THE DEMOCRATIC REPUBLIC OF THE SUDAN
MINISTRY OF AGRICULTURE, FOOD
AND NATURAL RESOURCES

FEASIBILITY REPORT
ON
RICE DEVELOPMENT PROJECT
IN ABU GASABA BASIN

ANNEX (SUPPLEMENTARY REPORT I)

DECEMBER, 1978

JAPAN INTERNATIONAL COOPERATION AGENCY

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LETTER OF TRANSMITTAL

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

We have a pleasure in submitting herewith the report on rice cultivation trials at Ed-Dueim in compliance with the Terms of Reference agreed between the Government of Japan and the Government of the Democratic Republic of the Sudan.

This rice cultivation trials were formulated in accordance with the advice from the advisory committee set for the feasibility study on rice development project in Abu Gasaba basin, and have been carried out from June, 1977. This report contains all the findings obtained during a period from June, 1977 to November 1978.

The purpose of this trials is to collect the reliable data on rice cultivation in the project area for the study on the rice development project. Findings obtained from the experiment were fully incorporated in the feasibility report.

It is our sincere hope that the data obtained from this experiment will be fully utilized for the development of rice cultivation in the Sudan. In submitting this report, we wish to express our sincere appreciation and gratitude to all personnel of your Agency, the Embassy of Japan in the Sudan and the officials of the Sudan Government concerned, for the courtesies and cooperation extended to us during our field work and home office work.

Very truly yours,

S. Matsushima

Seizo Matsushima
Rice Expert

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1. Introduction

Hereinunder prepared is the primary report on the rice cultivation trials at Ed-Dueim, White Nile Province, the Sudan.

In 1976, the Sudan Government requested the Japanese Government to despatch a survey team for the rice production development in the lower basin of the White Nile and in response to the request, the Japanese Government dispatched a technical survey team for the feasibility study on the Abu Gasaba Rice Development Project in May, 1977.

The rice cultivation trials at Ed Duiem have been carried out to clarify the possibility of rice cultivation twice a year and to realize the economical rice production with irrigation and mechanized farming under the arid climate, in the experimental farms of 0.3 ha and 2.0 ha, based upon the study results and recommendations issued by the teams.

The following programme were set for this trials.

(a) Field work

(i) Cultivation of rice from May, 1977 to November, 1978.

(ii) Reclamation of paddy field of 2.0 ha and the operation and management of the experiments

(iii) Observation of the condition of rice plants

(iv) Measurement of rice yield

(v) Technical training and guidance for counterpart personnel on the following items.

. Cultivation technique and crop management methods including way of fertilization

. Methods of plant growth observation

. Methods of crop yield determination

(b) Home office work

Based upon the test results in the above, the following study were made.

(i) Selection of appropriate varieties

(ii) Setting of appropriate cropping pattern and farming practices

This rice cultivation trials including crop experiments were carried out during a period from early June, 1977 to March, 1978, in experemental farms at Ed-Dueim, capital of White Nile Province. In the first stage of the experiment, about 0.3 ha of a test farm was established for a small scale experiment in May, 1977.

Subsequently, in order to estimate more accurate yielding potential and to multiply the rice seeds, and to demonstrate the rice cultivation for the officers and farmers the test farm was enlarged to 2.0 ha. The crop experiments and the seed multiplication as well as crop demonstration work have been continuously practiced till early November, 1978, in great co-operation with the counterpart personnel of the Government of the Sudan.

The total planted area in October, 1978 was about 1.6 ha with following breakdown.

Seasonal planting test	370 m^2
Fertilizer element test	210
Nitrogen amount test	200
Spacing test for transplanted rice	360
Spacing test for direct sown rice	710
Variety test	1,320
Cultivation method test	990
Herbicide test	1,350
Nursery bed	530
Seed multiplication	9,700
	15,740

All the data and findings obtained in the above work area contained in this report.

All experts assigned to this experiment would like to make use of this opportunity for expressing their sincere gratitude and appreciation

to H. E. Mohamed El Said El Shaar, Commissioner of White Nile Province, and Dr, Abdien Hassan Abdoun, Director General of Engineering Administration, and all other authorities concerned for the most helpful cooperation and kind arrangements extended to them during their field work.

2. General Description

The Democratic Republid of the Sudan is the largest country in Africa having a total area of approximately 2.5 million km^2. The population is about 16.5 million and its density is 6.6 capita per km^2.

The Sudan has a continental tropical climate with two distinct seasons, wet and dry, except for a narrow strip along the coast of the Red Sea where winter rainfall predominates.

The Nile and its tributaries play a very important role in the national economy by providing the irrigation water. Available water resources for the Sudan in the Nile water is 18.5 billion m^3, of which only about a half are being used for irrigation purposes. The rest are remained unused.

The Sudan possesses a vast fertile land for the agricultural development. According to the study of the agricultural development in Sudan conducted by FAO in 1970, it was estimated that about 30 % of the total area of the Sudan, equivalent to 75 million ha, is usable for crop and livestock production. However, only 13 % of the total area has been used for these purposes, namely 4 % for cropping and 9 % for pasture.

Agriculture is a predominant sector in the national economy. Around 40 % of the GNP is produced in this sector and about 70 % of the population is engaged in this sector. About 95 % of the total export value is deprived from this sector.

The principal agricultural commodities for export are cotton, groundnut, seasame, gum Arabic and meat. The export share of cotton is approximately half of the total export amount. The cotton has been subjected to the sharp fluctuation in the international price in recent years. This fluctuation is the major cause of unstability of the national economy. In this context, the Sudan Government has been encouraging

the diversification of the exportable crops from cotton to sugar, wheat and rice, etc., in the six-year Development Plan (1977/78-82/83).

A production and the planted area of rice in the Sudan in the past six years are estimated respectively at about 12,000 tons and about 10,000 ha. The major production areas of rice are Gezira, Bahr El Ghazal and Equatoria. The average yield of rice in 1975/76 in said areas is 1.19 ton/ha, 0.32 ha/ha and 0.57 ha/ha, respectively.

The consumption of rice in the Sudan and in the neighbouring Arabic countries have increased rapidly. About 13,000 tons of rice were imported by the Sudan in 1973/74.

The Sudan Government is planning to expand the rice production primarily to attain self-sufficiency and secondarily to export the surpluses to neighbouring countries, and in the first planned to promote the rice production in Abu Gasaba swampy area, 20,000 ha where have been subjected to seasonal inundation and been abandoned since the completion of the Jebel Aulia Dam.

Abu Gasaba swampy area is situated about 40 km south from Ed-Dueim and is a narrow and flat strip along the left bank of the White Nile. The average altitude of the area is about 376.2 m above a mean sea level. The climate in the area is tropical arid. The mean monthly temperature varies from 25°C to 33°C during a year. The relative humidity is low of 22 % in March and April, and high of 71 % in August. The average annual rainfall at Ed-Dueim is about 296 mm and 80 % of which is concentrated in months from July to September. Predominant soils in the area are Vartisols, and are characterized by heavy clay in texture.

3. Methods of Experiments

3.1 *Objective*

The rice cultivation trials at Ed-Dueim have been carried out to collect the necessary data on the rice cultivation for the feasibility study on the rice development project in Abu Gasaba basin. The experiments and trials were performed for the following objectives.

(1) Selection of the most suitable rice varieties to the project area.

(2) Setting of the most suitable cropping pattern particularly for introducing the double cropping in a year.

(3) Confirmation of the potential yield of rice

(4) Setting of the suitable cropping practices to be applicable to the mechanized large scale rice cultivation.

(5) Training of counterpart personnel and demonstrating the rice cultivation for the local farmers.

3.2

3.2 Methods

A test field of 0.3 hectare for a small scale experiment was reclaimed into a paddy field at Ed-Dueim in June, 1977. In this small scale experiment, variety test, cultivation method test, seasonal planting test, for the main cropping season (rainy season) were carried out. Along with the crop experiment, growth process of rice plant and local climatei conditions including water temperature were also investigated. Following the experiments in the main cropping season, off-season (dry season) experiments were made during the months from November, 1977 to March, 1978, in which the variety test and the seasonal planting test were mainly carried out. Reclamation of a new experimental field of 2.0 hectares was started in December 1977 and was finished in March. In this large scale experiment, the following tests were carried out with three replications except the seasonal test and the preliminary variety test.

1. Variety test
2. Seasonal planting test
3. Fertilizer element test
4. Nitrogen amount test
5. Cultivation method test
6. Spacing test
7. Herbicide test

i) Variety test

(a) Variety test in the main season in 1977

The objective of this experiments is to select the varieties sutiable to the Gasaba area with high-yielding ability, high resistance to diseases and insect pests, and lodging under the mechanized farming and irrigated conditions.

