.0	1
	B. Lagenaria leucantha				
	4. Kyoryokuchoju	5	5	100.0	0
	5. Yashu No. 2	5	5	100.0	0
	6. Tsugitop	5	5	100.0	0
2. Kaho	A. Cucurbita sps.				
	1. No. 8	5	4	80.0	1
	2. Tetsukabuto	5	4	80.0	0
	3. Local No. 3	5	5	100.0	0
	B. Lagenaria leucantha				
	4. Kyoryokuchoju	5	4	80.0	0
	5. Yashu No. 2	5	3	60.0	0
	6. Tsugitop	5	5	100.0	0
3. Patenga	A. Cucurbita sps.				
	1. No. 8	5	3	60.0	0
	2. Tetsukabuto	5	5	100.0	0
	B. Lagenaria leucantha				
	5. Yashu No. 2	5	4	80.0	0
	6. Tsugitop	5	5	100.0	0

Table 5. Difference of growth of plants grafted at different combinations

Name of scion variety	Species & varieties of stock	Plant height Days after grafting 12		17		Length increased between 12 and 17		No. of foliage leaf Days after grafting 12		17		Leaf No. increased between 12 and 17	
1. Sugar Baby	A. Cucurbita sps.												
	1. No. 8	3.2	(84.2)	4.0	(63.5)	0.8	(25.0)	2.5	(88.7)	3.5	(88.2)	1.0	(40.0)
	2. Tetsukabuto	3.4	(89.5)	4.9	(77.8)	1.5	(44.1)	2.6	(92.2)	3.8	(95.7)	1.2	(46.2)
	3. Local No. 3	2.9	(76.3)	3.7	(58.7)	0.8	(27.6)	2.6	(92.9)	3.7	(93.2)	1.1	(42.3)
	B. Lagenaria leucantha												
	4. Kyoryoku choju	4.6	(121.1)	8.4	(133.3)	3.8	(82.6)	3.0	(106.4)	4.2	(105.8)	1.2	(40.0)
	5. Yashu No. 2	4.1	(107.9)	6.8	(107.9)	2.7	(65.9)	3.1	(109.0)	4.2	(105.8)	1.1	(35.5)
	6. Tsugitop	4.6	(121.1)	10.0	(158.7)	5.4	(117.4)	3.1	(109.9)	4.4	(110.8)	1.3	(41.9)
	(mean value)	3.8	(100.0)	6.3	(100.0)	2.4	(100.0)	2.8	(100.0)	4.0	(100.0)	1.2	(100.0)
2. Kaho	A. Cucurbita sps.												
	1. No. 8	3.4	(122.3)	4.8	(101.1)	1.4	(41.2)	2.6	(110.6)	3.0	(96.8)	0.4	(15.4)
	2. Tetsukabuto	2.3	(82.7)	4.5	(94.7)	2.2	(95.7)	1.9	(80.9)	2.8	(90.3)	0.9	(47.4)
	3. Local No. 3	2.3	(82.7)	4.0	(84.2)	1.7	(73.9)	2.4	(102.1)	3.0	(96.8)	0.6	(35.0)
	B. Lagenaria leucantha												
	4. Kyoryoku choju	2.8	(100.7)	5.3	(111.6)	2.5	(89.3)	2.4	(102.1)	3.3	(106.5)	0.9	(37.5)
	5. Yashu No. 2	3.0	(107.9)	5.0	(105.3)	2.0	(66.7)	2.5	(106.4)	3.3	(106.5)	0.8	(32.0)
	6. Tsugitop	2.9	(104.3)	4.9	(103.2)	2.0	(69.0)	2.3	(97.9)	3.2	(103.2)	0.9	(39.1)
	(mean value)	2.8	(100.0)	4.8	(100.0)	2.0	(100.0)	2.4	(100.0)	3.1	(100.0)	0.7	(100.0)
3. Patenga	A. Cucurbita sps.												
	1. No. 8	2.6	(74.7)	3.3	(55.7)	0.7	(26.9)	2.1	(72.9)	3.3	(84.0)	1.2	(57.1)
	2. Tetsukabuto	2.6	(74.7)	4.0	(67.6)	1.4	(53.8)	2.5	(86.8)	3.6	(91.6)	1.1	(44.0)
	B. Lagenaria leucantha												
	5. Yashu No. 2	4.0	(114.9)	6.8	(114.9)	2.8	(70.0)	3.1	(107.6)	4.0	(101.8)	0.9	(29.0)
	6. Tsugitop	4.7	(135.1)	9.6	(162.2)	4.9	(104.3)	3.8	(122.1)	4.8	(122.1)	1.0	(26.3)
	(mean value)	3.5	(100.0)	5.9	(100.0)	2.5	(100.0)	2.9	(100.0)	3.9	(100.0)	1.1	(100.0)

3. Expt. No. 3: Comparison of 3 kinds of grafting methods.

(1) OBJECTIVE:

This experiment are conducted to compare with relative merits of 3kinds of grafting methods and to master grafting technique.

(2) MATERIALS AND METHODS:

'Sugar Baby' and 'Otome' were grafted with 6 stock varieties.

The seedling of watermelon, bottle gourd and pumpkin were used respectively 8. 14 and 11 days old.

The grafting was done on February 20, 1982.

(3) RESULTS AND DISCUSSION:

Under the condition of high temperature and low humidity, both methods of cutting and cleft were resulted unsuccessfully but in clip method, 60 ∿ 80% of taking root was obtained.

The clip method might be use in bud condition for temperature and humidity.

3. Screening of Cucumber Germplasm for CMV Resistance

OBJECTIVE:

In Bangladesh cucumber is a very important Vegetable through dry and rainy seasons as namely Khira and Shosha. CMV has a wide host range and in specially cucurbitaceous vegetables of cucumber, bottle gourd, watermelon, pumpkin and etc., give rise to considerable damage.

Nevertheless there has been no study in this regard to screen out the resistant varieties from local and exotic cucumber.

The purposes of this experiment are to develop the method of screening for resistance and to screen resistant varieties.

(A) Collection and identification of causal viruses

(a) Collection of the infected plants

In the 14th and 25th, January 1982, plants which seemed to be infected with virus disease were collected from the fields of Kashimpur B.A.D.C (Dacca) and Joydepur (B.A.R.I.).

11 Isolates were collected from 5 crops which appeared severe mosaic symptom in the newly developed leaf. New leaves contained growing point must be used because activity of causal virus has already decreased in old symptom.

Origin of 11 isolates was shown in Table 6.

Table 6. Origin of 11 isolates

Name of isolate	Host plant	Grade of mosaic symptom	Date of collection	Place of collection
I - 1	Cucurbita moschata	severe	14. 1. '82	Kashimpur
I - 2	-do-	very severe	-do-	-do-
I - 3	Lagenaria leucantha	severe	-do-	-do-
I - 4	-do-	very severe	25. 1. '82	Joydebpur
I - 5	-do-	-do-	-do-	-do-
I - 6	Cucurbita moschata	severe	-do-	-do-
I - 7	-do-	very severe	-do-	-do-
I - 8	Lycopersicum esculentum	-do-	-do-	-do-
I - 9	Capsicum annum	severe	-do-	-do-
I - 10	-do-	very severe	-do-	-do-
I - 11	Solanum melongena	severe and yellowish	-do-	-do-

(b) Raising of seedling of indicator plant

The indicator plant which classify kind of viruses infected to cucumber, namely CMV, WMV.CGMMV, must be grow from the seed in non infectious condition.

The plants grown in the fields can't be used because contamination with another viruses must be avoided. All so in the seedlings grown from seed, it is necessary to be protect from contamination with aphids.

The seedling is desirable to be grown softly.

Age of indicator plant to be inoculated is different in kind of species but in generally, optimum stage is between 3 ∿ 4 and 7 ∿ 8 leaves.

(c) Kinds of indicator plants and identification of causal viruses

Three kinds of virus, CMV.WMV.CGMMV. are known widely as pathogen against cucumber in the world. Cucumber is received single or complex infection by these pathogenic viruses.

Although there are many method for identification of kind of virus, sap inoculation to indicator plant is a superior method for simplicity and stability.

In this method sap contained virus is inoculated to some kinds of indicator plants and kind of virus are identified with appearance of systemic or local symptom on the inoculated and its upper leaves.

The kind of indicator plant and its symptom type which can identified kind of virus against cucumber are shown in Table 7.

Table 7. Kind of indicator plants and its symptom type for viruses of cucumber

Species of virus	Chenopodium amaranticolor		Datura stramamonium		Nicotiana glutinosa		Citrullus vulgaris		Solanum melongena	
	A	B	A	B	A	B	A	B	A	B
CMV	L	-	-	M	-	M	L	-(M)	-	M
WMV	L	-	-	-	-	-	-	M	-	-
CGMMV	-	-	L	-	-	-	-	M.N	-	-

A: Inoculated leaf M: Mosaic L: Local lesion
B: Upper leaf N: Necrosis -: No symptom

(d) Identification of collected virus isolates

Some kind of indicator plants and some varieties of cucumber were inoculated by eleven virus isolates collected. The symptom appeared on only three virus isolates. I-4,' I-5,' I-7,' and it could be determine that I-5.' is CMV. Reaction of indicator plant against I-5,' was shown in Table 8.

Table 8. Symptom type of some indicator plants against 'I-5'

Species of indicator plant	Symptom type on inoculated leaf	Symptom type on upper leaf
Chenopodium amaranticolor	local	no symptom
Datura stramonium	no symptom	mosaic
Nicotiana glutinosa	no symptom	mosaic
Nicotiana tabacum (Samson)	no symptom	mosaic
Cucurbita moschata (Shinko)	no symptom	mosaic
Solanum melongena	no symptom	mosaic

(e) Multiplication of inoculum

Many plants can be used for propagation of virus but it is suitable to use seedling of 5 ∿ 8 leaves stage of N.tabacum var. 'Samson', 'White Bariey' 'KY-57' when plenty of inoculum are required for testing.

Two or three leaves of Nicotiana tabacum are inoculated for propagation of virus and its upper leaves are used for inoculum of testing after 7 ∿ 10 days because virus particle increase maximum content.

(f) Methods of sap inoculation by smear

(1) Preparation of apparatus

The apparatus must be dry sterilized for protecting from contamination with another pathogenic viruses. Following apparatus must be prepared. 1) Mortar and Pestle, 2) Carborundum (600 ∿ 1000 mesh), 3) small ball (ϕ 5 ∿ 10 mm) of absorbent cotton, 4) Gauze, 5) sterilized water on 0.1M neutral phosphoric acid buffer soliction, 6) Ice and ice box.

(2) Preparation of sap solution

Procedure for preparing of sap solution is as follows:
1 ∿ 3 gram of leaves appeared symptom are added with 10 mℓ of distilled water or 0.1M neutral phosphoric acid buffer solution and ground sufficiently in mortar by pestle. Crude sap solution ground leaves are filtered with 1 ∿ 2 pieces of gauze. Sap solution can be diluted 100 times with distilled water if activity of virus particle is increased to maximum concentration.

Storage of sap solution is better under low temperature condition.

(3) Method of inoculation

Small boll of absorvent cotton is dipped with sap solution and spread with carborundum.

Surface of leaf is smeared slightly 2 ∿ 3 times with this cotton ball.

If intensity of smear is too weak infection rate decrease while leaves die in case of severe intensity after inoculation, inoculated leaves must be washed with distilled water before becoming dry.

The temperature of incubation is desirable at 20 ∿ 30 °C.

(B) Screening of resistant cucumber varieties against CMV.

A. Experiment No. 1

(a) Objective

To study resistance of local varieties and reaction of Japanese standard varieties to CMV strain 'I-5'.

(b) Materials and methods

Thirteen varieties of cucumber were used in Experiment No. 1.

The names and origin of these varieties are shown in Table 9. Seeds were first germinated in the incubator and then sown in wooden boxes of size 40 cm x 25 cm x 10 cm filled with sterilized soil.

Seedlings were grown under temperature of 27 °C in day 24 °C in night in phytotron until appearing symptom.

Seedlings were inoculated with sap concentration of 5 times at cotyledonary stage in the 2nd February, 1982.

Observation on the disease development were done 6, 9 and 13 day after inoculation, and the degree of the disease development of each variety was expressed by using disease index and percentage of infected seedlings. Disease index was calculated by the following formula.

Disease index (D. I)

$$\frac{\text{Total number of symptom class in each point}}{\text{Maximum number of symptom class (5)} \times \text{Total number of investigated points}} \times 100$$

Symptom class was divided into 6 grades as follow:-

0. No symptom
1. Indistinctly mosaicing
2. Slightly, clearly mosaicing
3. Medium mosaicing
4. Severly mosaicing
5. Severly mosaicing with dwarfing or dead

(c) Results and Discussion

The results of the screening test were shown in Table 9.

Inoculation was done completely as high infection rates about 100% were obtained in P.I.. Symptoms began to appear 5 day after inoculation. Both symptom types of mosaic (systemic) and local lesions were observed.

However local lesion didn't show constant tendency among the individuals and the varieties.

Among the tested varieties, all Japanese and American varieties showed the grade of same resistance which was known in Japan.

'Santou' is a most resistant variety against all Japanese CMV strain.

Against Bangladesh CMV strain 'I-5' 'Santo' was also most resistant.

As some of local varieties especially 'Local No.4 and No.8' were less germination, obtained results were not clear.

All local varieties except 'Local No.8' were considerably susceptible as same as susceptible variety 'Aofushinari No.3' in Japan.

Table 9. Results of screening 13 cucumber varieties against CMV strain 'I-5'

Origin and name of variety	D. I. days after inoculation 6	9	13	P. I. days after inoculation 6	9	13
A. Bangladesh						
1. Local No. 1	24.0	37.0	67.0	100.0	100.0	100.0
2. Local No. 3	16.0	33.0	65.3	100.0	100.0	100.0
3. Local No. 4	30.0	40.0	76.7	100.0	100.0	100.0
4. Local No. 5	34.0	45.0	78.0	100.0	100.0	100.0
5. Local No. 8	0	16.7	37.5	0	83.3	100.0
B. Japan						
1. Santou	0	8.4	31.7	0	41.7	100.0
2. Aojibai	28.0	34.0	42.7	100.0	100.0	100.0
3. Shimoshirazu	24.0	26.0	44.0	100.0	100.0	100.0
4. Sadoritsushu	34.0	44.0	51.3	100.0	100.0	100.0
5. Harigaya	32.0	46.0	51.3	100.0	100.0	100.0
6. Aofushinari No. 3	60.0	62.0	71.3	100.0	100.0	100.0
C. America						
1. Model	90.0	90.0	100.0	100.0	100.0	100.0
2. Comance-7	76.0	82.0	86.0	100.0	100.0	100.0

B. Experiment No. 2

(a) Objective

1). To study resistance of local and Japanese standard varieties to another CMV strain 'I-4'.

2). To study resistance of group jibai and group aonaga in Japanese varieties which were expected usefulness in Bangladesh.

(b) Materials and Methods

Twentyone varieties of cucumber were used in experimental No. 2.

The names and variety groups of these varieties are shown in Table 10.

Seedling boxes were placed firstly in phytotron and after inoculation moved under natural condition. Seedlings at cotyledonary stage were inoculated in the 19th February, 1982.

CMV strain 'I-5' was used with sap concentration of 5 times but another strain 'I-4' was used with 7.5 times. Observation on the disease development were done at 5, 10 and 14 day after inoculation.

Investigations were done by same methods for Experiment No. 1.

(c) Results and Discussion

The results of the screening test No. 2 was shown in Table 10. The response of local varieties against both strains were somewhat lower than response on Experiment No. 1.

However, the resistance that is better than 'Santou' was not found in any local varieties. The result in local No. 1 was not clear for lacking number of seedling. Difference of pathogenicity between 'I-4' and 'I-5' could not be recognized fundamentally.