From various rice growing countries of the world, 26 varieties were collected and raised in the plots under the anticipated farming techniques of rice cultivation in the project area. The name of each variety and its breeding country are listed below.

Variety	Country	Variety	Country
Fujiminori	Japan	IR-298-12-1-1-1	Philippine
Reimei	"	IR-2053	"
Toyonishiki	"	IR-2153	"
Koganenishiki	"	IR-22	"
Asominori	"	IR-1514	"
Taichung 65	Taiwan	IR-20	"
Taichuikyuku	"	IR-8	"
Toitsu	Korea	TOS-103	"
Dawn	U.S.A.	SLM-18	Surinum
Blue Bonnet	"	Kuang Chu 15 (C-15)	China
		Chen Chu Ai 11 (C-11)	"
Cawad Mali		BG-34-8	Sri Lanka
IR-127	Philippine	BG-90-2	"
IR-5	"		

Urea was applied at a rate of 200 kg per hectare in total, and its application was equally made 4 times; i.e., at the 5th leaf stage, just before the most active tillering stage, just before the reduction division stage and at the full heading stage. Triple superphosphate was applied at a rate of 100 kg per hectare as a basic application.

Herbicide (chlomethoxynil, X-52) was applied at a rate of 30 kg per hectare at the sowing and on the 7th day after transplanting:

The spacing was 30 cm x 15 cm (22.2 hills/m^2). The following specific items were measured or examined; heading date, maturity date, culm length, panicle length, disease resistance, insect resistance, lodging resistance, percentage of ripened grains, 1,000 grain weight and grains yield per hectare.

(b) Variety test in the off-season in 1977

It has been said that the rice cultivation in the off-season (dry season) is hardly possible meteorologically in the middle Sudan. Scrutinizing, however, the data obtained in Sudan and in other countries, following assumptions were made that even if the sowing were carried out in November, it would be possible to get 3 or 4 tons per ha, and if the sowing were carried out in February it would be able to get 4 or 5 tons per ha. In order to ensure the above assumption and, to select the adptable varieties to harsh climatic condition of cool and hot temperature in the off-season, the variety test was set up using 31 varieties to be sowing in November and 20 varieties sown in February. The name of each variety and its breeding country are listed below.

Varieties sown on November 3 to 6

Variety	Country	Variety	Country
Fujiminori	Japan	Toitsu	Korea
Reimei	"	C-6	China
Toyonishiki	"	C-11	"
Norin-17	"	C-15	"
Dewachikara	"	HINO	"
Mutsunishiki	"	IR-32	Philippine
Sasanishiki	"	IR-36	"
Matsumai	"	IR-38	"
Chuemon	"	IR-30	"

Varieties sown on November 3 to 6 (continued)

Kiyonishiki	Japan	IR-8	Philippine
Taichung native 1	Taiwan	IR-5	"
Waikyakunantoku	"	IR-28	"
Taichung 65	"	IR-24	"
Taichung Ikukyu	"	IR-29	"
Ishin	Korea	IR-40	"
		SLM-18	Surinum
		BG-34-8	Sri Lanka

Varieties sown on February 13

BG-34-8	Sri Lanka	BG-90-2	Sri Lanka
TOS-103	Philippine	IR-298-12-1-1-1	Philippine
IR-36	"	IR-36	"
IR-30	"	IR-22	"
IR-5	"	IR-28	"
IR-24	"	IR-29	"
IR-40	"	C-11	China
C-15	China	HINO	"
SLM-18	Surinum	Toitsu	Korea
ISHIN	Korea	Taichung 65	Taiwan

Variety sown in March

BG-34-8	Sri Lanka
IR-22	Philippine

The amount of 230 kg of urea and 100 kg of triple superphosphate per hectare in total were applied. The total amount of triple superphosphate was basically applied just after the transplanting. Urea was split-applied four times for the test started in November, i.e. 50 kg/ha at the transplanting time, 50 kg/ha on 14th day after the transplanting, 65 kg/ha at the reduction division stage and 65 kg/ha at the reduction division stage and 65 kg/ha at the full heading stage. In case of the test started in February urea was applied at a rate of 100 kg/ha just after the transplanting and no urea was applied around 14th day after the transplanting. Other fertilization was carried out in the same manner as that of the test started in November. Seedlings were uprooted and transplanted on around 20th day after the sowing. Planting density was 25x15 cm (26.7 hills/m^2). Percentage of unfertilized grains was added to the investigation items listed for the variety test in the main season in 1977 to estimate the damages caused by the hot and cold temperature.

c) Variety test in main season in 1978

The objective of this test is the same as that of variety test in the main season in 1977. In this test, experiments were carried out with 2 or 3 replications. Names of the varieties used and their breeding countries are shown below.

Variety	Country	Variety	Country
BG-11-11	Sri Lanka	IR-29	Philippine
BG-33-2	"	IR-30	"
BG-34-6	"	IR-36	"
BG-34-8	"	IR-38	"
BG-34-11	"	IR-40	"
BG-34-12	"	IR-298-12-1-1-1	"
BG-90-2	"	IR-2053	"
BR-4	Bangladesh	TOS-103	"
BR-5	"	C-6	China
IR-5	Philippine	C-11	"
IR-8	"	C-15	"
IR-20	"	Ishin	Korea

IR-24	Philippine	Toitsu	Korea
IR-28	"	Taichung 65	Taiwan
		Taichung Native 1	"

This test was made by the randomized block method with three replications for major varieties. Area of a plot was at least 13 m^2.

The total amount of 150 kg of nitrogen and 75 kg of phosphate per hectare was applied. The total amount of phosphate was basically applied just after the transplanting. Nitrogen was aplit-applied at three times i.e. 80 kg just after the transplanting, 40 kg at the spikelet differentiation stage (on 23rd day before heading), 30 kg at the full heading stage.)

Seeds were sown at a rate of 65 g per square meter in the nursery bed. Seedlings were uprooted around 20th day after sowing and were transplanted in the main field at a density of 26.7 hills/m^2 (25 x 15 cm). The following items were measured or examined; initial heading date, medium heading date, full heading date, maturity date, culm length, panicle length, disease resistance, insect resistance, lodging resistance, percentage of ripened grains, percentage of un-fertilized gains, 1,000 grain weight, quality of brown rice, and grain yield per hectare.

ii) Cultivation method test

(a) Cultivation method test carried out in 1977

In order to find out a difference of yield by planting methods, an examination was made by the following planting method using IR-298-12-1-1-1.

a. Direct sowing (drilling)
b. Direct sowing (broadcast)
c. Ordinary transplanting
d. Broadcast transplanting

Applications of fertilizers and herbicides were carried out in the same manner as that in the variety test carried out in the main season in 1977.

The spacing for both transplanting and broadcast transplanting methods was 30 x 15 cm (22 hills/m^2). The sowing rate for the direct sowing method was 60 kg of paddy seeds per hectare. The distance between rows was 30 cm. The investigation items were the same as those for the variety test carried out in the main season in 1977.

(b) Cultivation method test carried out in 1978

The objective of this experiment is to compare the transplanting method with the broadcast-transplanting method and direct sowing method.

Using the variety, C-11 the following 8 treatments were set up under the randomized block method with 3 replications.

Spacing and Seeding Rate

Transplanting	30 x 20 cm (16.7 hills/m^2)
	30 x 15
Broadcast-transplanting	16.7 hills/m^2
	22.2 hills/m^2
Hand transplanting with broadcastable seedlings	22.2 hills/m^2
Direct sowing in stripe	30 cm, 80 kg seed/ha
Direct sowing (Drilling)	12 cm, 80 kg seed/ha
Direct sowing (Broadcast)	80 kg seed/ha

Application of fertilizer was the same as that applied in the variety test in 1978.

Area of a plot was at least 13 square meters. Investigation items were the same as those applied in the variety test in 1978.

iii) Seasonal planting test

The objective of this test is to determine the optimum sowing and transplanting date for the main season cropping as well as for the off-season cropping for establishing the most suitable pattern of two croppings a year for the project area.

As the first stage of the test, a simple test was carried out using IR-298-12-1-1-1, to determine the optimum sowing date for the main season cropping. Fertilization and planting density and investigation items were the same as those for the variety test carried out in main season in 1977.

Following the test in the main season, the test for off-season was carried out using three varieties, i.e. IR-8, IR-20 and C-6. Sowing was carried out in every half month interval starting in November. The way of fertilization was the same as those for the variety test in off-season in 1977.

After the first trials of the seasonal planting test were preliminarily conducted, the seasonal planting test in precise way has been carried out from June, 1978. In this test four varieties are planed to be sown every month throughout a year; Chen-Chu-Ai (C-11) (Short term variety), IR-20 (medium-term variety), IR-8 (long-term variety), C-6 (long-term variety). Area of a plot is planed to be at least 13 square meters. The experiment has been carried out with two replications. Fertilization, planting density and the investigation items have been the same as those for the variety test carried out in 1978.

iv) Fertilizer element test

The objective of this experiment is to clarify the effectiveness of N,P, and K on the yield of rice planted in the main season.

The following five treatments were set up according to the randomized block method with three replications;

(a) Non-N, (b) Non-P, (c) Non-K, (d) Non-N.P. and K, (e) standard (150 kg N/ha, 75 kg P_2O_5/ha, 100 kg K_2O/ha).

The total amount of P and K was applied basically, but N was split-applied as in the case of the variety test in 1978.

Variety named C-15 was used for the experiment. Area of a plot was 13 square meters. Width between rows was 25 cm. Distance between hills was 15 cm.

Investigation items were the same as that for variety test in 1978.

v) Nitrogen amount test

The objective of this experiment is to clarify the response of rice to nitrogen dosage and the optimum amount of nitrogen to be applied under the climatic and soil conditions in Ed-Dueim area.

Using the medium-term variety C-15, the following treatments were set up with 3 replications in 1978. The amount of phosphate applied was half of the total amount of nitrogen in each treatment. The experiment was designed by the randomized block method.

	Total N	Basal application	1st top-dressing	2nd top-dressing
(a)	50 kg N/ha	30	10	10
(b)	100 kg N/ha	60	20	20
(c)	150 kg N/ha	80	40	30
(d)	200 kg N/ha	110	50	40
(e)	250 kg N/ha	140	60	50

Note: The time of top-dressing was the same as that of the variety test.

Area of a plot was 13 square meters. Planting density was 15 x 25 cm (26.7 hills/m^2). Investigation items were the same as those for the variety test in 1978. But in addition to the items listed for the variety test, number of tillers per hill, plant hight and leaf colour at intervals of 7 days were measured or observed on one specified block.

vi) Spacing test

The objective of this experiment is to find out the most suitable spacing for transplanted plants as well as directly sown plants and to compare the transplanting method with the direct sowing method.

Using the variety C-15, the following treatments were set up in 1978 under the randomized block method with 3 replications.

Transplanting	25 x 15 cm (26.7 hills/m^2)
	30 x 30 cm (11.1 hills/m^2)
	30 x 20 cm (16.7 hills/m^2)
	30 x 15 cm (22.2 hills/m^2)
	30 x 10 cm (33.3 hills/m^2)
Direct Sowing	20 cm, 80 kg seed/ha
	30 cm, 80 kg seed/ha
	40 cm, 80 kg seed/ha
	30 cm, 50 kg seed/ha
	30 cm, 100 kg seed/ha
	15 cm, 80 kg seed/ha
	Broadcast 80 kg seed/ha
	Broadcast 50 kg seed/ha

Fertilizer application was almost the same as that applied in the variety test in 1978, but in the direct sown plot, basal dressing was applied on 10th day after sowing. Area of a plot was at least 13 square meters. Investigation items were the same as those applied in the variety test.

vii) Herbicide test

The objective of this experiment is to select the appropriate herbicide to each of transplanted rice cultivation and direct-sown rice cultivation in due consideration of the effectiveness for weeding as well as the phytotoxicity.

Eight herbicides listed below were tested for each cultivation method with three replications in 1978. Control plots were set for each block. Total number of plots was 48. Area of a plot was 21.6 square meters. Width between rows for the transplanting was 25 cm. Distance between hills was 15 cm. Sowing rate for the direct-sown blocks was 80 kg of seeds per hectare. Nitrogen in element was applied at a rate of 150 kg per hectare in total; 80 kg just before transplanting, 40 kg at spikelet differentiation stage, 30 kg at full heading stage in case of transplanted rice.

The same amount of nitrogen as that applied for transplanted rice was applied to direct-sown rice at three times; i.e. 80 kg on about 10th day after sowing, 40 kg at spikelet differentiation stage, 30 kg at full heading stage. Total amount of phosphate was applied by 75 kg per hectare just before transplanting for the transplanted rice plants and just before sowing for direct-sown rice plants. In case of the test for the application of herbicide to soil, leaves and culms, Saturn was sprayed at the sowing time as a soil application, and then the application of herbicide to soil, leaves and culms was conducted.

The following items were investigated; number of weeds on 20th day after the treatment, phytotoxicity, plant height and number of tillers at the treatment time and on 10th day after the treatment, amount of weeds (eye estimation).

The Summary of the Design of Herbicide Test

(1) Transplanted rice

Name	Percentage of Active Ingredient		Formation	Application Time	Application Rate
Ronstar	Oxadiazon	12%	emulsion	just after puddling	5 L/ha
Saturn	Benthiocarb	50%	emulsion	do	8 L/ha
MO	CNP	7%	granule	5th day after transplanting	30 kg/ha
X-52	Chlomethoxynil	7%	granule	do	30 kg/ha
SWEP (M)	Swep	20%	granule	20th day after transplanting	30 kg/ha
	MCPA	0.7%			
NIP	Nitrofen	7%	granule	5th day after transplanting	30 kg/ha

(2) Direct-Sown rice under the puddled condition

Name	Percentage of Active Ingredient		Formation	Application Time	Application Rate
(a) Soil treatment					
MO	CNP	7%	granule	5th day after sowing	30 kg/ha
Saturn	Benthiocarb	50%	emulsion	do	6 L/ha
X-52	Chlomethoxynil	7%	granule	do	30 kg/ha
Ronstar	Oxadiazon	12%	emulsion	do	4 L/ha
(b) Soil, leaf and culm treatment					
Molinate	Molinate	8%	granule	at full emergence time of seedlings	30 kg/ha
Stam	Propanil	35%	emulsion	15th day after sowing	10 L/ha
Swep (M)	Swep	20%	granule	25th day after sowing	30 kg/ha
	MCPA	0.7%			

5. Meteorological Conditions at Ed-Dueim

Air temperature, minimum air temperature, relative humidity and rainfall during a period from June 1977 to October 1978 obtained from Ed-Dueim Meteorological Station are shown in Table 1-1. Monthly mean maximum and minimum water temperatures observed at a point about 2 cm below water surface in the rice field are also tabulated in Table 1-1. Total rainfall of 534.5 mm from March to October in 1978 was extremely much as compared with mean annual rainfall in the past 30 years.

Measurement of evapotranspiration by rice in a tank was carried out during a period of its growing season using a Japanese rice variety, Reimei, sown on January 16 and transplanted on February 15. The highest evapotranspiration recorded in this experiment was 20.0 mm per day. Details are shown in Table 1-2.3.4.

Water temperature investigation was carried out in the main cropping season. One of the most important environmental factors affecting the growth of rice plants under water-logged conditions is water temperature

in the paddy field. In the project area air temperature rises up very often more than 40°C during the day time, therefore, judging from the actual situation in Japan, water temperature is also estimated to be more than 40°C. When rice plants are subjected to higher water temperatures more than 37°C, they are easily damaged on the activity of roots and are very liable to be attacked by a root-rot disease, resulting in a marked decrease in yield. From these view-points, an actual observation on water temperature in a paddy field was carried out during the period from June 14 to 22 in Dueim District.

An instance of the observation results is illustrated in Fig. 1-1, which indicates the diurnal change of water temperature together with air temperature. In the figure the most noteworthy point is that the water temperature does not rise over 36°C, even in the cases of the air temperature being above 40°C. The fact was always noted in any other observations conducted on different days, which was quite strange to Japanese situation. For clarifying the reason of the fact, another observation was further carried out as follows.

City water was taken in a tinned vessel at 1:30 in the afternoon on July 17, and it was kept indoors thereafter. The changes of water temperature as well as air temperature were traced up and illustrated in Fig. 1-2. The figure clearly shows that water temperature decreases rapidly irrespective of air temperature being over 40°C until 3 o'clock which is corresponding to one hour and half after taking out water from a water pipe and it keeps constant after that time. According to Fig.1-1 the relative humidity during 1:30 to 3:00 p.m. is very low (25 - 20 %). These facts clearly suggest that water temperature is lowered by the latent heat due to evaporation from water surface.

On the basis of the reason mentioned above, the strange fact that the water temperature in the paddy field does not exceed 36°C even when the air temperature is more than 40°C can be well understood.

This fact is quite advantageous for the rice cultivation in the project area, because higher water temperatures than 37°C not only damage seriously the germination of seeds but also definitely cause the depression of root activity and the occurrence of a root-rot disease, which are closely connected with the reduction in rice yield.

3.4 Growth Pattern of Rice and Pests and Diseases Observed during the Test Period

Growth patterns of rice were observed during its growing period using IR-20 sown on July 3, 1978 for the main season and IR-8 sown on Nov. 6, 1977 for the off-season. The results are shown in Fig. 1-3, 4, 5. The most noticeable points obtained from IR-20 were that

(1) the pancile initiation stage occurred around 23th day before the maximum tiller number stage.