It was found that all varieties of group Aonaga were highly susceptible.

On the other hand, the varieties of group Jibai were comparably resistant and the growth of seedling was not inhibited but only a little.

The growth rates of local varieties was lower than the varieties of group Jibai.

From the view point of only resistance, utilization for germplasm of 'Sontou' were most favarable but from the view point of ecological reason, were considered that the varieties of group 'Jibai' were most suitable for breeding material.

Table 10. Results of screening 21 cucumber varieties against two CMV strains 'I-4', 'I-5'

Variety group and variety name	D.I.				P.I.			
	I-4		I-5		I-4		I-5	
	10	14	10	14	10	14	10	14
A. Bangladesh variety								
1. Local No. 1	-	-	12.5	32.5	-	-	75.0	100.0
2. Local No. 3	25.0	52.5	20.0	34.0	100.0	100.0	100.0	100.0
3. Local No. 5	26.0	50.0	34.0	41.3	100.0	100.0	100.0	100.0
4. Local No. 8	44.0	44.0	44.0	50.0	75.0	100.0	100.0	100.0
B. Kahoku group								
1. Santou	10.0	37.5	6.0	33.3	100.0	100.0	100.0	100.0
2. Sadoritsushu	40.0	51.3	56.0	55.0	100.0	100.0	100.0	100.0
C. Jibai group								
1. Aojibai	-	-	15.8	42.9	-	-	100.0	100.0
2. Shimoshirazu	35.0	46.0	34.0	48.7	100.0	100.0	100.0	100.0
3. Aonagajibai	20.0	25.0	25.0	45.0	75.0	100.0	100.0	100.0
4. Tokiwajibai	24.0	26.0	22.0	45.0	100.0	100.0	100.0	100.0
D. Aonaga group								
1. Aodai	45.0	50.0	42.0	72.5	100.0	100.0	100.0	100.0
2. Banseiaodai	40.0	80.0	40.0	67.5	100.0	100.0	100.0	100.0
3. Owariaodai	46.7	63.3	40.0	62.0	100.0	100.0	100.0	100.0
4. Kagaaobuto	65.0	77.5	60.0	76.0	100.0	100.0	100.0	100.0
E. Hanjiro group								
1. Sagamihanjiro fushinari	54.0	56.0	77.5	87.5	100.0	100.0	100.0	100.0
F. Aofushinari group								
1. Aofushinari No. 3	-	-	42.0	62.0	-	-	100.0	100.0
2. Harigaya	72.0	68.0	-	-	100.0	100.0	-	-
G. Hybrid F_1								
1. Chikanari santou	26.7	27.7	32.0	47.5	100.0	100.0	100.0	100.0
2. Konron	22.0	34.0	22.5	50.0	100.0	100.0	100.0	100.0
H. American variety								
1. Model	-	-	86.7	97.8	-	-	100.0	100.0
2. Comace-7	79.3	87.0	-	-	100.0	100.0	-	-

4. Investigation of the Causes and Its Control of Low Fruit Setting in Eggplant Cultivation During Rainy Season

OBJECTIVE:

Eggplant is the most important and widely consumed vegetable in Bangladesh, grown in rainy and dry seasons. But the production is received heavy damage under the condition of high temperature and high humidity because the fruit setting fall down and moreover the quality of fruit fall down.

Fruit setting and fruit thickening of eggplant are started after when normal embryo is formed and normal fertilization is carried out. Under the bud environmental condition in the rainy season, it is considerable that these factor is inhibited on any processes. If the relationship of environmental condition and (1) the frequency of appearance of short styled flower, (2) Rate of abortive pollen and pollen germination rate, (3) rate of pollen tube elongation in the style, (4) rate of fruit setting, are investigated, the causes of low fruit setting will be made clear.

As it is known that these type of low fruit setting and low fruit thickning are restored by treatment of any kind of plant growth regulator, methods of appropriate selection and utilization of plant growth regulator are examined.

Materials and Methods:

(A) Investigation of causes

(1) Relationship between appearance of short-styled flower, and temperature, solar radiation and nutrient condition

(2) Relationship between rate of normal pollen and germination rate of pollen, and temperature

(3) Relationship between pollen tube elongation in style and temperature

(B) Increase of fruit setting rate and promotion of fruit thickning with plant growth regulator

(1) A kind of plant growth regulator

(a) Tomato tone (DCPA 0.15%)

(b) Nasu leaf (2.4-D Na-salt 0.25% + 5-nitrosoguanicol Na-salt 0.3%)

(c) 2.4-D amine salt

(2) Method of treatment

(a) Mono flower treatment

(b) Foliar application treatment

(c) Concentration of application

(d) Effect of treatment

Fig. 1 Grafting of watermelon

Fig. 2 Maintenance of humidity after grafting

Fig. 3 Clip grafting method

Fig. 4 Cutting off of stock root

Fig. 5 Preparing of sap solution

Fig. 6 Inoculation of CMV by smear method

Fig. 7 Washing after inoculation

Fig. 8 Incubation after inoculation

Fig. 9 Raising seedling of indicator plant

Fig. 10 Indicator plant --- Nicotiana tabacum var. White Barley

Fig. 11 Indicator plant --- Nicotiana glutinosa

Fig. 12 Indicator plant --- Chenopodium amaraticolor

Fig. 13 Indicator plant --- Datura stramonium

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Fig. 17 Symptom of standard varieties inoculated with 'I-5'
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Sadoritsushu, Model

Fig. 18 Symptom of local varieties inoculated with 'I-5'
from left to right: Santou, Aofushinari No. 3, Local No. 1
Local No. 5, Local No. 8

Fig. 1

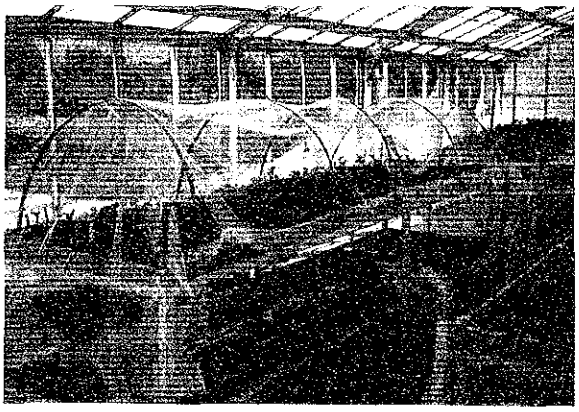

Fig. 2

Fig. 3

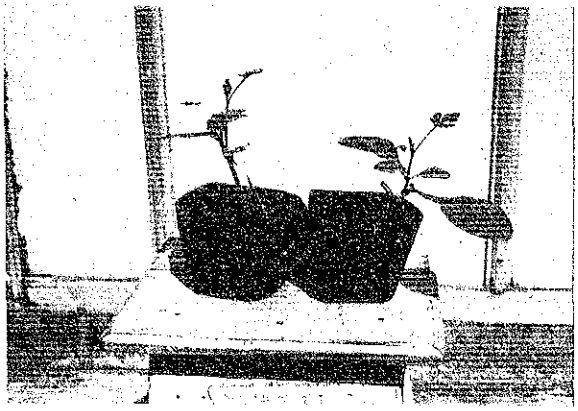

Fig. 4

Fig. 5

Fig. 6

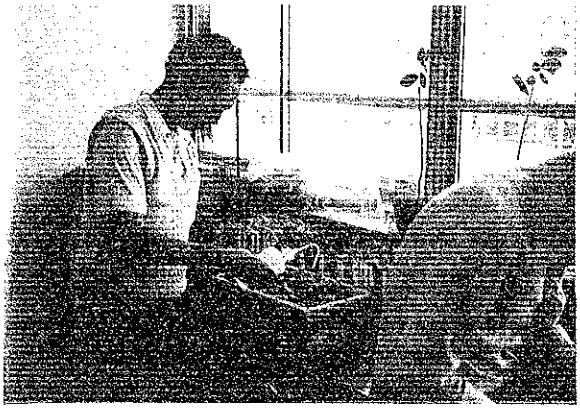

Fig. 7

Fig. 8

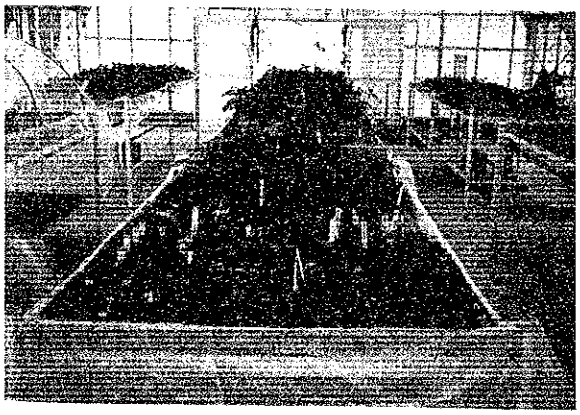

Fig. 9

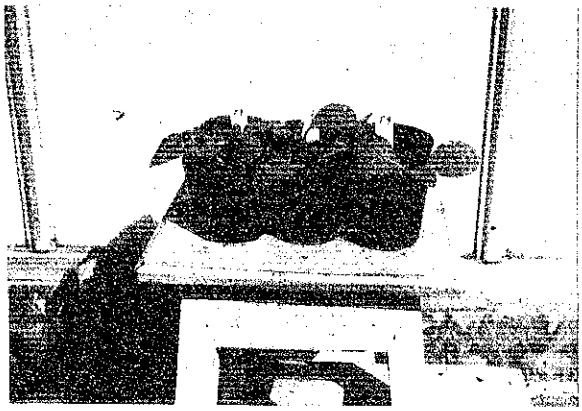

Fig. 10

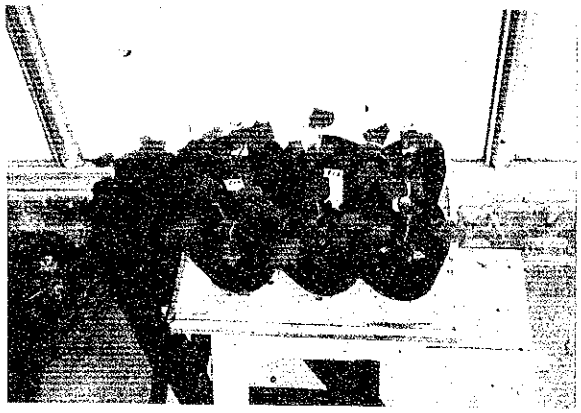

Fig. 11

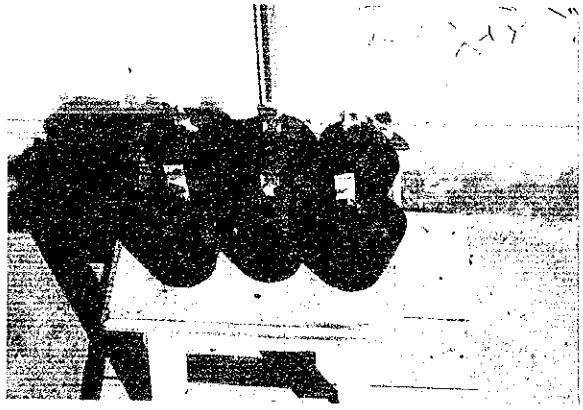

Fig. 12

Fig. 13

Fig. 14

Fig. 15

Fig. 16

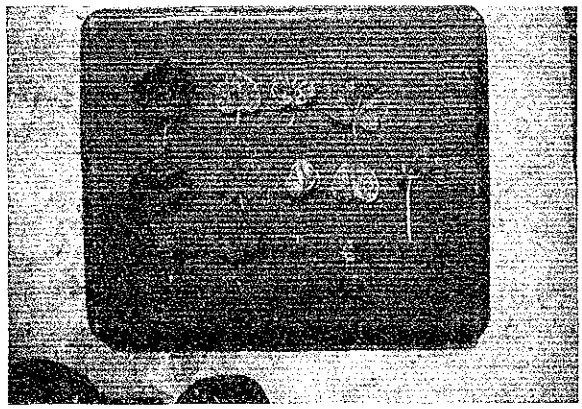

Fig. 17

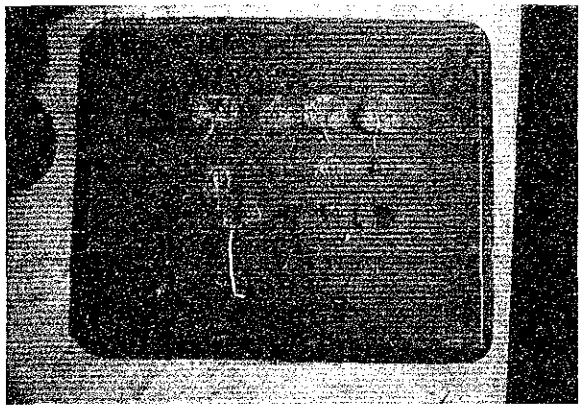

Fig. 18

Report on the Vegetable Breeding Works

Dec. 15, 1981 to Mar. 12, 1982

submitted by

Kenichi Hida

(Mr. Kenichi HIDA)

CONTENTS

1. Forward and Acknowledgement

As a short term vegetable exper for the technical cooperation on citrus and vegetable research project in Bangladesh, the writer was dispatched to CVSRSC (Citrus and Vegetable Seed Research Center) from December 15, 1981 to March 12, 1982, in order to investigate the problems of the vegetable breeding and research works in it, and to give the local researchers assistance to cope with them.

Actually the writer's main activities requested were the assistance for the mother plant selection of the radishes, planning of their succeeding breeding, and the following technical investigations.

Several technical problems had been already pointed out and listed in the report of the evaluation on the project. The subject of the investigation to be assigned to the writer was selected from them and materialized through the discussion with the local researchers. It was to establish the method of artificial low temperature treatment of radish seeds for their seed vernalization, combined with the technique of germination control during the treatment and the technique of vernalized seed preservation, in order to make the practical seed production of Japanese radishes possible in this country.

The writer introduced the basal idea and the experimental technique to Mr. Abul Hussain through the cooperation on this subject. This is the report on their experiments.

The writer wishes to express sincere gratitude to Mr. Aihara, Japanese team leader, Mr. S. Tasaki, long term vegetable expert, Mr. A Ahad Miah, S.S.O. of CVSRC, and the other expert and staffs of the project, for their heartfelt assistance in both the research works and the everyday living of the writer; to Dr. K.M. Badruddoza, Director of BARI (Bangladesh Agricultural Research Institute), and Dr. A. Hussain, P.S.O. of CVSRC, for their support to the writer's activities; to Dr. M. Rashid, Head of Horticultural Division of BARI, for his kind consideration during the writer's stay. Lastly, particular thanks are due to Mr. A. Hussain, who cooperated dilligently with the writer throughout this study.

2. Studies on the Seed Production of Japanese Radishes in Bangladesh by Means of Artificial Low Temperature Treatment of the Seeds, Combined with the Techniques of the Germination Control and the Vernalized Seed Preservation

Japanese radishes are nowadays gainning popularity in Bangladesh due to their high productivity and quality. But most of them can hardly produce seed under natural environment of this country, since the temperature is not sufficiently low for vernalization even in the most cool winter season. Thus, artificial low temperature treatment is required for the seed production of Japanese radishes.

It is well known that Japanese radishes can be vernalized with low temperature treatment of their seeds. Because the treatment can be done in a home refrigerator without very expensive facilities, the method is well feasible in this country. But when the technique is applied to the practical seed croping system, following two problems must be considered.

1) In the course of low temperature treatment, germination of seeds is frequently promoted by the unexpected increase of the temperature in a refrigerator caused by electric power failure which occurs frequently in this country. It is difficult to sow germinated seeds in wide fields without damage.

2) In the local districts where the radishes are to be grown for seed production, facilities for low temperature treatment are likely not available at present. Therefore, some institutes equipped with the facilities must undertake the treatment and distribute the vernalized seeds to those districts, although the circumstance may be improved in the future. Several days may be necessary for the distribution, and meanwhile the vernalized seeds must be preserved by some appropriate method.