(2) the time of the final emergence of effective tillers occurred on 65th day after sowing and on 42th day after transplanting, which means only the tillers emerged within 65 days after sowing can bear panicles and any tillers emerged after that time can hardly bear panicles.

While, the most noticeable points obtained from IR-8 were that

(1) the panicle initiation stage occurred around 8th day after the maximum tiller number stage.

(2) the time of the final emergence of effective tillers occurred around 100th day after the sowing.

Major pests and diseases observed during the test period are listed below in the order of the occurrance time.

Pests and Diseases Observed

Name	Occurrence season	Damaged variety	Degree of Damages
Army worm	August	IR-8, IR-20	great
Ants	October	All	great
Disease like orange leaf disease	November	BG-90	medium
Mice	harvesting season	lodged varieties	slight
Sparrows	harvesting season, sowing time	all	great
Damping off	December, January	IR-28, IR-29, IR-5 IR-24, C-15, IR-38 C-11, IR-40, Toitsu, IR-36, IR-30	medium
Bacterial leaf streak disease	June, July	C-15, IR-20	slight
Disease like, bacterial leaf blight disease	August, September	IR-298, C-15	slight
Leaf miner fly	August	varieties transplanted in late August	slight
Rice stem borer	August, September	IR-298, C-15, BG-90	slight

Army worms gave much damages to rice plants. Army worms gathered in the rice field from surrounding fields where their food, grass, had been destroyed by plowing.

Ants gave much damages to rice plants by carrying ripened grains to their nests. Damages caused by ants could be prevented by keeping the paddy field under flooded condition.

The disease something like orange leaf disease was observed on TOS-103 at its ripening stage. Following symptons were observed.

1) Orange discoloration on the leaves affected that begins with lower leaves and starts from the leaf tip.

2) Longitudinal rolling of leaves affected.

3) Rapid death of plant affected and white head. No leaf hopper was observed. Orange coloured insects like melon fly stuck to the foot of rice plants infected.

Sparrows damaged the ripening of rice plants. Without necessary means such as nets or guards, no yield would be expected. Damping off was observed on rice seedlings sown in December or January. This was caused by the low air-and water-temperature.

Monthly minimum water temperature was 12.7°C and 11.7°C in December and January, respectively. Damping off was well prevented by applying a fungicide named hymexazol to nursery bed.

Bacterial leaf streak disease is the common rice disease in the Sudan. The damages by this disease diminished around the maximum tiller number stage.

White heads caused by the rice stem borers were observed sporadically and damages caused by them were slight at the early stage of the experiment.

3.5 Results and conclusions

The yield determination was made by the sampling method using the representative hill method before harvesting. The representative hill method follows such a procedure as that stated below. Statistical and agronomical meanings of the method are discussed in the book titled "Crop Science in Rice" edited by Dr. S. Matsushima, 1975.

1) Sampling about 150 hills at definite intervals along 5 oblique lines.

2) Calculating of an average number of panicles per hill of the samples

3) Choosing of 20 to 30 hills those have nearest number of panicles per hill to an average number of panicles worked out by step 2)

4) Calculating the average weight of panicles per hill out of hills chosen in step 3)

5) Choosing of three hills those have nearest weight of panicles to the average (representative hills)

6) Threshing of representative hills by hand, removing of their rachis-branches and drying of grains for one day under the sun

7) Selecting of sunk grains using salt water with 1.06 specific gravity, washing of salt on the grains, drying one day under the sun

8) Weighing of the sunk grains per hill

9) Determination of yield

In case of paddy by direct sowing, yield determination was made by harvesting two or three plots of $1m^2$ each.

Measuring of culm length and panicle length was made before harvest and the yield was analyzed into four components, i.e. number of panicles per hill, percentage of ripended grains and 1,000 grain weight.

The results of the tests are shown in Table 2-1.2.3.4

i) Variety test

(a) Variety test in the main season

The performances of varieties harvested so far in the main season are summarized in Table 3. So long as the present experiments are concerned, the following conclusion can be drawn out.

Japanese varieties and American varieties were not so good, while Chinese varieties, Philippines varieties and Sri Lanka varieties were excellent in yield. C-15 (Chinese variety) showed the highest yield (10.4 tons per ha, 4,4 tons per fed.) which was said to be the highest yield record in the Sudan, followed by TOS-103 (Philippine variety) showing 9.8 tons per ha (4.1 tons per fed.). From the viewpoint of yielding ability as well as the quality of brown rice the following varieties were found to be suitable in the project area for the main season cultivation;

IR-298, IR-5, C-11, C-15, BG-34-8, BG-90, TOS-103, IR-20, RG-33-2, BG-34-12, IR-36, BG-34-6, IR-24,

(b) Variety test in the off-season

Yields of varieties sown in the off-season are summarized in table 4.

Yield varied according to the sowing time. In general varieties sown in February gave higher yields than varieties sown in November. Among the varieties sown in November, varieties yielded more than 6.0 ton/ha were Taichung native 1 (6.6 ton/ha), IR-30 (6.2 ton/ha) and IR-8 (6.2 ton/ha).

Japanese varieties gave less yields than 1.5 ton/ha. In general varieties sown in February showed as good performances as those by the varieties in the main season. The following varieties produced high yield when they were sown in February. BG-90 (9.3 ton/ha), IR-8 (8.2 ton/ha), IR-36 (7.0 ton/ha), IR-8 (6.8 ton/ha), C-6 (6.7 ton/ha), IR-24 (6.6 ton/ha) and TOS-103 (6.5 ton/ha).

ii) Cultivation method test

The results of the cultivation method test carried out in the main season in 1977 are shown below.

Cultivation method	Yield (ton/ha)
Direct sowing (Drilling)	7.0
Direct sowing (Broadcasting)	5.8
Transplanting (Regular)	7.5
Transplanting (Broadcast)	7.9

These results indicate that the broadcast transplanting method is the highest in yield, followed by the ordinary transplanting method and the broadcast direct sowing method was the lowest.

The results of the cultivation test carried out in 1978 have not obtained yet.

iii) Seasonal planting test

The variation in yield due to sowing dates through a year using IR-8 is shown in Fig. 2.

The figure shows that the highest yield is found when rice was shown on June 20 and then the yield decreases with some fluctuation as the sowing date come nearer to January and again the yield increase as a sowing date came nearer to February 15. The yield seems to be closely related with the meteorological conditions at the heading time. Further, relationship between the heading date and the yield was studied as follows.

To make clear the relationship between the sowing date and the yield in the main season, another planting test was made using a medium-term variety, IR-298-12-1-1-1.

The results of the test are shown below.

Sowing date	Yield (ton/ha)	Yield ratio
June 15	7.5	100
July 7	6.6	88
August 7	4.1	55
October 9	3.7	49

Judging from the above data, it can be said that earlier the sowing is done higher the yield increase. This trend coincides with the general trend mentioned before.

The results of the seasonal planting test in the off-season are shown below.

Relationship between Sowing Date and Yield

Sowing Date	Yield (ton/ha)			Ratio		
	C-6	IR-8	IR-20	C-6	IR-8	IR-20
Nov. 15	4.9			73		
Nov. 16		3.5			43	
Nov. 22			3.4			58
Dec. 1	4.9	4.5	3.3	73	55	56
Dec. 15	3.3	2.6	4.0	49	32	68
Jan. 2	2.7	4.0	3.4	40	49	58
Jan. 16	4.9	5.4	3.9	73	66	66
Feb. 1	5.6	6.8	3.6	84	83	61
Feb. 15	6.7	8.2	5.9	100	100	100

As shown in the above table, sowing in February gave the highest yield for each variety. There are considerable differences in yield among three varieties when sown before February. The differences between maximum and minimum yields obtained by sowing from November 15 to January 16 were 2.2 ton/ha, 2.8 ton/ha and 0.7 ton/ha for C-6, IR-8 and IR-20, respectively. Yield is much affected by the interaction between the growth stage of rice and the environmental conditions mainly the climatic conditions. The reduction division stage and heading stage are the most sensitive stage of rice to adverse circumstances. To examine the effect of harsh climatic conditions on the yield in the off-season, the relationships between the unit yield and the heading date, between percentage of ripened grains and the heading date, between the percentage of the unfertilized grains and the heading date and between the percentage of imperfectly ripened grains and the heading date are shown in Fig. 3-1. 2,3 and 4. Judging from the above-mentioned figures, the following characteristics can be drawn out.

(a) Yields were generally low when the rice plant headed in May and were high when the rice headed after June. Yields of rice plants headed around April varied considerably with the variety.

(b) The percentage of the ripened grains decreased when the rice plant headed in May. The percentage of ripened grains of rice plants headed from around the latter part of April to the latter part of May was below 70 percent. The percentage of ripened grains of IR-8 shows the lowest percentage (40 %) when it headed on 23rd of May.

(c) The percentage of unfertilized grains of rice plants has a trend to vary with the variety. The percentage of unfertilized grains of IR-8 increased to 30 percent when it headed from around end of April to middle of May, while those of IR-20 and C-6 considerably flactuated. No definite relationship between the heading date and the percentage of unfertilized grains among three varieties was observed.

(d) The percentage of imperfectly ripened grains increased when the rice plant headed from the latter part of April to the latter part of May.

It can be said that the decrease in the yield of rice headed during the period from the latter part of April to the latter part of May can be ascribed to the decrease of the percentage of ripened grains and further the decrease of the percentage of ripened grains was caused mainly by the increase of the percentage of imperfectly ripened grains. This increase of the percentage of imperfectly ripened grains can likely be attributable to the high air and water temperatures from the latter part April to the latter part of May.

Overall relationships between the yield and the heading date, between the percentage of the ripened grains and the heading date and between the percentage of unfertilized grains and the heading date are shown in Table 5-1.2.3 using all varieties planted in the off-season. The following fact can be drawn out from the tables.

(e) The yields of varieties headed in January and February were very low and their percentages of ripened grains as well as their imperfectly ripened grains were also low, except some special cases. On the contrary, the percentages of unfertilized grains of them in that period were very high, i.e. nearly 75 percent, except some cases. The low yields of these varieties, therefore, can be attributable to the high percentage of unfertilized grains caused by low air-and water-temperatures, less than 17 degrees centigrade.

(f) A big varietal deference was observed on the tolerance for the low temperature and the high temperature at the heading time.

Based upon the above discussion, two proper heading periods can be pointed out; one is from the beginning of March to the middle of April and the other is from the beginning of June. Further tests are necessary to find out the varieties with high adaptability to high or low temperatures.

iv) Fertilizer element test

Detailed results of the fertilizer element test are shown in Table 6. Yield in treatments are indicated in the following table.

Summary of the Results of Fertilizer Element Test

Block Number	Yield (ton/ha)					
	Non-N	Non-P	Non-K	Nothing	Everything	
1	3.5	7.7	8.9	2.8	9.4	9.5
2	4.2	9.7	9.4	3.0	7.9	6.6
3	6.7	7.2	7.5	3.5	7.7	7.3
Average	4.8	8.2	8.6	3.1	8.1	

By using the "Student's method" a significance test for the difference of the average yield was carried out, obtaining the following results.

Results of Significant Test

	Student's "t" value	Degrees of Freedom
Non-N vs. Non-P	2.75	4
Non-N vs. Non-K	3.38*	4
Non-N vs. Nothing	1.71	4
Non-N vs. Everything	3.51*	7
Non-P vs. Non-K	0.42	4
Non-P vs. Nothing	6.44**	4
Non-P vs. Everything	0.12	7
Non-K vs. Nothing	9.08**	4
Non-K vs. Everything	0.64	7
Nothing vs. Everything	7.09**	7

Remarks **: Significant with 99% probability
*: Significant with 95% probability

Significant differences between the average yields with 95 percent probability of confidence were observed between treatment Non-N and Non-K, Non-N and Everything, while those with 99 percent probability of confidence were observed between treatment of Non-P and Nothing, between Non-K and nothing, between Nothing and Everything. A clear significant difference was observed between the treatment of "Nothing" and all the other treatments, except the treatment of Non-N. While, no significant difference was found between the treatment of "Everything" and all the other treatment, except the treatment of "Non-N" and "Nothing". The results of the significant test clearly proved that the nitrogen is the indespensable and the most efficient element for increasing the rice yield.

The effects of the application of phosphatic and potash fertilizers were hardly observed. Especially potash fertilizer seems not to be necessary to be applied, which is a big advantage in the rice cultivation in the project area.

v) Nitrogen amount test

Results of the nitrogen amount test are shown in Table 7. A correlation between the yield and the amount of nitrogen applied is shown in Fig. 4. As shown in Fig. 4, the yield increased proportionally to the amount of nitrogen applied within the range of the nitrogen application between 50 kg N/ha and 150 kg N/ha. No significant difference, however, is observed in yield between treatments applied with more than 150 kg N/ha. With respect to the average yield, the yield increases progressively with the increased application of nitrogen. A significant test for the difference of the average yield was carried out in the same manner as that applied to the fertilizer element test.

The results are shown below.

Summary of Results of Nitrogen Amount Test

	Total amount of nitrogen applied				
Block number	50 kg/ha	100 kg/ha	150 kg/ha	200 kg/ha	250 kg/ha
1	4.3 ton/ha	5.5	7.4	6.3	7.9
2	4.2	5.4	7.1	8.4	10.0
3	4.1	5.7	6.8	7.6	7.0
Average	4.2	5.5	7.1	7.4	8.3

Results of Significant Test

	Student's "t" value	Degrees of Freedom
50 kg vs. 100 kg	12.3**	4
50 vs. 150	15.9**	4
50 vs. 200	5.2**	4
50 vs. 250	4.6**	4
100 vs. 150	8.2**	4
100 vs. 200	3.1*	4
100 vs. 250	3.1*	4
150 vs. 200	0.47	4
150 vs. 250	1.33	4
200 vs. 250	0.83	4

Remarks: ** Significant with 99% probability
* Significant with 95% probability

As revealed by the significant test, no significant difference was observed between yields in the treatments applied with more than 150 kg of nitrogen.

The results mean the optimum amount of nitrogen to be applied is likely to be 150 kg N/ha as far as this test is concerned.

vi) Spacing test

Results of the spacing test are shown in Table 8.

Summary of the spacing test and the results of significant test for the difference of the average yield are shown below.

Summary of the Results of Spacing Test

Block Number	30 x 30 cm 11.1 (hills/m^2)	30 x 20 cm 16.7 (hills/m^2)	30 x 15 cm 22.2 (hills/m^2)	25 x 15 cm 26.7 (hills/m^2)	30 x 10 cm 33.3 (hills/m^2)
1	7.3 ton/ha	7.4	7.6	10.4	8.8
2	5.7	6.5	7.6	9.7	8.7
3	6.1	7.1	7.3	6.3	7.8
Average	6.4	7.0	7.5	8.8	8.4

Results of Significant Test for the Spacing Test

			Student's "t" value	Degrees of Freedom
30 x 30 cm	vs.	30 x 20	1.10	4
30 x 30	vs.	30 x 15	2.24	4
30 x 30	vs.	25 x 15	1.77	4
30 x 30	vs.	30 x 10	3.46*	4
30 x 20	vs.	30 x 15	1.79	4
30 x 20	vs.	25 x 15	1.41	4
30 x 20	vs.	30 x 10	3.40*	4
30 x 15	vs.	25 x 15	1.02	4
30 x 15	vs.	30 x 10	2.69	4
25 x 15	vs.	30 x 10	0.31	4

* Significant with 95% probability

Judging from the above table, it can be said in general that the denser the planting density is, the higher the yield is. A noticeable point, however, is that no significant difference is found between treatments with denser planting than 22.2 hills per m^2. This fact means that the planting density of 22.2 hill per m^2 may be taken as an optimum density from the view point of labour saving.

To make clear the relationship between planting density and yield, correlations between yield and number of grains produced per m^2, between yield and number of panicle and between yield and percentage of ripened grains were illustrated in Fig. 5-1.2.3.4 using the data obtained from the nitrogen amount test and the spacing test. The correlation between yield and number of grains per m^2 was highest, showing a correlation coefficient of 0.93. This figure revealed also that a higher yield might be obtained by increasing the number of grains. The correlation between the yield and the number of panicles per m^2 was also strong, showing a correlation coefficient of 0.80. Then, higher yields might also be obtained by increasing the number of panicles per m^2. The correlation coefficient between yield and the percentage of ripened grains was as low as -0.27. This low coefficient explaines why the higher yields are brought about by the large number of grains per m^2, even when a large number of grains is obtained. In view of this fact, it is quite important to increase the number of grains of panicles per square meter for obtaining higher yields than those attained so far.

vii) Herbicide test

Results of the test of the herbicides for soil application are shown in Table 9. A summary of them is shown below.

Effect of Herbicide for Soil Application

Herbicide	Survived Weeds	
	Cyperaceae	Echinochloa crus-galli
	(hills/m^2)	(hills/m^2)
Control (no application)	69	10
MO	4	2
Saturn	0	0
X-52	1	1
Ronstar*	0	0

Remark: Sever phytotoxicity was observed on the rice plant applied with Ronstar.
Measurement of survived weeds was carried out on 20th day after the treatments.

The effects of herbicides for soil application were very remarkable compared with the result of no-application plot. The most effective and safety herbicide was Saturn followed by X-52 and MO. Ronstar brought about severe phytotoxicity on the rice plant showing a low percentages of established seedlings and many stunted plants.