Taking these problems into consideration, the writer planed experiments to establish the method of the artificial vernalization of Japanese radishes, combined with the germination control and the vernalized seed preservation techniques. There were six experiments in all. They were divided into three parts according to their contents and reported on each part.

2-1. Experiment on the methods of the germination control and the vernalized seed preservation

Material and Methods

In order to check the germination of seeds during low temperature treatment without any harmful effect on their germinability, following solutions were tested in place of pure water. (1) polyethylene glycol 4000* [abbreviated as PEG, hereafter abbreviations will be shown in square brackets, when they appear for the first time] 40%, (2) PEG 45%, (3) PEG 50%, (4) PEG 55%, (5) NaCℓ 11.6%, KCℓ 1.4%, $MgSO_4$ 5.1% ['Na.'], (6) KH_2PO_4 1/5M['K.'], (7) NaH_2PO_4 3.45%, Na_2HPO_4 8.95% ['P.'], (8) sucrose 33% ['Suc.'].

PEG is a kind of water soluble wax. It has been recently reported to be useful for the hastening of germination of many kinds of vegetable seeds with its one or two weeks treatment (during the treatment, germination is restrained). No. (5) to (8) are mentioned in 'Developmental physiology and cultivation technology of vegetables' compiled by N. Sugiyama (1967), as germination controlling solutions for the low temperature treatment of seeds.

The radish seeds of the variety 'Suikomi Ninengo' were put in petri dishes in which two sheets of filter paper were layed and 10 mℓ of each solution was added. The number of seeds in one petri dish was about 60.

The period of the low temperature treatment in a 5 °C refrigerator, which was also the period of the germination controlling treatment, was either (1) 4 days, (2) 8 days, or (3) 12 days. The germination controling solutions No. (5) to (8) were used only in the 12 days' plots.

As the vernalized seed preservation, following two methods were tried: after the low temperature treatment with each germination controlling solution, (1) the seeds were kept under room temperature without washing the solution off (that is, the petri dishes were merely transferred from the refrigerator to the laboratory without any additional treatment) - ['Wet'], or (2) the the seeds were washed and then dried in a dessicator with silica gel, kept there under room temperature - ['Dry']. The period of these seed preservations were eight days.

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* PEG 6000 is more frequently used for the control of germination, but only PEG 4000 was available during the writer's stay.

When the duration of the low temperature treatment is short or the variety is late bolting one, the seeds will not be sufficiently vernalized. Even in such cases, the above two methods will be mentioned, in this report, as the vernalized seed preservation regardless of the degree of their vernalization. The plots which do not include the seed preservation treatments (i.e. the seeds were sown just after the low temperature treatment or the germination controlling treatment) will be designated the 'no s.p.' plots.

The main experimental plots were consisted of the combinations of the above mentioned three factors: the kinds of germination controlling solution, the duration of low temperature treatment (equal to the duration of germination controlling treatment), and the method of the vernalized seed preservation. In addition to them, the plots in which seeds were treated with each solution under room temperature and sown just after the treatment ('no s.p.'), and as a control, a plot given pure water without any additional treatment were prepared. Plots without germination control during low temperature treatment were not planned, because it was shown in the preliminaly tests that radish seeds would germinate considerably in a 5 °C refrigerator when they were given pure water and kept there more than two weeks. This period is regarded as the shortest period for practical low temperature treatment of radish seeds for seed production.

When the given period of the seed preservation or the germination controlling treatment had finished, the seeds were washed (except those of the control and of the 'Dry' plots in which the seeds had been already washed) to be free from the solution, put on new filter paper, and supplied 10 mℓ pure water in each petri dish. The petri dishes were placed in the laboratory where the room temperature was approximately 13 (min.) ∿ 20 (max.) °C during the course of the experiment.

From this second sowing day, the number of germinated seeds in each plot had been counted once a day (9:00 ∿ 10:00 a.m.) for a week. Since larger part of the seeds had germinated within 24 hours after the sowing, the data were represented as the following three terms of germination percentage: (1) germination percentage just before the (second) sowing, (2) one day after the sowing, (3) one week after the sowing. Mean germination times (or days) could not be calculated from the data. Instead of it, the promptness of germination was indicated by the '1 day/1 week' term, the proportion of the germination

percentage one day after the sowing to that of one week after.

The plots were repeated twice, so that the total number of seeds in each plot was approximately 120. The first and the second sowing dates of each plot were shown in Figure 1.

Result and Discussion

The germination percentage of each plot was shown in Table 1.

PEG 40 to 55% solution completely restrained the germination of the seeds during its treatment either under 5 °C or room temperature without giving harmful effect to their germinability. Moreover, in some plots of the 'Wet' seed preservation, the PEG-treated seeds showed faster and higher percentages of germination (hereafter, when germination percentage is mentioned without specific notion, it means that of one week after the sowing) than the control. In contrast to the favorable effect of PEG, the other four solutions were proved useless for the purpose, because 'K.' and 'Suc.' could not check the germination during low temperature treatment, and 'Na.' and 'P.' completely deprived germinability of the seeds under both temperature. Hereafter only the treatments in which PEG was used will be mentioned.

In the 'Wet' plots, seeds were kept contact with PEG solution during both the low temperature treatment and after that until the end of the preservation, while in the 'Dry' plots, the seeds were washed PEG solution off at the end of the low temperature treatment. The effect of the concentration of PEG and the duration of the treatment under low temperature on their germination was naturally different between the two.

The germination of the 'Wet' plots was generally faster and higher in percentage than that of the 'Dry' plots, especially when the period of the low temperature treatment (i.e. germination controlling treatment under low temperature) was 4 to 8 days. The plots of PEG 45 to 50% - 8 days' low temperature treatment were even sperior to the control. The difference of the concentration of PEG from 40 to 50% did not cause significant difference of germination. But its increase up to 55% delayed the germination while the final germination percentage was higher in the 55% plots than in the rest. This delay of germination was remarkable by the 12 days' treatment. Except

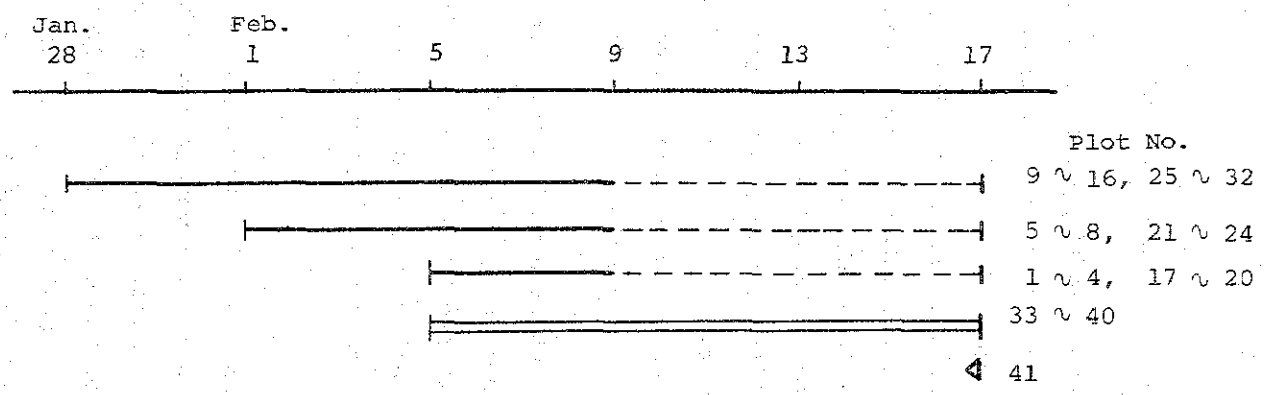

Fig. 1 The period of each treatment of Experiment 1

Table 1. Germination of radish seeds treated with several solutions during the low temperature treatment [L.T.T.] and preserved by the two methods under room temperature (Experiment 1)

Period of L.T.T.	Solution	Germination percentage of seeds preserved by the 'Wet' method					Germination percentage of seeds preserved by the 'Dry' method				
		Plot No.	Before sowing	1 day after sowing	1 week after sowing	1 day/[b] 1 week	Plot No.	Before sowing	1 day after sowing	1 week after sowing	1 day/[b] 1 week
			%	%	%	%		%	%	%	%
4 days	PEG 40%	1	0	70.3	78.9	89.1	17	0	50.8	71.0	75.5
	45%	2	0	43.2	77.9	94.0	18	0	44.4	69.1	63.6
	50%	3	0	55.2	68.5	80.4	19	0	41.2	68.9	64.4
	55%	4	0	54.6	85.5	63.2	20	0	51.0	80.6	64.4
8 days	PEG 40%	5	0	65.6	74.2	88.4	21	0	51.4	62.6	82.5
	45%	6	0	75.2	83.2	89.7	22	0	40.6	66.4	78.2
	50%	7	0	75.9	92.0	82.6	23	0		61.0	62.5
	55%	8	0	52.2	92.1	58.1	24	0		73.9	55.1
12 days	PEG 40%	9	0	60.4	71.7	84.2	25	0	59.2	70.4	83.2
	45%	10	0	46.9	68.4	68.6	26	0	49.5	62.6	76.6
	50%	11	0	53.1	70.8	75.0	27	0	66.3	79.6	83.9
	55%	12	0	27.7	74.5	37.2	28	0	37.0	71.7	50.9
12 days	Na.	13	0	0	0	-	29	0	0	0	-
	K.	14	30.3	54.5	69.7	62.1	30	-c	-	-	-
	P.	15	0	0	0	-	31	0	0	0	-
	Suc.	16	81.0	90.5	94.3	92.4	32	-c	-	-	-
		-- 'no s.p.' plots --									
12 days[a]	PEG 40%	33	0	65.8	71.2	72.4					
	45%	34	0	57.1	72.4	78.9					
	50%	35	0	54.6	67.0	81.5					
	55%	36	0	42.1	62.7	70.0					
12 days[a]	Na.	37	0	0	0	-					
	K.	38	69.7[d]	-	-	-					
	P.	39	0	0	0	-					
	Suc.	40	52.6[d]	-	-	-					
Control		41		55.8	75.7	73.7					

a: Period of germination controlling treatment under room temperature

b: (the number of germinated seeds 1 day after sowing/that of 1 week after sowing) x 100

c: Since the seeds had germinated during L.T.T., the 'Dry' preservation was impossible.

d: By the end of L.T.T., ungerminated seeds had been deteriorated.

this 55% plots, the promptness and the percentage of their germination of the 12 days' plots was about the same as those of the average 'Dry' plots.

In the 'Dry' plots, the difference of PEG concentration and the period of the low temperature treatment did not cause so much difference of germination as in the 'Wet' plots. They showed slower and lower percentage of germination than the 'Wet' plots of 4 to 8 days' low temperature treatment. But the promptness and the percentage of their germination was not significantly lower than that of the control. The delay of germination by the higher concentration (55%) of PEG was observed, but the degree of the delay was lower than that of the 'Wet' plots.

The germination of the 'no s.p.' plots, in which seeds were treated with PEG under room temperature for 12 days and then sown, was similar to the germination of the 'Wet'-12 days' plots. The germination percentage was not significantly different among the four levels of PEG concentrations, and the delay of germination with PEG 55% appeared strongly.

By this experiment, the effeciency of PEG treatment as a technique of germination control was confirmed. Also the possibility of the vernalized seed preservation was suggested at least for keeping germinability. There was variation of the percentage and promptness of germination according to the concentration of PEG, the duration of PEG treatment, and the method of vernalized seed preservation, but no combination of them significantly reduced the germinability when compared with the control.

Two plots of the 'Wet' seed preservation showed faster and higher percentage of germination than the control. Each plot had only two replication, which may be not enough to determine the difference of germination between each experimental plot and the control. But at least the hastening of germination with PEG treatment is a well-documented and reasonable phenomenon so that the favorable effect can be regarded valid.

By the 'Wet' method of the seed preservation, the germination of the seeds were restrained with PEG from the beginning of the low temperature treatment to the end of the seed preservation; the duration of the PEG treatment was the sum of that of the low temperature treatment and the seed preservation. In this experiment, it was maximum 20 days (12 days low temperature treatment plus 8 days' seed preservation). Since the germination control was complete

during the period with PEG 40% solution, the concentration over 40% is probably unnecessary. Also higher concentration of PEG than 55% will not be profitable, which delayed the germination though not reduced germination percentage. The effect increases with the increase of the duration of the treatment and is larger under room temperature than 5 °C. But it was not known whether the higher concentration of PEG is required or not for the longer periods of low temperature treatment and the seed preservation. It requires another experiments.

It is natural that the 'Dry' method check the germination during the preservation completely. It is possible regardless of the concentration of PEG solution during low temperature treatment, but if the germination control is incomplete, germinating seeds will be damaged by the drying and their germinability will be much reduced. Complete germination control during low temperature treatment is necessary for the 'Dry' method.

This experiment was a preliminary one, including only short durations of PEG treatment, the longest being 12 days; they were not the practical durations of low temperature treatment of Japanese radish seeds for seed vernalization. The optimum levels of the three factors are to be determined in combination with the longer duration of low temperature treatment with PEG, and also through the examination of the actual efficiency of the seed vernalization under the germination controlled condition. It will be discussed later.

2-2. Experiments on the methods of artificial low temperature treatment of the seeds, combined with the techniques of the germination control and the vernalized seed preservation

Materials and Methods

The effect of the following factors on the flowering of Japanese radishes (in some experiments also on the germination) was examined in the four experiments.

1) duration of low temperature treatment of seeds
2) gibberellin [GA] application to seeds and/or foliage
3) method of vernalized seed preservation
4) environment after sowing

Low temperature treatment of seeds was conducted in the same way as in Experiment 1. After the treatment or the seed preservation, the seeds were sown in 12 cm black polyethylene pots. The number of seeds per one pot was six. The periods of treatments and the dates of sowing were shown in Figure 2.

(a) Experiment 2:

Effects of the duration of low temperature treatment, the GA seed and/or foliar application, and the germination control with PEG on the flowering of the radish, variety 'Wakayama Shiroagari'.

This experiment was consisted of all the combinations (24 plots in all) of the four factors represented in Table 2.

Table 2. The factors and their levels of Experiment 2

Factor	Levels
Duration of low temperature treatment	2, 3 weeks
GA* seed application	-, + (50 ppm)
GA* foliar application	-, + (100 ppm, 3 times)
Concentration of PEG (during the low temperature treatment)	0, 5, 10%

* 'Gibberelin Kyoowa', which contains mainly GA_3

The seeds of each plot were supplied in a petri dish with 10 mℓ of either pure water or one of solutions which contained the given concentration of gibberellin and/or PEG, and set in the refrigerator for the given period. The concentration of PEG was set low, because the seeds were to be kept under 5 °C until sowing and its effect on vernalization was unknown.

In the plots including GA foliar application, GA solution was applied to the foliage of the radishes by hand spray three times after sowing. The first application was at the cotyledon full expansion stage (nine days after sowing) and the second was four days, the third was eight days after the first application. Each plot had six replication.

(b) Experiment 3:

Effect of the duration of low temperature treatment of seeds, and of the environment after sowing, on the flowering of six radish varieties which differs in their demand of low temperature for vernalization.

The varieties and the duration of low temperature treatment were shown in Table 3.