4. Training of Counterpart Personnel and Farmers

The successful rice development in the future will largely depend upon the competence of agriculturists and farmers in managing the rice cultivation by themselves. Rice in the Sudan is a newly introduced crop and competent rice experts are very scarce. It is urgently needed to train those agriculturists and farmers and to transfer knowledge of rice cultivation for successful implementation of the Project. In the above context, the following programme of training of counterpart personnel (agriculturists) and farmers were prepared and put into practice in which three (3) counterparts and eight (8) farmers were particularly trained.

- Seed pretreatment such as salt water selection and seed disinfestation.
- Fertilization (application time and quantity)
- Water management for good germination and establishment of seedlings
- Method of the plant growth observation
- Method of crop yield determination
- Herbicide (kind and way of application)
- Rice pest and diseases and the control of them
- Operation of thresher and mill

5. Recommendation

The primary rice cultivation trials and crop experiments reveal that the physical environmental conditions in the Abu Gasaba area are very suitable for rice production from the plant-physiological point of view.

From the results of rice cultivation trials and experiments metioned above, the possibility of two cropping of rice a year, potential yields of rice plants grown in the main season as well as the off season and the cultivation methods in the both seasons have vaguely been clarified. Detailed practices of the two cropping of rice a year, however, have still been left ungratified, and the potential yeilds will also be much increased by finding out the more appropriate varieties and cultivation methods than those so far used. The trials and experiments of rice cultivation, therefore, should be more intensified than before on the following items.

1. Experiment on varieties
2. Experiment on seasonal sowing dates
3. Experiment on four primary elements of fertilizers
4. Experiment on an optimum dosage of nitrogen
5. Experiment on plant spacing including optimum amount of seeds for direct sowing
6. Experiment on sowing practices
7. Experiment on effectiveness of herbicides
8. Experiment on crop-water management.

Table 1-1. Meteorological Condition at Ed-Dueim (June, 1977 - Oct., 1978)

	1977												1978				
	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.
Maximum Air temperature (°C)	39.5	36.0	33.9	37.2	35.7	34.4	30.7	30.6	34.1	36.5	41.1	41.5	37.8	33.0	33.7	36.2	38.1
Minimum Air Temperature (°C)	25.9	24.7	24.1	24.5	23.2	20.3	17.7	15.8	18.1	20.6	26.4	26.8	26.2	23.2	23.7	24.5	24.5
Average Air Temperature (°C)	32.7	30.4	29.0	30.9	29.5	27.4	24.2	23.2	26.1	28.6	33.8	34.2	32.0	28.1	28.7	30.4	31.3
Maximum Water Temperature (°C)						30.1	26.2	27.0	31.1	31.7	37.6	39.6	34.0	33.0	36.8	34.8	34.7
Minimum Water Temperature (°C)						13.4	12.7	11.7	14.2	15.3	19.3	22.9	21.0	23.0	24.5	23.8	22.5
Average Water temperature (°C)						21.8	19.5	19.4	22.7	23.5	28.5	31.3	27.5	28.0	30.7	29.3	28.6
Relative Humidity at 8:00 a.m. (%)	63	67	74	62	47	36	37	37	35	26	26	39	43	77	76	65	54
Rainfall (mm)	10.8	47.2	28.9	18.8	5.1	-	-	-	-	2.6	1.1	0.6	104.7	237.0	156.9	13.9	17.7

Remark: 1. Data on maximum air temperature, minimum air temperature, relative humidity at 8:00 a.m. and rainfall were obtained from the meteorological station at Ed-Dueim, while water temperature was measured in the rice field.

Table 1-2 NET WATER REQUIREMENT BY RICE AND RELATED METEOROLOGICAL DATA

February, 1978

Date	Net water Requirement (mm)	Piche Evaporation (mm)	Wind Velocity at 8:00 a.m (kts)
18	10.0	17.5	9
19	10.0	19.9	6
20		20.8	4
21		21.6	7
22		22.0	8
23	20.0	25.8	6
24	19.0	20.9	9
25	10.0	18.2	6
26	11.0	14.3	5
27	10.0	17.9	5
28	9.0	15.0	5

Note : Net water requirement is equal to the sum of evapotranspiration and percolation.

Table 1-3 Evapotranspiration by Rice and Related Meteorological Data

March, 1978

Date	Evapotranspiration (mm/day)	Piche Evaporation (mm/day)	Wind Velocity at 8:00 A.M. (kts)
1	10.0	20.7	5
2	9.0	21.1	2
3	12.0	20.5	5
4	12.0	21.8	4
5	12.5	22.7	7
6	12.5	20.9	5
7	10.5	19.2	6
8	11.0	18.2	5
9	7.0	14.4	5
10	7.5	13.4	5
11	9.0	11.4	5
12	10.6	19.7	12
13		17.4	7
14		19.6	7
15	12.0	20.9	7
16	10.0	20.8	7
17	11.0	22.1	5
18	12.5	22.2	6
19	11.5	21.3	7
20	10.5	25.1	3
21	10.5	21.6	7
22	11.0	24.4	6
23	11.0	21.4	5
24	11.0	24.5	7
25	12.0	23.5	7
26	9.5	26.7	5
27		23.2	4
28		19.8	5
29		19.7	5
30		18.8	7
31	10.0	21.9	4
Mean		20.6	6

Table 1-4 Evapotranspiration by Rice and Related Meteorolgical Data

April, 1978

Date	Evapotranspiration (mm/day)	Piche Evaporation (mm/day)	Wind Velocity at 8:00 A.M. (kta)
1	11.0	21.2	2
2	11.0	20.7	5
3	11.5	20.3	5
4		25.7	5
5		20.2	5
6		25.3	4
7/1		21.0	7
8	16.0	22.3	5
9	14.0	22.5	7
10	14.0	25.5	6
11	17.5	11.3	8
12		20.7	6
13		24.3	7
14		21.0	7
15	15.0	12.3	5
16	14.0	13.8	6
17	14.0	21.0	6
18	17.0	17.6	11
19		12.0	7
20	15.5	10.2	3
21	15.0	15.6	2
22	20.0	22.4	4
23	19.5	23.0	7
24		24.7	6
25	19.0	22.5	12
26		19.2	4
27		16.6	4
28		21.1	6
29	20.0	25.0	3
30		16.7	3
Mean		19.8	6

/1: Heading date of rice plants in the tank used.

Table 2-1 Performances of Varieties in the Main Season (1977)

Trials	Sowing date	Heading date	Maturity date	Panicle length (cm)	Culm length (cm)	No. of panicles per hill	No. of grains per panicle	No. of grains per m^2 (x1000)	Percent of ripened grains (%)	Wt. of 1,000 grains (g)	Yield Ton/ha	Yield Ton/fed
1. Cultivation Method Trial (Variety used: IR-298-12-1.1.1.)												
Direct sowing (Drilling)	Jun. 23	Sep. 21	Oct. 19	23.2	75		122	43.0	83	19.6	7.0	2.9
Direct sowing (Broad casting)	Jun. 23	Sep. 21	Oct. 19	21.6	69	-	99	34.9	84	19.8	5.8	2.4
Transplanting (regular)	Jun. 15	Sep. 21	Oct. 20	22.2	69	12.6	150	41.9	90	19.9	7.5	3.2
Transplanting (Broad cast)	Jun. 15	Sep. 15	Oct. 17	22.4	74	14.1	120	44.9	88	20.0	7.9	3.3
2. Variety Trial												
Fujiminori (Japan)	Jun. 7	Aug. 15	Sep. 9	21.3	73	14.5	78	25.1	78	24.5	4.8	2.0
Reimei (Japan)	Jun. 7	Aug. 22	Sep. 9	20.5	60	15.1	75	25.1	82	25.7	5.3	2.2
Toyonishiki (Japan)	Jun. 7	Aug. 22	Sep. 9	18.6	65	16.1	66	23.3	92	26.1	5.6	2.3
Koganenishiki (Japan)	Jun. 7	Aug. 3	Sep. 1	16.5	53	12.2	30	8.0	73	20.6	1.2	0.5
Asominori (Japan)	Jun. 7	Aug. 1	Sep. 1	16.3	52	12.6	46	12.8	73	23.6	2.2	0.9
Toitsu (Korea)	Jun. 7	Sep. 4	Oct. 8	21.8	55	14.5	114	37.0	83	24.4	7.5	3.2
Taichung-65 (Taiwan)	Jun. 7	Aug. 28	Oct. 3	21.7	85	10.7	98	23.2	86	25.6	5.1	2.1
Taichuikukyu (Taiwan)	Jun. 7	Aug. 27	Oct. 15	20.5	71	12.5	159	44.1	69	23.0	7.0	2.9
Down (U.S.A.)	Jun. 7	Aug. 28	Oct. 11	27.0	69	5.2	298	34.3	63	20.8	4.5	1.9
Blue Bonnet (U.S.A.)	Jun. 7	Sep. 12	Oct. 17	26.8	87	4.6	199	20.3	79	22.4	3.6	1.5
Basmati (U.S.A.)	Jun. 20	Sep. 15	Oct. 11	27.2	109	12.2	103	28.0	75	20.0	4.2	1.8
Cawad Mali (U.S.A.)	Jun. 20	Oct. 14	Nov. 8	27.6	114	10.3	122	28.0	74	22.6	4.7	2.0
IR-127 (Philippines)	Jun. 7	Sep. 4	Oct. 15	24.1	68	6.6	355	52.2	70	18.6	6.8	2.9
IR-298-12-1.1.1. (Philippines) (Broadcast transplanting)	Jun. 15	Sep. 15	Oct. 17	22.4	74	14.1	120	44.9	88	20.0	7.9	3.3
IR-5 (Philippines) (Broadcast transplanting)	Jun. 15	Sep. 4	Oct. 12	23.0	60	18.1	99	35.6	87	23.6	7.3	3.1
IR-2053 (Philippines)	Jun. 15	Sep. 21	Oct. 20	24.7	66	14.8	117	38.4	77	23.0	6.8	2.9
IR-22 (Philippines)	Jun. 15	Sep. 21	Oct. 18	21.8	59	17.3	90	34.7	88	22.3	6.8	2.9
IR-2153 (Philippines)	Jun. 15	Sep. 17	Oct. 18	21.9	62	20.0	75	33.3	86	22.0	6.3	2.7
IR-1514 (Philippines)	Jun. 15	Sep. 24	Oct. 22	24.1	62	20.0	126	56.0	74	18.1	7.5	3.2
IR-1561 (Philippines)	Jun. 15	Sep. 9	Oct. 12	22.0	53	22.0	91	44.4	90	19.3	7.7	3.2
IR-298-12-1.1.1. (Philippines)	Jun. 15	Sep. 21	Oct. 20	22.2	69	12.6	150	41.9	90	19.9	7.5	3.2
IR-20 (Philippines)	Jun. 20	Sep. 27	Oct. 29	26.0	61	16.0	153	54.4	79	18.7	8.1	3.4
IR-8 (Philippines)	Jun. 20	Sep. 28	Oct. 31	23.0	58	14.5	117	37.7	86	26.8	8.7	3.7
C-11 (China)	Jun. 15	Aug. 27	Oct. 2	22.9	56	15.7	88	30.1	91	24.8	6.8	2.9
C-15 (China) (Broadcast transplanting)	Jun. 15	Sep. 13	Oct. 15	23.7	68	16.0	128	44.6	90	22.4	9.0	3.8
BG-34-8 (Sri Lanka)	Jun. 20	Sep. 9	Oct. 8	23.6	66	10.2	189	43.1	77	19.9	6.6	2.8
BG-34-8 (Sri Lanka)	Jul. 7	Sep. 25	Oct. 30	24.1	79	12.0	170	45.3	81	21.7	8.0	3.4
SLM-18 (Surinum)	Jun. 7	Sep. 4	Oct. 11	25.6	77	11.6	55	18.8	83	35.2	5.5	2.3
Native Variety (Nigeria)	Jul. 7	Oct. 8	Nov. 9	25.4	118	16.3	93	33.8	63	22.0	4.7	2.0
IR-298-12-1.1.1.	Jul. 7	Oct. 4	Nov. 8	22.9	68	12.0	140	37.5	91	19.4	6.6	2.8
TOS-103 (Philippine)	Jul. 28	Oct. 17	Nov. 18	25	53	19.8	118	51.8	83	22.8	9.8	4.1
BG-90 (Sri Lanka)	Jul. 28	Nov. 1	Nov. 28	29	54	19.1	169	71.6	44	25.4	8.0	3.4
IR-298-12-1-1-1 (Philippine)	Aug. 7	Nov. 8	Dec. 13	24	62	19.7	111	31.3	77	17.0	4.1	1.7
BG-34-8 (Sri Lanka)	Aug. 22	Nov. 5	Dec. 13	21	49	14.4	138	44.0	63	20.9	5.8	2.4
IR-20 (Philippine)	Aug. 22	Nov. 27	Dec. 22	22	49	18.4	119	48.7	66	16.8	5.4	2.3
IR-8 (Philippine)	Aug. 22	Dec. 8	Jan. 9	22	40	19.3	91	38.8	49	24.7	4.7	2.0
Cawad Mali (U.S.A.)	Aug. 22	Nov. 2	Dec. 6	22	74	13.7	76	23.2	58	20.8	2.8	1.2
C-11 (China)	Sept. 11	Dec. 3	Jan. 14	19	45	20.1	92	41.1	70	21.2	6.1	2.6