Table 3. The varieties and the duration of low temperature treatment of Experiment 3

Variety	Duration of low temperature treatment
Taiwan	10, 14, 18 days
Shiroagari Kiichi	10, 18 days
Kounou Shougoin	14, 18 days
Awa Bansei	14, 18 days
Taibyou Nishimachi	18 days
Motohashi Minawase	18 days

The seeds of all the varieties were obtained from Japanese seed companies but 'Taiwan' is originally a Formosan variety. The seeds of each plot were equally supplied with 10 mℓ of PEG 15%-GA 50 ppm solution and set in the refrigerator for the given period. After the treatment, the seeds were washed and sown in the pots, which were placed either in a open grass house shaded by white paint- ['Shade'], or in the open terrace in front of the grass house-

['Open']. In the former, the temperature was about 15 (min.) ∿ 28 (max.) °C, and the light intensity was 6,000 lux at noon; in the latter, the minimum and the maximum temperature were about the same as those of the former, and the light intensity was 65,000 ∿ 80,000 lux at noon.

(c) Experiment 4:

Effect of the germination controlling treatment with different concentration of PEG and the method of the vernalized seed preservation on the germination and the vernalization of the radish, variety 'Everest'.

The method of the vernalized seed preservation were the same as mentioned in Experiment 1. After the 10 days' low temperature treatment with 30, 40 or 50% PEG, the seeds were either sown in pots (the 'no s.p.'), or preserved by the 'Dry' or the 'Wet' methods for 10 days. As a control, the plot of the 'no s.p.' without PEG treatment was added. Low temperature treatment of all the plots started at the same time. Consequently the sowing of the 'Dry' and the 'Wet' plots was 10 days later than the sowing of the 'no s.p.' plots. It was due to the circumstances of the experimental facilities. The germination was examined one week after sowing. Each plot had four replications.

(d) Experiment 5:

Effect of the GA seed application, the germination control, and the duration of the vernalized seed preservation on the germination and the vernalization of the radish, variety 'Taiwan'.

Seeds were supplied with GA 0, 100 or 200 ppm solution. They were either sown just after the 10 days' low temperature treatment (the 'no s.p.') with or without PEG 40% solution, or preserved by the 'Wet', the 'Dry' or the ['WP'] methods for 4 or 9 days under room temperature. The former two methods were the same as were mentioned previously. In the 'WP' method seeds were not treated with PEG during the low temperature treatment but PEG was added after the low temperature treatment to their petri dishes, which were then kept under room temperature. Germination percentage was measured both just before (in petri dishes, except the 'Dry' plots) and one week after sowing (in pots). In this experiment, the seeds were sown in pots at the same time, as is shown in Figure 2.

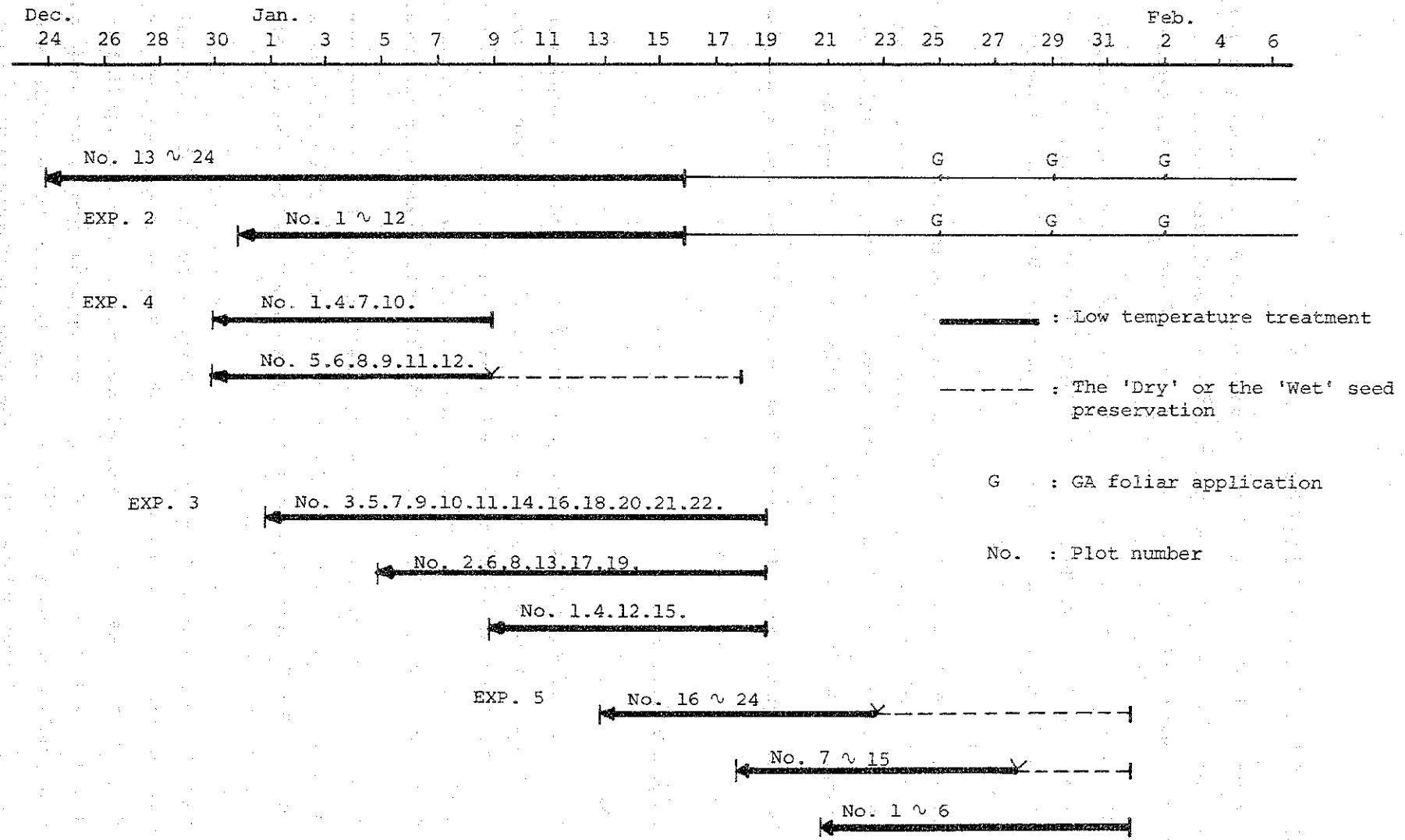

Fig. 2. The Period of each treatment of Experiment 2. 3. 4 and 5

Notes Common to the Four Experiments

Though each plot was replicated four or six times after sowing in pots, the replication was incomplete in the sense that seeds for one plot were treated in one petri dish, due to the shortage of number of petri dishes.

The plants of Experiment 2, 4, 5 and the 'Shade' plots of Experiment 3 were at first set in the open grass house and later transferred to the outside in front of the grass house (February 17), because the plants had become too succulent.

It may be more common that 'bolting' implies unexpected stem elongation in ordinary radish cultivation for root production. Also 'flowering' may indicate flower bud initiation. In this report, however, by 'bolting' was meant simply stem elongation, and by 'flowering' flower bud opening.

Data were taken every four days from the days of the first appearance of bolting.

Result and Discussion

(a) Experiment 2:

The result of Experiment 2 was shown in Table 4. While the plants were grown in the shaded grass house, they became succulent. Although they had begun bolting in rather short time, their stem elongation was slow. When they were moved to the outside under direct sunshine, their growth once stopped, but after a few days they began vigorous stem elongation and soon flowered.

The plots of the 23 days' low temperature treatment showed higher percentages of bolting and flowering than those of the 17 days' on every date of examination. The difference between them were larger in the flowering percentages than in the bolting percentages.

Both the GA 50 ppm seed application and the GA 100 ppm foliar application proved to be effective for the promotion of bolting and flowering. The effect of each application was clearly observed when both of them were applied in combination as well as when one of the two was applied singly; the seed- and the foliar application worked additively. The degree of the promotion was not significantly different between them. The promotion appeared more clearly in

Table 4. Effect of the duration of low temperature treatment [L.T.T], the GA seed [GAs] and/or foliar [GAf] application, the germination control with PEG on the bolting and flowering of the radish, variety 'Wakayama Shiroagari' (percentage bolting [p.b.] and flowering [p.f.])

L.T.T.	GAs	PEG	GAf	No.[c]	2/3[a] (18)[b] p.b.	2/6 (21) p.b.	2/11 (26) p.b.	2/15 (30) p.b.	2/20 (35) p.b.	2/25 (40) p.b.	2/25 (40) p.f.	3/1 (44) p.b.	3/1 (44) p.f.	3/3 (46) p.b.	3/3 (46) p.f.	3/8 (51) p.b.	3/8 (51) p.f.
					%	%	%	%	%	%	%	%	%	%	%	%	%
17 days	-	-	-	1	0	0	0	0	3.4	9.6	0	9.6	0	-[d]	-	-	-
			100ppm	2	0	34.0	62.8	81.6	91.2	94.1	0	94.1	3.4	-	-	-	-
		5%	-	3	0	0	0	5.6	5.6	5.6	0	16.7	0	16.7	0	23.3	5.6
			100	4	0	18.0	45.7	71.6	77.8	77.8	0	80.8	0	80.8	6.7	80.8	6.7
		10%	-	5	0	0	0	3.9	7.2	10.5	0	57.4	7.2	65.1	11.1	65.1	18.2
			100	6	0	35.5	57.4	85.7	96.4	96.4	0	100.0	11.8	100.0	34.3	100.0	41.4
	50ppm	-	-	7	11.1	48.5	79.0	79.0	84.0	84.5	0	91.7	21.0	917	31.0	91.7	36.5
			100ppm	8	5.9	77.5	100.0	100.0	100.0	100.0	0	100.0	8.8	100.0	43.1	100.0	43.1
		5%	-	9	0	14.3	20.5	71.4	71.4	85.7	0	85.7	14.3	85.7	14.3	85.7	14.3
			100	10	0	53.5	65.3	94.4	94.4	94.4	0	94.9	11.1	94.5	53.5	94.5	53.5
		10%	-	11	0	21.0	35.4	55.5	62.1	72.4	0	82.3	10.0	86.2	27.4	86.2	27.4
			100	12	4.2	58.3	70.8	83.3	91.7	91.7	0	100.0	25.0	100.0	29.2	100.0	33.3
23 days	-	-	-	13	0	7.1	17.0	44.2	77.2	77.2	0	80.4	39.7	80.4	74.1	83.5	80.4
			100ppm	14	0	59.5	93.3	96.7	100.0	100.0	0	100.0	37.6	100.0	100.0	100.0	100.0
		5%	-	15	0	10.0	27.1	42.9	82.1	82.1	0	96.4	32.1	96.5	96.5	96.5	96.5
			100	16	15.3	46.8	75.6	88.8	100.0	100.0	0	100.0	35.1	100.0	95.5	100.0	95.5
		10%	-	17	0	10.5	24.9	36.4	46.9	76.9	0	80.8	20.5	80.8	65.7	80.8	65.7
			100	18	0	53.5	90.9	95.5	95.5	100.0	9.1	100.0	50.0	100.0	80.1	100.0	80.1
	50ppm	-	-	19	63.3	93.3	96.7	96.7	96.7	100.0	0	100.0	65.5	100.0	93.4	100.0	93.4
			100ppm	20	73.3	100.0	100.0	100.0	100.0	100.0	0	100.0	50.8	100.0	90.9	100.0	95.8
		5%	-	21	25.0	75.0	83.3	95.8	95.8	95.8	0	95.8	41.7	96.5	79.8	100.0	84.5
			100	22	30.7	86.4	86.4	90.9	95.5	100.0	0	100.0	50.0	100.0	95.5	100.0	95.5
		10%	-	23	11.9	48.1	71.8	92.0	92.0	100.0	0	100.0	25.0	100.0	63.8	100.0	72.1
			100	24	33.4	71.3	76.3	88.8	100.0	100.0	0	100.0	30.0	100.0	88.8	100.0	88.8

a: Date of observation b: Number of days from sowing c: Plot number d: The data were missed.

their earlier stage of bolting than in flowering. In the observation earlier than February 16, the presence or absence of GA application caused more difference of bolting percentage than the difference of the duration of the low temperature treatment, though for the flowering of the later observation, the latter affected more than the former.

The 23 days' low temperature treatment plus GA seed- or foliar application could completely induce the vernalization of this variety. When both methods of GA application was combined, the bolting became earlier. Forty-six days after sowing, they flowered 80 to 90%, and the rest were also expected to flower eventualy.

Although the seed- and the foliar application of GA were highly effective, the flowering percentages 51 days after sowing were much lower in the plots of 17 days' low temperature treatment than in the 23 days' even when the both methods of GA application were combined.

PEG 5 to 10% solution were not sufficiently effective for germination control, almost all of the seeds having germinated at the end of the 17- and the 23 days' low temperature treatment. Their effect on vernalization were also not great, but there was a slight tendency to lower percentage of bolting and flowering in the plots treated with PEG.

From these results, it can be said that under similar condition as this experiment, the radish variety 'Wakayama Shiroagari' requires more than 23 days' low temperature treatment of the seeds to be vernalized completely, if GA is not given. When GA is given to the seeds or the foliage parts, 23 days' low temperature treatment is enough, but longer period of the treatment will be necessary under germination controlled condition with PEG.

This period of low temperature treatment necessary for the complete floral induction of this variety is longer than that expected from the data obtained in Japan by many researchers. It is partly because of the short photoperiod under which this experiment was conducted. This condition is inevitable because the winter when the daylength is short is the sole possible season for radish seed production. Another reason is the disturbance of the seedling growth, which is common to the 'Shade' plots of Experiment 3, Experiment 4 and 5. As mentioned earlier, the plants were transferred abruptly from the shaded environment to another environment under direct shunshine, which disturbed

their development considerably. It may have caused devernalization of some plants. If they had grown normally, the time necessary for flowering could as well have been shorter.

(b) Experiment 3:

The result of Experiment 3 was shown in Table 5.

The solution of PEG 15% -GA 50 ppm give to all the plots did not control their germination sufficiently, and larger part of the seeds have germinated by the end of the low temperature treatment.

The plots set under the shaded grass house ('Shade') showed earlier bolting than those under direct sunshine ('Open'). But the growth of the former was succulent as mentioned earlier, and subsequent stem elongation was much retarded even after the flower buds had become visible. On the contrary the plants of the latter grew fairly hard, and after the stem elongation had visibly appear, their growth was so quick that flowering was earlier in all the plots of the latter than in the corresponding plots of the former.

Variety 'Taiwan', which belongs to South Chinese group and was the earliest bolting one in this experiment, bolted completely or almost completely by the 10 to 18 days' low temperature treatment in both the 'Open' and the 'Shade' plots, though it was much earlier in the 14- and the 18 days' plots than in the 10 days'. The 14- and the 18 days' plots showed almost the same degree of bolting and flowering in both the 'Open' and the 'Shade' plots. In the 'Open' plots of those durations of the low temperature treatment, all the plants flowered within 36 days after sowing. The flowering of the 'Shade' plots were delayed, and 47 days after sowing, they flowered about 80%. In the 10 days' plots, though they bolted 100% ultimately, the bolting was slower than in the 14- or the 18 days'. Their flowering were much more delayed, especially in the 'Shade' plots. Although in the 'Open' plots, their flowering percentages reached 90% forty-seven days after sowing, in the 'Shade' plots none of them flowered.

'Shiroagari Kiichi' bolted 100% in the 'Shade', 91% in the 'Open' plots by the 18 days' low temperature treatment. In contrast, flowering percentage was only 35% in the former while it was 100% in the latter. They did not bolt at all by the 10 days' low temperature treatment in both the 'Open' and the 'Shade' plots.

Table 5. Effect of the duration of low temperature treatment [L.T.T.] and the after-sowing environment on the bolting and flowering of six radish varieties which differs in their demand of low temperature for vernalization (percentage bolting [p.b.] and flowering [p.f.])

Variety	Period of L.T.T.		Shaded (the 'Shade' plots)										Not shaded (the 'Open' plots)									
			2/4[a] (16)[b]	2/9 (21)	2/12 (24)	2/24 (36)	3/1 (41)		3/4 (43)		3/8 (47)			2/12 (24)	2/17 (29)	2/24 (36)	3/1 (41)		3/4 (43)		3/8 (47)	
		No.[c]	p.b.	p.b.	p.b.	p.b.	p.b.	p.f.	p.b.	p.f.	p.b.	p.f.	No.	p.b.	p.b.	p.b.	p.f.	p.b.	p.f.	p.b.	p.f.	p.b.	p.f.
	days		%	%	%	%	%	%	%	%	%	%		%	%	%	%	%	%	%	%	%	%
	10	1	9.1	30.3	30.3	65.9	91.3	0	100.0	0	100.0	0	12	8.7	8.7	90.9	0	100.0	68.2	100.0	27.7	100.0	90.9
Taiwan	14	2	56.7	86.4	86.4	95.5	95.8	12.5	95.8	54.1	95.8	81.8	13	95.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	18	3	43.9	87.1	91.4	95.5	100.0	4.6	100.0	13.7	100.0	87.1	14	90.9	95.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Shiroagari	10	4	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0
Kiichi	18	5	20.0	60.0	60.0	95.0	95.0	0.5	100.0	10.0	100.0	35.0	16	17.0	61.4	91.3	56.1	91.3	70.9	91.3	86.8	91.3	91.3
Kounou	14	6	11.0	29.2	63.9	69.4	69.4	0	69.4	0	69.4	0	17	6.3	12.5	60.0	0	78.6	0	78.6	64.0	78.6	71.3
Shougoin	18	7	25.0	75.0	91.7	100.0	100.0	0	100.0	0	100.0	0	18	18.8	60.7	92.9	6.3	78.6	55.0	100.0	86.6	100.0	100.0
Awa	14	8	0	24.1	52.7	100.0	100.0	0	100.0	0	100.0	0	19	0	0	0	0	8.7	0	8.7	0	8.7	0.5
Bansei	18	9	8.3	62.5	95.8	100.0	100.0	0	100.0	0	100.0	0	20	0	17.5	23.8	0	28.8	23.8	35.0	23.8	41.3	30.0
Taibyou Nishimachi	18	10	0	33.9	46.4	92.9	92.9	0	92.9	0	92.9	0	21	0	0	12.5	0	12.5	12.5	12.5	12.5	25.0	12.5
Motohashi Minowase	18	11	0	47.2	70.1	94.4	94.4	0	94.4	0	94.4	0	22	0	0	22.2	0	33.3	0	33.3	16.7	33.3	22.2

a: Date of observation b: Number of days from sowing c: Plot number

'Kounou Shougoin' bolted 100% by the 18 days' low temperature treatment in both the 'Shade' and the 'Open' plots. 69% plants in the 'Shade', and 78% plants in the 'Open' plots bolted by the 14 days' low temperature treatment. While almost all of the bolted plants of the 'Open' plots flowered 47 days after sowing, none of the 'Shade' plants flowered.

Bolting percentages of the varieties 'Awa Bansei, Taibyou Nishimachi, Motohashi Minawase' by the 18 days' low temperature treatment were much higher in the 'Shade' plots, in which they exceeded 90%, than in the 'Open' plots, in which they were below 40%. But more than half of the bolted plants flowered in the 'Open' plots, in spite of lower percentages of bolting. On the other hand, larger part of the bolted plants in the 'Shade' plots stopped their stem elongation and did not flower at all.

It was not clear whether or not the shading prevented the devernalization of the young seedlings at any rate. Though the bolting percentages of the medium to medium-late bolting varieties were higher in the 'Shade' plots than in the 'Open' plots, many plants in the former stopped their stem elongation at about 0.5 to 1.0 cm long. Since low light intensity under warm temperature promotes succulent stem elongation independently of vernalization, the results are not the valid proof for the shading effect to prevent devernalization.

But it cannot be said that such incomplete bolting had no relation to vernalization, because when the duration of the low temperature treatment was too short for a variety, as was the case for the 'Shiroagari Kiichi'- 10 days' plot, visible stem elongation did not occured at all even under the 'Shade' condition. Probably the degree of vernalization will be properly compared on the basis of the bolting percentage including those incomplete bolting, though the accuracy of experiment may be reduced, so far as the plots to be compared with each other are not different in their growing condition or some factors which affects stem elongation other than low temperature. It is, however, not the present case.

When the necessary durations of low temperature treatment for each varieties are estimated based on the result of this experiment, the plants of the 'Open' plots were free from the problem of the disturbance of the growth mentioned in Experiment 2. The effect of the mixed solution of GA and PEG was not known since it was applied to all the plots. But judging from the result

of the former experiment, the vernalization-promoting effect of GA had been probably to some expent set off by PEG.

It has been already known that the variety 'Taiwan', which was included in this experiment as a representative of very early bolting variety, can flower under natural environment of the winter of this country without artificial low temperature treatment. The treatment is practically unnecessary for the seed production of this variety.

Without low temperature treatment, they flower after they have aged to complete enlargement of their roots. When earlier seed production by young plants is required, the low temperature treatment is useful. Considering the result that although they flowered by the 10 days' low temperature treatment, the flowering was much delayed compared with the flowering of the 14 days', and that the flowering of the 14 days' and the 18 days' were nearly equal, it can be said that 10 days is the shortest duration of the low temperature treatment which can manifest its direct influence, and the vernalizing effect reaches its maximum level by the treatment of up to 14 days.

For the flowering of 'Kounou Shougoin', the 14 days' low temperature treatment is not enough. By the 18 days', they flowered 100% in the 'Open' plots but not in the 'Shade' plots at all. Probably 18 days is the shortest period of the treatment for their flowering.

The necessary condition for the flowering of 'Shiroagari Kiichi' is thought to be not very different from that of 'Kounou Shougoin'. But it is a closely related variety to 'Wakayama Shiroagari' of Experiment 2 and possibly require longer duration of low temperature treatment.

The flowering percentage of 'Awabansei' was low, and more than 18 days' low temperature treatment is necessary for this variety. 'Awa bansei' is usually regarded as medium-early bolting, and the one tested here may have been a later bolting line.

'Taibyou Nishimachi' and 'Motohashi Minawase' are medium-late bolting varieties and flowered little by the 18 days' low temperature treatment. They will require much longer period of the treatment for their flowering.

(c) Experiment 4:

The results were shown in Table 6.

Germination in petri dishes during the low temperature treatment and the 'Wet' seed preservation:

The seeds not treated with PEG had germinated completely in the petri dishes by the end of the 10 days' low temperature treatment, while those treated with 30 to 50% PEG did not germinate at all during the same period of the low temperature treatment and, in the 'Wet' plots, during the 10 days' preservation as well.

Germination after sowing in pots:

The germination percentages of the 'Wet' plots one week after the sowing in the pots were 76 ∿ 84%, which was about 10% lower than that of the 'no s.p.'. The seeds of the 'Dry' plots showed higher germination percentages almost equal to that of the 'no s.p.'. It might be because some of the smaller or malformed seeds had been removed beforehand. There was not significant difference of germination among the plots of the three levels of PEG concentration.

Bolting and flowering:

Since the 'no s.p.' plots had been sown 10 days earlier than the 'Dry' and the 'Wet' plots, their bolting and flowering were compared separately.

The plants of all the 'no s.p.' plots in which the seeds were sown in pots just after the low temperature treatment bolted 100% at the end of the experiment (58 days after sowing). Among them, while plot 1 which had not treated with PEG showed 100% flowering, the plants of plot 4 in which the seeds had been treated with PEG 30% solution flowered only 17.6%, and those of plot 7 with PEG 40%, plot 10 with PEG 50% did not flowered at all.

All the plants of the 'Dry' and the 'Wet' plots also did not flowered, regardless of the concentrations of PEG (30 to 50%). But the bolting percentage was a little higher in the PEG 30% plots than in the plots of higher concentrations of PEG. The difference of the bolting percentage between the two methods of the seed preservation was irregular and no clear tendency could be seen.

Table 6. Effect of the germination control with PEG and the method of vernalized seed preservation [S.P.] on the germination and the bolting and flowering of the radish, variety 'Everest' (percentage bolting [p.b.] and flowering [p.f.])

PEG	S.P.	No.[c]	Germination percentage (in pots)	2/5[a] (27)*[b] (18) p.b.	2/10 (32)* (23) p.b.	2/15 (37)* (28) p.b.	2/20 (42)* (33) p.b.	2/24 (46)* (37) p.b.	3/4 (54)* (42) p.b.	3/4 (54)* (42) p.f.	3/8 (58)* (47) p.b.	3/8 (58)* (47) p.f.
				%	%	%	%	%	%	%	%	%
-	-	1*	-d	39.8	95.5	95.5	100.0	100.0	100.0	41.7	100.0	100.0
30%	-	2*	86.8 ± 4.1	0	4.6	18.4	40.2	61.0	100.0	0	100.0	16.7
	'Wet'	3	79.2 ± 5.5	0	4.2	8.4	20.8	20.8	20.8	0	66.7	0
	'Dry'	4	87.5 ± 4.1	0	0	0	37.5	45.8	45.8	0	79.2	0
40%	-	5*	93.0 ± 3.3	4.2	25.4	25.4	25.4	29.9	34.1	0	100.0	0
	'Wet'	6	84.4 ± 4.8	0	0	0	0	0	0	0	6.3	0
	'Dry'	7	94.1 ± 2.7	0	0	0	20.8	20.8	25.0	0	41.7	0
50%	-	8*	93.6 ± 3.3	0	0	0	5.0	9.2	34.2	0	100.0	0
	'Wet'	9	75.2 ± 5.4	0	4.2	8.3	29.2	41.7	41.7	0	41.7	0
	'Dry'	10	84.3 ± 4.0	0	0	4.2	8.4	8.4	8.4	0	8.4	0

a: Date of observation

b: Number of days from sowing, the upper rank is for plot No. 1, 2, 5, 8 (with *), the lower rank is for the rest (without *)

c: Plot number

d: Not counted. (The seeds had been already germinated in petridishes)

Since the germination could be completely restrained with PEG 30% solution during the 18 days' treatment (10 days' low temperature treatment plus 8 days' preservation under room temperature) in the 'Wet' plots, the concentration of 30% is enough for the treatment.

Germination control with PEG clearly showed inhibitory effect on the seed vernalization, and the degree of the inhibition increased with the increase of its concentration. It seems to affect considerably on the vernalization when the concentration of PEG is high enough to check germination completely.

The effect of the 'Dry' and the 'Wet' methods of seed preservation was not clear because their sowing date was not the same as that of the 'no s.p.' plots. But under the insufficiently vernalized condition of this experiment, they did not seem to act very inhibitory when the effect of the germination control was deducted.

The 10 days' duration of the low temperature treatment can be regarded as the critical duration for the floral induction of the variety 'Taiwan'. It is likely because of this critical condition that the adverse effect of PEG appeared strongly. Longer period of low temperature treatment is surely necessary for complete floral induction when PEG is used for the germination control.

(d) Experiment 5:

The results were shown in Table 7.

Germination in petri dishes during low temperature treatment:

The seeds treated with PEG 40% solution during the 10 days' low temperature treatment did not germinate at all in the petri dishes until the end of it. Without PEG, however, about 30% of the seeds had germinated by the end of the treatment, as was shown in the result of plots 1 to 3.

Germination in the petri dishes during the 'WP' and the 'Wet' seed preservation under room temperature:

The seeds of the 'WP', which were kept in the petri dishes and given PEG 40% solution after the low temperature treatment, germinated considerably during the 4- and the 9 days' preservation under room temperature, and the germination percentage was much higher in the plots with GA 100 ∿ 200 ppm

Table 7. Effect of the GA seed application [GA], the germination controlling treatment and the duration of the vernalized seed preservation [S.P.] on the germination and the bolting of the radish, variety 'Taiwan'

S.P.	PEG[a]	GAs	No.[b]	Germination percentage		Bolting percentage			
				c	d	2/22[e] (21)[f]	2/26 (25)	3/3 (30)	3/6 (33)
				%	%	%	%	%	%
-	0%	0 ppm	1	28.3	81.7	0	3.0	3.0	23.5
		100	2	28.3	71.7	8.4	30.6	33.3	72.2
		200	3	33.3	65.0	3.0	36.8	35.3	70.6
-	40%	0 ppm	4	0	82.1	0	0	0	27.4
		100	5	0	38.6	7.7	7.7	11.6	54.6
		200	6	0	88.3	0	0	0	22.2
4 days 'WP'	0%	0 ppm	7	53.6	69.6	0	0	0	51.1
		100	8	80.3	54.1	0	10.3	13.8	37.1
		200	9	77.2	59.6	0	17.2	24.4	68.5
4 days 'Dry'	40%	0 ppm	10		81.7	5.6	8.4	16.7	36.6
		100	11		81.7	0	0	0	33.7
		200	12		85.0	0	13.9	22.2	53.6
4 days 'Wet'	40%	0 ppm	13	1.7	63.3	0	0	0	21.3
		100	14	93.3	1.7*[g]	-	-	-	-
		200	15	92.9	14.3*	-	-	-	-
9 days 'WP'	0%	0 ppm	16	15.0	68.3	3.6	3.6	3.6	35.0
		100	17	60.0	38.3	0	0	4.6	64.5
		200	18	50.0	55.0	6.7	6.7	20.0	73.3
9 days 'Dry'	40%	0 ppm	19		75.0	0	0	0	8.4
		100	20		80.0	0	0	0	38.9
		200	21		85.0	0	0	0	30.6
9 days 'Wet'	40%	0 ppm	22	1.7	90.0	0	0	0	23.3
		100	23	94.0	0 *	-	-	-	-
		200	24	93.0	0 *	-	-	-	-

a: PEG during the low temperature treatment

b: Plot No.

c: Germination percentage just before sowing (in petri dishes)

d: Germination (or sprouting) percentage one week after sowing (in pots)

e: Date of observation

f: Number of days from sowing

g: The seeds had been deteriorated before sowing

than in those without GA. In the 'Wet' plots, the seeds which were not given GA showed almost no germination, while those which were given GA, in spite of PEG 40% treatment, germinated more than 90% as early as 4 days after low temperature treatment.

Germination after sowing in pots:

The germination (or sprouting) percentages counted one week after sowing in pots were about 80% in the 'no s.p.', the 'Dry', and the 'Wet' plots without GA. Those of the 'WP' was somewhat lower. In the 'Wet' plots with GA, most of the seeds had already germinated during the low temperature treatment, and deteriorated through the propagation of fungus and bacteria during the 4- or the 9 days' preservation; their sprouting percentage were naturally low.

Bolting and flowering:

As the result of the former experiment showed, 10 days' low temperature treatment was not enough to vernalize the variety 'Taiwan' when their germination was checked with PEG. But in this experiment, the bolting was very slow even in the plots without PEG and no flowering was observed at all in every plot.

Promotion of bolting by GA seed application was observed as well as in the former experiments, but only a few plants elongated their stems more than 1 cm. No clear difference of the effect was found between the 100 and 200 ppm solution.

In the 'no s.p.' plots, those treated with PEG (40%) showed less bolting than those without PEG. Among the seed preservation plots, the plants of the 'WP' bolted more than those of the 'Dry'. Since the GA treated plots of the 'Wet' method were lost, the 'Wet' had only one plot without GA treatment, the bolting of which was also less than that of the 'WP'.

As to the duration of the seed preservation, the average bolting percentages of the 4 days' and the 9 days' 'WP' plots were not significantly different from those of the 'no s.p.' plots (without PEG). On the other hand, the bolting percentages of the 9 days' 'Dry' were lower than those of the 4 days' 'Dry' and the 'no s.p.' plots (with PEG).

The adverse effect of PEG was indicated again and no flowering could be observed at all. But in this experiment, even those plots without PEG treatment showed only incomplete bolting, while in Experiment 4, the variety 'Everest' which is a closely related one to the variety 'Taiwan' had shown 100% flowering with the same duration (10 days) of low temperature treatment without PEG. 'Everest' in Experiment 4 and 'Taiwan' in the present experiment are very closely related varieties, and the necessary condition for their vernalization can be regarded almost the same.

Also 'Taiwan' flowered almost 100% in Experiment 3 by the 10 days' low temperature treatment, though the seeds were supplied GA and lower concentration of PEG solution. Probably the difference of the results was largely because this experiment was conducted later than Experiment 3 and 4, and the temperature after-sowing had already increased. It suggests that by the critical duration of low temperature treatment, the ambient temperature after-sowing is very important for their completion of vernalization.

GA supplied to the seeds promoted their germination considerably and PEG 40% solution could not restrained the germination. When GA is applied in the same manner, the 'Wet' seed preservation is impossible.

The 'WP' method was originary planned to examine the effect of PEG during or after low temperature treatment and was not intended to serve practical use. The result indicated that PEG treatment during low temperature treatment reduces the vernalizing effect but that after low temperature treatment does not affect it, and that the vernalizing effect does not decrease during the preservation under room temperature.

The drying of the low-temperature-treated seeds reduced the vernalizing effect. Though it was not very clear under the insufficiently vernalized condition, the reduction appeared significantly after the 9 days' drying. The 'Dry' seed preservation had two adversely affecting factors to vernalization - the germination control with PEG during low temperature treatment and the drying of low-temperature-treated seeds.

The 'Wet' plots resulted incomplete, but judging from the result of the 'WP', its effect on vernalization is probably less than that of the 'Dry'.

2-3. Experiment on the response of eighty-four Japanese radish varieties to artificial low temperature treatment of the seeds (Experiment 6)

Materials and Methods

Eighty-four Japanese radish varieties of not late bolting were selected (Exactly, some of them were Chinese radish varieties whose seeds were produced in Japan.). The seeds of them were put in petri dishes in each of which two sheets of filter paper were layed, and 10 mℓ of GA 50 ppm solution was added. They were kept in a refrigerator adjusted to 5 °C for 20 days. When the low temperature treatment finished, almost all the seeds had already germinated. They were planted carefully in 15 cm black polyethylene pots. When the seedlings had well established, they were thined to twelve plants per pot. For one variety, three pots were used.

The dates of the beginning and the ending of the low temperature treatment were January 5 and January 25, respectively. Data were taken every 4 or 5 days from February 11.

Result and Discussion

The bolting and flowering percentages of each variety was presented in Table 8. The results of February 27 and March 8 were summerized in Figure 3 and 4, respectively. There was clear difference of bolting and flowering percentage both between and within varietal groups.

The varieties of Minowase group tested here were found to flower easily by the present method of low temperature treatment except one variety. This group includes many late bolting varieties which are popular in Japan, but in this experiment, those varieties were excluded.

Though Nerima group as a whole showed slower bolting and flowering than the other groups, the earlyness of bolting was considerably different among types and varieties. All the varieties of Ookura type were found late bolting. None of them bolted more than 50% and the flowering percentage was still lower. They must require longer period of low temperature treatment for floral induction. Among varieties included in Miura type, there was much difference of the degree of flowering. While 'Shin Miura No. 1, -No. 2' flowered completely

Table 8. Bolting and flowering of 84 Japanese radish varieties with 20 days' low temperature treatment of seeds (percentage bolting [p.b.] and flowering [p.f.])

Variety	num.[c]	2/17[a](23)[b] p.b.	p.f.	2/22(28) p.b.	p.f.	2/27(33) p.b.	p.f.	3/4(38) p.b.	p.f.	3/8(42) p.b.	p.f.
Shijuunichi ('40 days') Group		%	%	%	%	%	%	%	%	%	%
Kaiware	30	83.3	0	90.0	6.7	100.0	66.7	100.0	86.7	100.0	90.0
Hakata 40 days	27	37.0	0	58.1	0	100.0	6.5	100.0	61.3	100.0	100.0
Tokkyuu Hinode	31	29.0	0	41.9	0	53.3	0	51.6	0	51.6	0
Minowase Group											
Kurobakei Minowase	3*[d]	66.7	0	66.7	0	66.7	0	66.7	66.7	66.7	66.7
Kuroba Soubutori Minowase	29	86.2	12.8	100.0	3.4	100.0	51.7	100.0	78.6	100.0	100.0
Kurobakei Shimura Minowase	34	100.0	0	100.0	23.5	100.0	85.3	100.0	100.0	100.0	100.0
Kuroba Choukei Minowase	5*	60.0	0	100.0	0	100.0	60.0	100.0	80.0	100.0	100.0
Shimurakei Minowase	20	100.0	0	100.0	0	100.0	40.0	100.0	80.0	100.0	100.0
Shimura Minowase	16	43.8	0	75.0	0	93.8	0	93.8	12.5	93.8	50.0
Goku Hayabutori 45 days	14	85.7	0	92.8	7.1	92.9	64.3	92.9	64.3	92.9	85.7
Taibyo Shin Minowase	18	72.2	0	100.0	5.6	100.0	33.3	100.0	66.7	100.0	100.0
Chuo Taibyou Minowase	15	0	0	20.0	0	53.3	0	53.3	0	60.3	60.3
Minonishiki Minowase	35	91.4	0	100.0	11.4	100.0	45.7	100.0	82.9	100.0	94.3
Minowase Natsu No.3	13	92.3	0	100.0	7.7	100.0	69.2	100.0	100.0	100.0	100.0
Minowase Shin No.3	32	93.8	0	96.9	0	96.9	43.8	96.9	71.9	96.9	87.5
Nerima G. -Ookura Type											
Akitsumari	29	0	0	0	0	0	0	3.4	0	3.4	0
MS Akitsumari	22	13.6	0	18.2	0	36.4	0	36.4	4.5	36.3	9.1
Choukei Akitsumari	29	0	0	17.2	0	17.2	0	24.1	6.9	24.1	13.8
Shinmachi Okutsumari	26	0	0	0	0	0	0	0	0	0	0
Akidomari	35	8.6	0	20.0	0	38.7	0	38.7	3.2	45.7	5.7
Bansou Soubutori	27	0	0	0	0	0	0	0	0	0	0
Ookura	33	6.1	0	21.2	0	25.0	0	25.0	3.1	25.0	18.2
Kairyou Ookura	23	4.3	0	13.0	0	39.1	0	39.1	0	39.1	8.7
Kounou Wase Ookura	30	3.3	0	3.3	0	3.3	0	3.3	0	3.3	0
Nerima G. -Miura Type											
Haru Hikari	13	0	0	0	0	38.5	0	38.5	0	38.5	0
Hayabutori Miyako	25	65.7	0	91.7	0	94.1	0	94.3	8.6	96.9	56.3
Nakabukura	33	18.2	0	72.9	0	87.9	5.1	87.9	31.3	87.9	54.5
Shin Miura	34	5.9	0	14.7	0	32.3	0	38.2	2.9	38.2	8.8
Shin Miura No. 1	30	46.7	0	100.0	6.7	100.0	6.7	100.0	100.0	100.0	100.0
Shin Miura No. 2	27	48.1	0	96.3	0	100.0	3.7	100.0	15.4	100.0	55.6
Shin Miura No. 3	29	100.0	0	100.0	3.4	100.0	44.8	100.0	100.0	100.0	100.0
Nerima G. -Risou Type											
Kairyou Risou	27	74.1	0	81.5	3.7	85.0	25.0	88.9	44.4	92.6	81.5
Kairyou Nishimachi	31	46.7	0	71.0	0	83.9	6.5	87.1	22.6	87.1	61.3
Shin Nishimachi Risou	18	77.8	0	94.4	0	100.0	11.1	100.0	27.8	100.0	88.9
Shin Risou	28	28.6	0	46.4	0	60.7	3.6	60.7	10.7	60.7	21.4
Joubu Risou	21	28.6	0	42.9	0	47.6	0	47.6	0	47.6	15.3
Miyoshi Risou	35	51.4	0	77.1	0	100.0	17.1	100.0	17.1	100.0	74.3
Gunma Risou	26	38.5	0	65.4	0	80.8	15.4	80.8	26.9	80.8	50.0
Kawage Risou	31	38.7	0	61.3	0	96.8	13.3	96.8	35.5	96.8	71.0
Kogarashi	31	0	0	9.5	0	23.8	0	23.8	0	23.8	0
Toujou	36	55.6	0	86.1	0	100.0	8.0	100.0	25.0	100.0	52.8
Tousui	35	54.3	0	91.4	0	100.0	2.9	100.0	8.6	100.0	45.7

Table 8 (continued)

Variety	num.[c]	2/17[a](23)[b] p.b.	p.f.	2/22(28) p.b.	p.f.	2/27(33) p.b.	p.f.	3/4(38) p.b.	p.f.	3/8(42) p.b.	p.f.
Nerima G. -Nerima Type		%	%	%	%	%	%	%	%	%	%
Nerima Oonaga	23	30.4	0	56.5	0	73.9	0	73.9	13.0	73.9	30.4
Hayabutori Nerima	25	56.0	0	92.0	0	92.0	19.2	92.0	48.0	92.0	92.0
Shiroagari Group											
Nezumi	34	2.9	0	20.6	0	44.1	2.9	51.5	9.1	60.5	50.0
Shiroagari Kiichi	30	26.7	0	86.7	6.7	93.3	56.7	93.3	63.0	96.7	83.3
Wakayama Shiroagari	28	14.3	0	64.3	0	92.9	28.6	96.4	28.6	96.4	75.0
Shirokubi Wakayama	10*	0	0	20.0	0	40.0	0	40.0	10.0	40.0	30.0
Miyashige G.											
Aokubi Niyashige Nagabuto	22	63.6	0	77.3	0	86.4	18.2	86.4	59.1	90.9	81.8
Taibyousei Aokubi Niyashige Nagabuto	20	45.0	0	80.0	0	90.0	50.0	95.0	60.0	95.0	80.0
Banchuukei Koba Miyashige Nagabuto	32	96.9	0	100.0	21.9	100.0	90.6	100.0	96.9	100.0	100.0
Miyashige Oonaga	35	14.3	0	48.6	0	66.7	6.7	76.5	23.5	77.1	45.7
Koba Miyashige Oonaga	23	78.3	0	82.6	4.3	95.7	60.9	95.7	91.3	95.7	95.7
Oonaga Miyashige	25	88.0	0	92.0	16.0	92.0	72.0	92.0	92.0	92.0	92.0
Miyashige Shirimaru	28	92.9	0	92.9	17.9	96.3	70.4	96.4	92.9	96.4	92.9
Choukei Miyashige Soubuto	21	95.2	0	95.2	9.5	95.2	95.2	95.2	95.2	95.2	95.2
Tankei Miyashige Soubuto	33	97.0	0	100.0	18.2	100.0	60.6	100.0	100.0	100.0	100.0
Izumi Hayabutori	33	93.9	0	100.0	12.1	100.0	84.8	100.0	93.9	100.0	100.0
Shirokubi Miyashige Shirimaru	35	97.1	0	100.0	14.3	100.0	97.1	100.0	97.1	100.0	97.1
Shougoin G.											
Wase Sunashi Shougoin	24	91.7	0	95.8	33.3	100.0	100.0	100.0	100.0	100.0	100.0
Heian Taibyou Wase Shougoin	21	95.2	0	100.0	9.5	100.0	76.2	100.0	95.2	100.0	100.0
Nakate Oomaru Shougoin	20	100.0	0	100.0	20.0	100.0	100.0	100.0	100.0	100.0	100.0
Shougoin No. 3	32	100.0	0	100.0	15.6	100.0	100.0	100.0	100.0	100.0	100.0
Shougoin Honmaru	31	100.0	0	100.0	0	100.0	87.1	100.0	100.0	100.0	100.0
Choukei Shougoin	25	96.0	0	100.0	0	100.0	92.0	100.0	92.0	100.0	92.0
Shin Oomaru Shougoin	27	100.0	0	100.0	0	100.0	74.1	100.0	88.9	100.0	100.0
Kounou Shougoin	26	100.0	0	100.0	50.0	100.0	100.0	100.0	100.0	100.0	100.0
Kunitomi	21	66.7	0	85.7	0	85.7	4.8	85.7	23.8	85.7	42.9
Awabansei G.											
Kounou Awabansei No. 3	29	100.0	0	100.0	3.4	100.0	86.2	100.0	100.0	100.0	100.0
Kounou Awabansei New No. 1	34	91.2	0	100.0	0	100.0	5.9	100.0	32.4	100.0	82.4
Katou	32	96.9	0	100.0	0	100.0	53.1	100.0	84.4	100.0	100.0
North Chinese G.											
Shina Ao	18	61.0	0	72.2	0	77.8	5.6	88.9	16.7	88.9	83.3
Nishiki Akamaru	35	100.0	0	100.0	0	100.0	60.0	100.0	88.6	100.0	100.0
South Chinese G.											
Kana	33	93.9	0	100.0	3.0	100.0	93.9	100.0	100.0	100.0	100.0
Taiwan	36	100.0	0	100.0	33.3	100.0	100.0	100.0	100.0	100.0	100.0
Man'you	35	100.0	0	100.0	57.1	100.0	97.1	100.0	100.0	100.0	100.0

a: Date of observation b: Number of days from sowing c: Number of plants examined

d: Data of the varieties marked with * were omitted in Fig. 6 and 7.

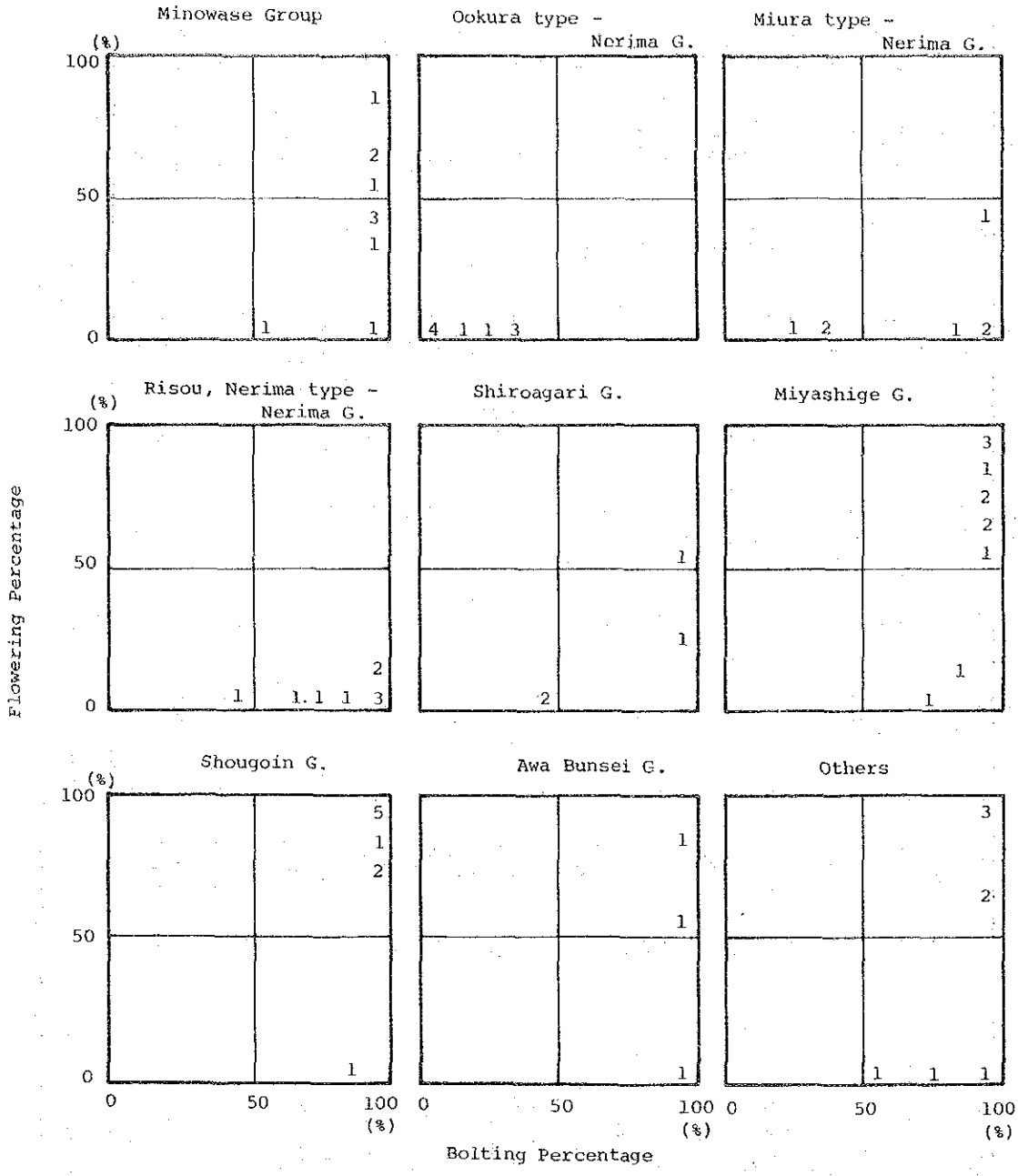

Fig. 3 Bolting and flowering of 84 Japanese radish varieties with 20 days' low temperature treatment; Feb. 27, 33 days after sowing
(The figures in the squares indicate the number of varieties)

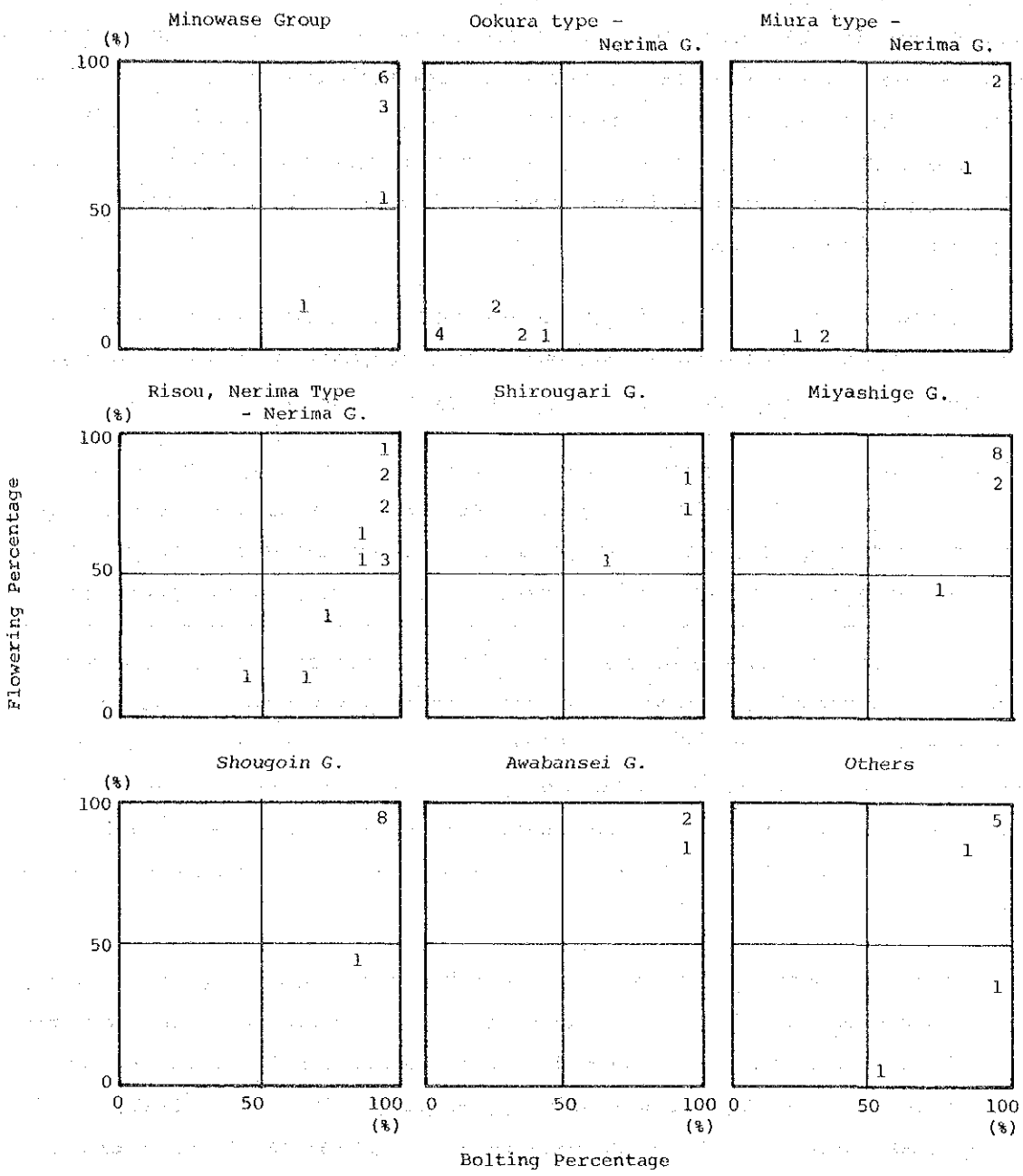

Fig. 4 Bolting and flowering of 84 Japanese radish varieties with 20 days' low temperature treatment; March 8, 42 days after sowing
(The figures in the squares indicate the number of varieties)

or almost completely, 'Haru Hikari' (though it is not a typical Miura variety) did not flower at all. There was also wide variation of bolting and flowering percentage among Risou type and Nerima type 'Hayabutori Nerima, Kairyou Risou, Shin Nishimachi Risou 'having flowered 80 to 90%, while 'Joubu Risou', Shin Risou', below 20%. But their bolting percentages were generally so high that most of them were expected to flower completely with a little longer duration of the low temperature treatment.

Miyashige group and Shougoin group are early flowering groups, and almost all the varieties flowered more than 80%. They can easily produce seeds in this country with the aid of artificial seed vernalization.

Varieties of Chinese group flowered early and completely, except 'Shina Ao' which belongs to North Chinese group. As for the others, Shiroagari group were proved medium early, Awabansei group and Shijuunichi group except 'Hinode' (which has the hybrid origin with European radishes) were early flowering.

By this experiment, the possibility of the radish seed production with artificial seed vernalization was confirmed for many varieties. Though late bolting varieties were excluded, practically almost all the morphologically representative types which are expected to adapt well to the cultivation in this country were tested here. This result can be well utilized for the selection of Japanese radish varieties to be popularized in Bangladesh in near future.

Since the purpose of the present research was to help the establishment of the seed production of Japanese radishes, all the varieties tried were true breds. F1 hybrids may not be required in this country, but some of the true bred varieties are nowadays seldom grown commercially in Japan. Practically important characters other than the earlyness of bolting should be examined by field observation, and the feasibility should be confirmed through the consideration on both their possibility of seed production and their field performances.

General characters and the possibility of seed production of each varietal groups or types are as follows.

A few varieties of South Chinese, Minowase and Miyashige group have been already introduced. Among them, South Chinese varieties have actually no problem on practical seed production. For this group, it is enough to select varieties of higher quality.

While larger part of the F1 hybrids of Minowase group are later bolting, the true bred varieties tested here were rather early bolting. Generally Minowase varieties grow comparatively well under moderately high temperature and mature early. Many of them projects their roots much on the ground. These characters are advantageous in the shallow cultivated soils of this country. Proper choice among these varieties will give good result, both in their root and seed production. But Minowase group is the one by which hybridization for F1 varieties has been most advanced and requires attention to the problem of true bred varieties. They are liable to become pithy earlier than the varieties of the other groups. Also their tapering tips are sometimes easy to branch. Therefore, the selections of variety must be done carefully.

All the varieties of Miyashige group have much projecting roots and are early bolting. They are well adaptable in this country. Among the Miyashige varieties, 'Soubuto' type will be most profitable in that they have cylindrical roots of middle length with round bottoms, which is expected to perform comparatively well in the shallow, compact soil.

Shogoin group had almost the same physiological characters as those of Miyashige group. They have round roots and can be grown in the most shallow soil.

Nerima group includes excellent true bred varieties which are still commercially grown in Japan. Since high yielding is very important in Bangladesh and the people are generally fond of large roots, Ookura and Miura types have great merits. But all the varieties of Ookura type flowered only incompletely by the 20 days' low temperature treatment. They have thick, cylindrical, projecting roots with round or flat bottoms, in which pithyness develops slowly. Such root character is very profitable. The seed production is the remainder problem. Miura type produces very large roots with round bottoms, but requires deeper cultivated soil. If soil condition allows, they will perform very well. Since considerable varietal difference of the earliness of bolting was observed, it is necessary to select early bolting ones. Riso type includes many excellent true bred varieties, which have projecting roots of medium length, with round bottoms. Their bolting are generally rather late, but they are expected to flower well by a little longer duration of low temperature treatment than 20 days.

In this experiment, PEG was not used and GA was applied, allowing the seeds to germinate during the low temperature treatment. It was because the maximum effect of the seed vernalization was to be examined. When PEG is used for germination control, the vernalizing effect will be reduced, as was shown by the results previously mentioned. Then, the necessary duration of low temperature treatment will be longer.

2-4. General discussion

Although the planning and the results of the experiments were incomplete due to the limited period of the experiments, as a whole they could afford useful information on the method of the artificial seed vernalization of Japanese radishes. But the techniques of the germination control during low temperature treatment and the vernalized seed preservation are at the start of the investigation and the result obtained through the experiments had given only introductory information for the succeeding researches. When the technique of artificial low temperature treatment of seeds is combined with them and put into the practical seed production system, there are still several problems which must be solved.

(a) Germination control

Since vernalizing seeds proved to germinate during the shortest period, (10 days) of low temperature treatment, germination control is regarded always necessary when most of Japanese radishes are to be vernalized.

Germination control is not very important so far as the number of seeds is not great, as is the case of laboratory experiment. But when they are sown in wide fields, they must not be germinated. It is much laborious and difficult for the farmers of this country to sow a large number of germinated seeds without injuring them.

Among the solutions for germination control tested here, PEG solution was proved to check the germination of radish seeds completely during its treatment without harmful effect on their germinability. Moreover, its treatment at a proper concentration hastened their germination and increased their germination percentage to some extent when sown after the treatment.

Apart from the present main purpose of the germination control, the latter effect of PEG treatment is practically useful for making their germination faster and more uniform in fields. Such use of PEG is reported by Nakamura et. (1980) and many other researchers. The hastening of germination is advantageous in this country, since radish seeds are sown in the dry season and sometimes irrigation is necessary after sowing, PEG treated seeds requires less water supply before they germinate and establish themselves.

All the other solutions other than PEG, such as some salts and sucrose solutions failed to control germination. The effect of them have been commonly described and the reason why they failed is not known. But each of them were tried at only one level of concentration. There might be another concentration at which they can work desirebly for radish seeds.

The concentration of PEG required for complete germination control is 30%. But there was the problem that the PEG treatment disturbs the vernalizing effect of low temperature treatment, which decreases with the increase of PEG concentration, and the adverse effect of PEG appears considerably when the concentration is high enough to control the germination completely.

There is another problem that when GA is added to PEG solution, the germination controlling effect of PEG is much reduced and germination is promoted. These problems are discussed in the next column.

(b) Seed vernalization

In the series of the experiments, the effect of the duration of low temperature treatment, the GA seed and/or foliar application, the environment after the low temperature treatment, the germination control with PEG during low temperature treatment, and the vernalized seed preservation, on the vernalization of Japanese radishes were examined. Among them, difficult problem lies in the latter two factors. (The vernalized seed preservation will be discussed separately).

The PEG treatment of seeds during low temperature treatment restrained their germination but reduced the vernalizing effect. It is probably because of the restriction of their water imbibition. Water content of seeds has great influence on their sensitivity to low temperature, and the vernalizing effect decreases with its decrease (HAGIYA, 1953; TASHIMA, 1957). The sensitivity appears only on the physiologically active seeds, and naturally no vernalization occurs when the seeds are not given water at all.

But so far as seeds are at any rate sensitive to low temperature with lower water content than is required for germination, seed vernalization is possible under germination controlled condition. Actual germination itself is not necessary for vernalization, because the seeds become sensitive to low temperature at very early stage of germination when no visual growth can be

seen. The sensitivity is reported to even decrease with the advance of germination (NISHI, 1967). The reduced sensitivity caused by the restriction of water imbibition will be compensated by the prolongation of low temperature treatment, which will be safely done so far as the seeds do not germinate during the treatment. But it must be confirmed under longer period of low temperature treatment.

Also lower temperature than 5 °C for seed treatment should be tried. By the lower temperature (1 to 2 °C), while its effect on vernalization is reduced, germination will be much more restricted. But the germination control should not depend solely on the temperature adjustment, because the temperature in a refrigerator cannot be kept constant in this country, which has originaly raised the necessity of germination control.

The GA seed and/or foliar application significantly promoted the bolting and flowering. It is well documented that GA application combined with low temperature treatment promotes the vernalization of radishes. The favorable effect shown in these experiments can be regarded valid.

GA seed application is so easy and convenient as to be well feasible in this country. But there was a problem that when GA was added to PEG solution, the solution could not control germination sufficiently, even when the concentration of PEG was as high as 50%. Germination promoting effect of GA, which is well known for many kinds of crops, affected unfavorably in these experiments.

This effect may be, however, comparatively easily avoided. While GA were supplied to the seeds throughout the low temperature treatment in the present experiments, such long lasting application is not necessary because GA application is much more effective for vernalization in the later stage of or after low temperature treatment (TSUKAMOTO et. 1959; KAGAWA, 1960). When GA solution is given to seeds a few days or just before sowing, germination promoting effect of GA will be minimized without significant reduction of its effect on vernalization.

The concentration of GA used here for seed application was either 50, 100 or 200 ppm. It was effective at all these concentrations, and the 200 ppm solution did not show more effect than the 100 ppm solution. Probably it can be lower, judging from the fact that GA can promote floral initiation even at

the concentration as low as 0.1 ppm (TSUKAMOTO et. 1958). The proper concentration of GA should be determined through further experiments in combination with the method to minimize its effect on germination.

GA foliar application promoted vernalization as well as the seed application. When the both were combined, they worked additively; the most pronounced effect appeared when GA was applied to both the seeds and the foliage. The foliar application is free from the problem of germination control mentioned earlier, which is its another merits. On the other hand, the foliar application requires more cost and labor. To save them, appropriate concentration and times of application should be determined. It may be combined with insectiside spraying at least once.

The effect of the after-sowing environment on vernalization, which was represented as the 'Shade' and the 'Open' in Experiment 3, was not clear. This experiment was planned expecting that devernalization occurs due to the strong sunshine of this country, and it would be prevented by shading. But the result was ambiguous. It was probably because in the 'Shade' plots, the shading lasted too long under the warm condition of the open grass house, which did not allow the normal growth of the plants.

Shading should have done in some open place with something like cheese cloth and ended within about two weeks. If so, some favorable result may have been obtained with the shading. But from practical viewpoint, shading is rather laborious when applied in wide fields. It had better be re-examined when the vernalization of some promising varieties cannot be completed with the other means.

The duration of low temperature treatment necessary for complete flowering depends on variety and the other various factors. When germination is not restrained by PEG during low temperature treatment and GA is applied to the seeds, almost all the varieties which belong to Miyashige, Shiroagari, Shogoin groups, varieties of Minowase group except spring and summer sowing type, some varieties of Miura type of Nerima group, proved to flower completely with three weeks' low temperature treatment at 5 °C. South Chinese varieties do not require so long duration of it, but only two weeks' is enough.

Varieties of Riso type of Nerima group generally do not flower completely with the three weeks' treatment, but a little longer duration of it is believed

to be enough for their floral induction. All varieties of Ookura type of the same group flowered only poorly or not at all under the same condition. Longer period fo low temperature treatment is required for their vernalization.

For the floral induction of those varieties which did not flower well in Experiment 6, GA foliar application will be much helpful, other than the prolongation of low temperature treatment. Also earlier sowing dates than the present ones will be advantageous for their floral induction and seed production; lower temperatures of the natural environment, which alone is insufficient for their vernalization, lasts longer in their growing period, and plants will be well vernalized with the cummulative effect of artificial and natural low temperature. The temperature of their flowering time will be also lower, which is suitable for seed production.

When germination is checked with PEG and/or the temperature for vernalization is lower than 5 °C, longer durations of low temperature treatment will be required for the flowering of each variety than is mentioned above.

(c) Vernalized seed preservation

In the discussion on the necessary duration of low temperature treatment, the effect of the vernalized seed preservation was devoided from consideration because the result on it obtained here was not enough to be based on. While both 'Dry' and the 'Wet' methods did not reduce the germinability of the preserved seeds, the bolting percentage seemed to be lower in those plots. The reduction was considered largely due to the germination controlling treatment during low temperature exposure, which is common to the both methods.

The 'Wet' method can be simply said to be the extension of the germination control after low temperature treatment. Since the vernalizing effect did not decrease while the vernalized seeds were kept under room temperature with PEG, it can be said that the reduction of the bolting percentage in the 'Wet' plots were mostly due to the germination control during low temperature treatment and the preservation itself does not affect the vernalization.

In the 'Dry' plots, besides the adverse effect of PEG, the drying of the vernalized seeds itself is considered to have been inhibitory for their vernalization. In Experiment 5, the bolting percentage of the 9 days' 'Dry' plots was significantly lower than that of the 4 days', which was not different from

that of the 'no s.p.' plots with PEG. It showed that the vernalizing effect was gradually lost with the advance of the drying.

TASHIMA (1957) suggested that the drying nullifies the later process of vernalization but does not affect the earlier process of it, judging from the fact that the bolting percentage is reduced when well vernalized seeds are dried but not when incompletely vernalized seeds are dried. It was likely because the seeds had not been sufficiently vernalized that the reduction of the bolting percentages of the 'Dry' plots was not clearly seen in Experiment 4 and 5.

The 'Dry' method is practically of no use so far as it is done in the same manner as in the present experiments. The 'Wet' method is applicable for the practical seed production. Also some modification can be deviced, for example; after low temperature treatment, put the seeds on filter paper or new paper to remove the surrounding solution, then keep them in a vessel, e.g. a pottery pot, in which respiration of the seeds is not prevented but evaporation is moderately restricted. By this alternative, the seeds can keep some water for a few days, and it is expected that the vernalizing effect is kept but germination is not allowed.

The necessary durations of low temperature treatment under these condition could not be determined through the present experiments, which must be examined in the further researches. But there is also the possibility that later bolting varieties are not sufficiently vernalized in spite of the prolongation of low temperature treatment and the optimization of the other condition, so far as their germination is restrained during the treatment.

For practical seed production, however, such sufficient seed vernalization as can induce flowering within a month is not always required so far as all the plants eventualy flower well. As mentioned previously, when seeds are sown earlier than middle January, the mildly low temperature of the after-sowing environment works effectively for vernalization in addition to that of the artificial low temperature treatment. When it is taken into consideration, the techniques of the germination control and the vernalized seed preservation are possibly applicable to larger part of the varieties tried in Experiment 6. But it must be confirmed by December sowing.

2-5. Summary

In order to establish the method of seed production of Japanese radishes in Bangladesh, the optimum condition for artificial seed vernalization, the method of germination control during low temperature treatment, and the method of short term preservation of low-temperature-treated seeds under room temperature (vernalized seed preservation) were investigated. Also the response of 84 varieties to the low temperature treatment of the seeds was examined.

(1) When gibberellin [GA] was applied to seeds, the necessary duration of the low temperature treatment (5°C) of the seeds for complete vernalization was about 2 weeks for the varieties of South Chinese group; 3 weeks for the varieties of Miyashige, Shogoin, Shiroagari groups, the varieties of Minowase group except late bolting type, some of the varieties of Miura type of Nerima group; more than 3 weeks for Riso, Nerima, Ookura types of Nerima group.

(2) With GA seed (50 ppm) and/or foliar (100 ppm, three times) application, both the bolting and the flowering became earlier and increased in percentage. The degree of the promotion was not significantly different between the two methods. The effect was additive when they were combined, and was more pronounced in the bolting than in the flowering. When the low temperature treatment was not enough, they could not induce bolting as well as flowering.

(3) When the plants were shaded after low temperature treatment, their flowering was delayed and decreased in percentage.

(4) The moderately low temperature of the natural environment which cannot induce flowering of Japanese radishes by itself, promoted vernalization by its cummulative effect in addition to the low temperature treatment, when the seeds were sown earlier than January but not later than February.

(5) Seeds would germinate during the low temperature treatment of more than 10 days. PEG solution (more than 30%) could keep the seeds ungerminated during the treatment and hastened the germination after it, but reduced the vernalizing effect significantly.

(6) GA seed application promoted germination during and after the low temperature treatment and disturbed the germination controlling effect of PEG.

(7) For vernalized seed preservation, the seeds were either kept dried in a dessicator or kept wet in petri dishes (germination was restrained by PEG) after low temperature treatment. The vernalized effect was lost to some extent in the former while it was expected to be kept in the latter.

2-6. Literature cited

1. HAGIYA, K. and K. HURUTA. 1953. Studies on vernalization of radish 2. Relation between the water supply during the vernalization and bolting (in Japanese). Agric. & Hort. 28: 459

2. KAGAWA, K. 1960. Studies on the effect of low temperature induction in radish plants 5. Effect of plant growth regulators on the floral initiation in vernalized and unvernalized radish plants (in Japanese). Res. Bull. Fac. Agric. Gifu Univ. 12: 19-33

3. NAKAMURA, S. and N. ENOHARA. 1980. Germination improvement of vegetable seeds using polyethylene glycol. 1. Eggplant, Cryptotaenia japonica and carrot. J. Japan. Soc. Hort. Sci. 48: 443-452

4. NISHI, K. 1967. Studies on the relations between the seedling stage of Raphanus sativus L. and vernalizations 2. Sensitivity to vernalization in the seedling stage of Raphanus sativus L. (in Japanese). Sci. Bull. Fac. Agr. Kyushu Univ. 23: 9-14

5. TASHIMA, Y. 1957. Ein Beitrag zur Physiologie der Blütenbildung von Raphanus sativus mit besonderer Rücksicht auf die Vernalization (in German). Mem. Fac. Agric. Kagoshima Univ. 3: 25-58

6. TSUKAMOTO, Y. and T. ASAHIRA. 1958. Studies on chemical vernalization of radish. Mem. Res. Inst. Food Sci., Kyoto Univ. 14: 1-13

7. TSUKAMOTO, Y. and K. KONISHI. 1959. Effect of gibberellin on the vernalization of growing plant of radish. Mem. Res. Inst. Food Sci., Kyoto Univ. 18: 48-56

3. Figures

Here presented some photographs of the experiments of this report, and other than these, photographs of the maternal line selection of Chinese radishes, and variety trials of Japanese radishes, in which the writer was concerned.

Fig. 1 The bolting and flowering of the 'Open' plots of Experiment 3, upper row- left to lower row- right; 'Taiwan'-18, -14, -10 days', 'Shiroagari Kiichi'-18, -10 days', 'Kounou Shougoin'-18, 14 days', 'Awa Bansei'-18 days', 'Taibyou Nishimachi'-18 days', 'Motohashi Minowase'-18 days' low temperature treatment: 36 days after sowing (February 24)

Fig. 2 Germination of the seeds either supplied or not supplied PEG and/or GA solution (Experiment 5): at the end of the low temperature treatment

Fig. 3 - do - : four days after the low temperature treatment (kept under room temperature)

Fig. 4 The bolting and flowering of Japanese radishes with 20 days' low temperature treatment of seeds (Experiment 6, representative varieties; Upper row-left to lower row-right; Kuroba Soubutori Minowase, Kurobakei Shimura Minowase, Izumi Hayabutori, Tankei Miyashige Soubuto, Akizumari, Shin Miura No.1, Shin Risou, Taiwan, Chuusei Sunashi Shogoin, Nishiki Akamaru, Shiroagari Kiichi, Onnayama San-gatsu): 28 days after sowing (February 22)

Fig. 5 Sowing of low-temperature-treated seeds in pots (Mr. A. Hussain and his assistant)

Fig. 6 Counting of the number of bolted and/or flowered plants (- do -)

Fig. 7 Maternal line selection of Chinese radish breeding. 1. variety 'Chinese 45 or 55 days': selected plants

Fig. 8 - do - : a elite plant

Fig. 9 Maternal line selection of Chinese radish breeding. 1. variety 'Chinese 45 or 55 days': planting mother plants

Fig. 10 - do - : elite seed production

Fig. 11 Maternal line selection of Chinese radish breeding. 2. variety 'Chinese pink': elite plants

Fig. 12 Variety trials of 84 Japanese radishes, which were examined their earliness of bolting in Experiment 6.

Fig. 1

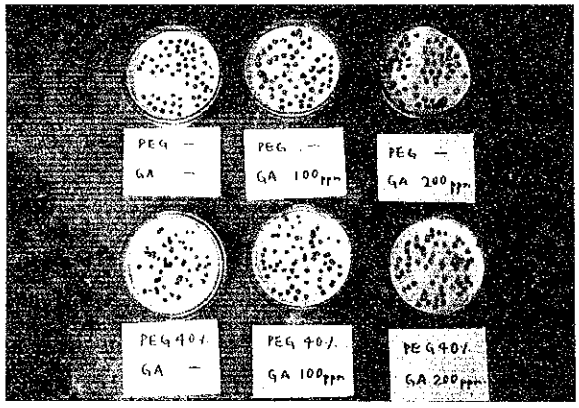

Fig. 2

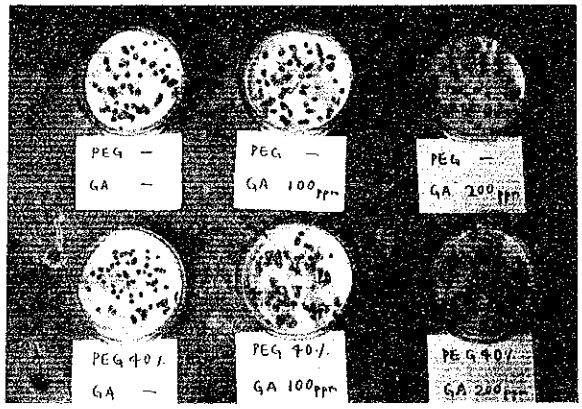

Fig. 3

Fig. 4

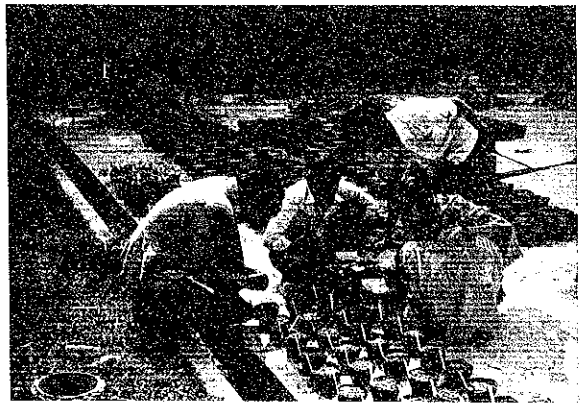

Fig. 5

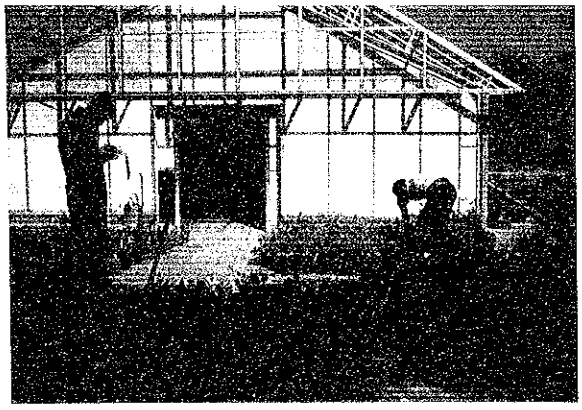

Fig. 6

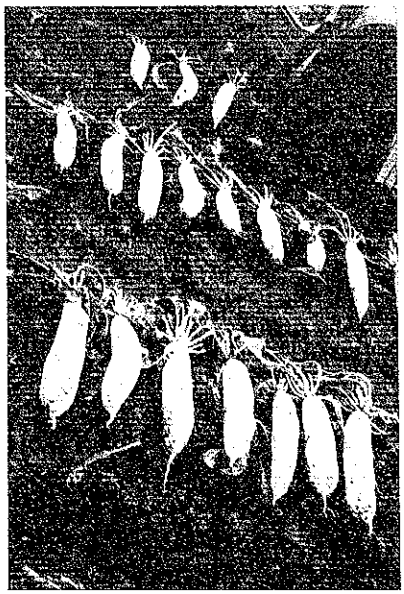

Fig. 7

Fig. 8

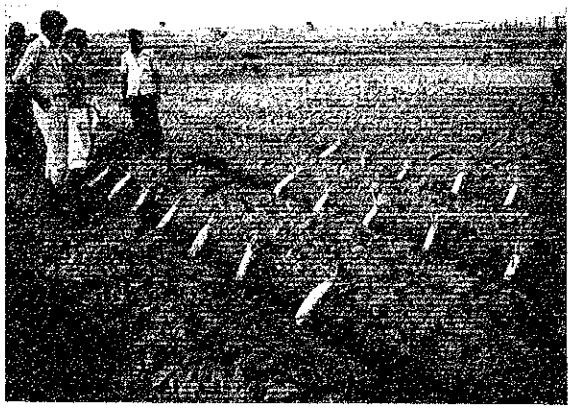

Fig. 9

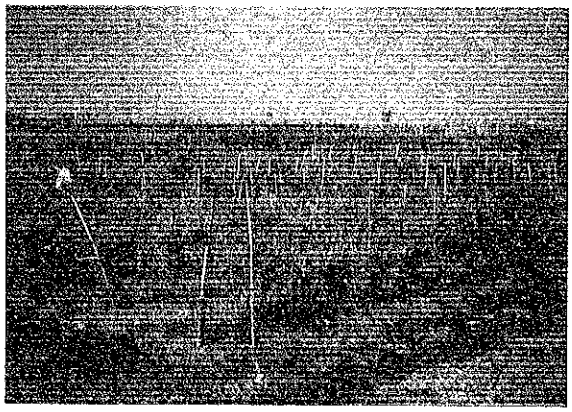

Fig. 10

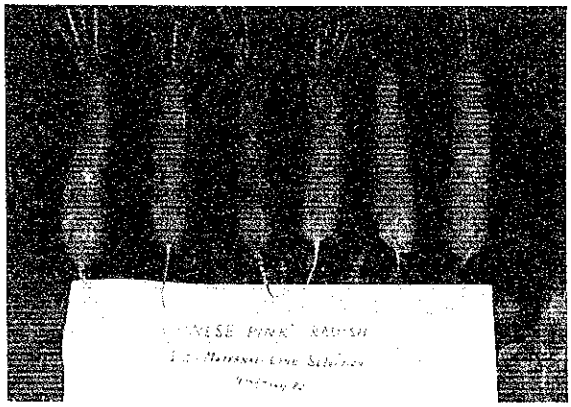

Fig. 11

Fig. 12

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