Table 2-2 Performances of Varieties in Off-Season

	Seeding Date	Trans-planting date	Heading date	Maturity date	Culm length (cm)	Panicle length (cm)	No. of panicle per m^2	No. of grains per m^2 ($x10^3$)	Yield (ton/ha)	Percentage of ripened grains	Percentage of non-fertilized grains	1,000 grains weight (g)	Quality of Brown Rice
IR-298-12-1-1-1	Oct. 9	Nov. 6	Feb.19	Apr.11	52	20	364	33.5	3.7	66.6	25.2	16.6	good
C-11	Oct.10	Nov. 6	Feb. 5	Apr.16	42	17	912	70.5	3.0	21.7	60.9	19.6	
Fujiminori	Nov. 3	Dec. 6	Mar. 3	Apr.29	66	18	857	22.2	0.3	5.3	90.0	25.0	
Reimei	Nov. 3	Nov.29	Feb.25	Apr.26	57	17	1113	34.8	1.1	16.2	96.3	22.0	
Taichung native 1	Nov. 3	Dec. 7	Mar.15	Apr.15	40	21	654	49.6	6.6	66.6	17.8	20.0	
Toyonishiki	Nov. 3	Nov.29	Feb.24	Apr.13	59	17	487	25.0	0.8	18.9	78.7	16.9	
Nohrin 17	Nov. 3	Nov.30	Feb.19	Apr.11	49	14	328	26.8	-	0.5	97.5	24.0	
Dewachi kara	Nov. 3	Nov.29	Feb. 1	Apr.13	55	16	526	42.1	0.1	1.3	79.0	17.5	
Matsunishiki	Nov. 3	Nov.29	Feb.24	Apr.12	57	16	435	23.6	0.2	4.2	94.4	20.2	
Ishin	Nov. 3	Nov.29	Mar.15	Apr.26	412	20	798	41.1	5.5	66.3	19.9	20.2	Good
Chen-chi-ai-11(C-11)	Nov.3	Dec. 7	Mar.18	Apr.16	40	18	531	40.1	5.0	64.0	20.0	19.5	
C-15	Nov. 3	Dec. 7	Mar.24	May 10	42	20	593	38.4	5.8	83.4	9.2	18.1	Bad
Waikyakunatoku	Nov. 3	Dec. 8	Apr. 2	May 11	39	20	999	41.2	3.5	52.6	39.3	16.5	Bad
IR-22	Nov. 3	Nov.29	Mar. 4	Apr.25	33	17	744	33.4	2.9	52.8	36.8	16.3	Good
SLM-18	Nov. 3	Nov.29	Mar. 6	Apr.25	49	19	547	14.3	0.3	5.9	92.0	28.1	
IR-36	Nov. 3	Dec. 8	Mar.21	Apr.19	27	17	349	17.8	1.8	58.0	16.5	33.0	
IR-38	Nov. 3	Dec. 7	Apr. 2	May 10	44	22	400	20.5	2.6	65.8	31.5	19.6	Bad
IR-30	Nov. 3	Dec. 8	Mar.15	Apr.24	41	20	753	52.4	6.2	71.3	25.0	16.6	Medium
Sasanishiki	Nov. 3	Nov.29	Jan.28	Apr.26	53	14	1631	37.1	0.1	3.7	95.3	23.6	
Matsumai	Nov. 3	Dec. 7	Feb. 2	Apr.27	44	13	769	10.9	1.1	47.9	27.6	14.4	
Chuemon	Nov. 3	Nov.30	Jan.28	Apr.29	55	15	697	18.6	0.3	6.9	90.3	20.5	
Toitsu	Nov. 4	Dec. 8	Apr. 2	May 9	37	18	513	29.4	3.5	56.4	22.2	21.1	Bad
Taiching 65	Nov. 4	Dec. 7	Mar.11	Apr.19	70	18	392	17.7	2.0	48.4	14.0	23.3	Medium
Taichung ikukyu	Nov. 4	Dec. 7	Mar. 9	Apr.18	66	19	368	23.7	0.7	17.9	17.2	16.5	
IR-5	Nov. 4	Dec. 7	Mar.31	May 13	41	19	830	52.3	5.4	56.3	31.0	18.3	Bad
IR-28	Nov. 4	Dec. 6	Mar.15	Apr.25	39	19	756	27.3	1.1	21.1	75.7	20.0	Good
IR-24	Nov. 4	Dec. 7	Apr.17	May 16	40	20	489	37.3	4.9	70.0	23.7	19.2	
IR-29	Nov. 4	Dec. 6	Apr. 7	May 21	39	18	1239	40.6	0.9	13.9	69.7	16.1	
HINO	Nov. 4	Dec. 7	Mar.15	Apr.18	34	18	445	29.9	2.9	58.7	24.2	16.5	Good
Kiyonishiki	Nov. 4	Dec. 7	Feb.24	Apr.27	58	16	977	21.8	0.4	6.3	80.5	25.3	
C-6	Nov. 5	Dec. 8	Mar.15	Apr.12	79	20	569	35.0	2.1	29.4	16.6	20.4	
BG-34-8	Nov. 5	Dec. 8	Mar.10	Apr.15	46	18	451	46.5	5.9	66.8	27.4	19.0	Bad
IR-40	Nov. 5	Dec. 8	Mar.15	Apr.15	37	18	670	31.5	3.2	63.9	23.6	15.9	Medium
IR-8	Nov. 6	Dec. 8	Apr.21	May 24	41	22	622	46.0	6.2	57.1	18.9	23.9	Bad
Reimei	Nov.15	Dec. 7	Mar. 3	Apr.27	58	17	828	29.7	2.5	39.1	45.5	21.5	
C-6	Nov.15	Dec.14	Apr.12	May 14	46	21	502	31.8	4.9	65.3	20.0	23.6	Bad
IR-8	Nov.16	Dec.14	Apr.26	May 24	42	22	478	31.3	3.5	51.8	30.8	21.5	
IR-20	Nov.22	Dec.14	Mar.26	May 9	44	20	459	33.9	3.5	73.0	20.2	12.4	Bad
IR-20	Dec. 1	Jan. 5	Apr. 9	May 13	38	19	318	30.4	3.3	72.4	19.6	15.0	
C-6	Dec. 1	Jan. 5	May 5	Jun. 5	46	23	481	36.4	4.9	58.5	10.4	23.0	
IR-8	Dec. 1	Jan. 5	May 13	Jun. 6	64	20	505		4.5	Sample missing			
IR-20	Dec.15	Jan.28	Apr.19	May20	45	20	507	37.6	4.0	76.6	9.1	13.9	
IR-8	Dec.15	Jan.28	May 23	Jun.15	62	21	438	28.0	2.6	41.0	28.9	23.0	
C-6	Dec.15	Jan.28	May 17	Jun. 8	66	21	467	30.7	3.3	47.3	21.0	23.0	
Reimei	Jan. 2	Feb. 1	Mar.31	May 16	53	16	561	17.8	0.1	3.2	37.7	17.6	
IR-20	Jan. 2	Feb. 2	Apr.23	May 24	42	20	451	28.4	3.4	74.9	11.0	15.8	
C-6	Jan. 2	Feb. 1	May 23	Jun.15	65	21	382	28.4	2.7	49.3	21.8	22.5	
Reimei	Jan.16	Feb.15	Apr. 7	May 20	41	15	793	22.8	0.4	8.2	20.2	22.5	
IR-20	Jan.16	Feb.15	May 8	Apr.30	45	22	510	48.1	3.9	51.4	18.0	15.7	
Reimei	Feb. 1	Fe.27	Apr.18	Jun. 1	53	16	630	20.3	2.0	46.0	32.4	21.9	
IR-20	Feb. 1	Feb.27	May 23	Jun.15	73	24	417	32.5	3.6	68.5	8.5	16.4	
Reimei	Feb.15	Mar.16	May 4	Jun. 3	47	17	569	20.1	3.0	65.5	27.6	22.8	

Table 2-3 Perfomances of Varieties in Off-Season (Jan. - Aug.) and in the Main the Main Season (1978)

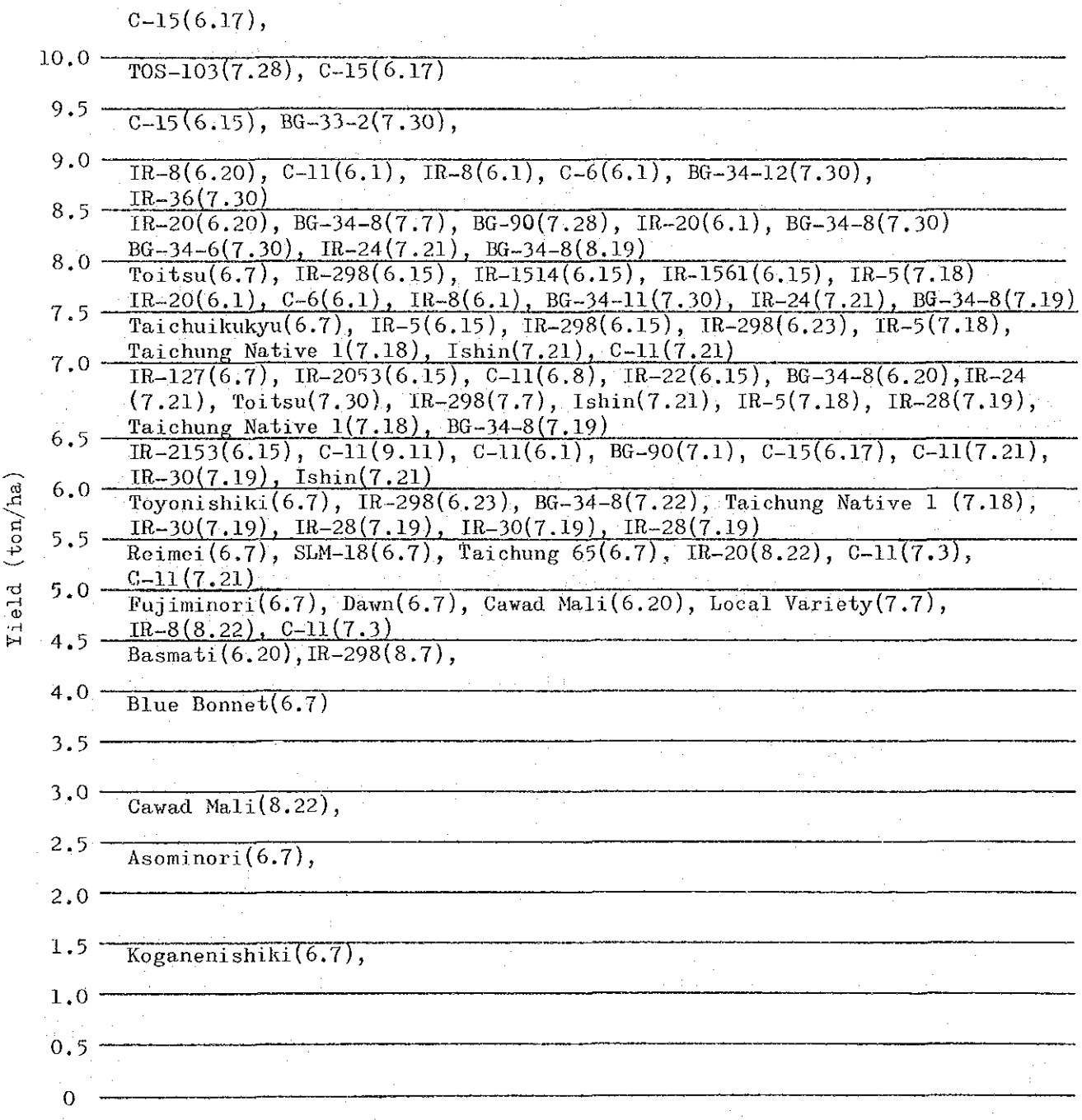
	Seeding date	Transplanting date	Heading date	Maturity date	Culm length (cm)	Panicle length (cm)	No of panicles per m^2	No. of grains per m^2 (x10^3)	Yield ton/ha	Percentage ripened grains	Percentage of non-fertilized grains	1,000 grains weight (g)	Quality of Brown Rice
IR-8	Jan. 2	Feb. 2	May 26	Jun.27	63	21	411	24.3	4.0	65.7	15.4	24.9	
C-6	Jan.16	Feb.16	May 26	Jun.27	70	22	454	32.7	4.9	61.0	20.6	25.0	
IR-8	Jan.16	Feb.16	May 29	Jul. 9	48	20	473	30.8	5.4	68.2	12.0	25.4	
IR-8	Feb. 1	Feb.27	Jun.10	Jul.24	49	23	457	30.2	6.8	88.7	2.2	25.3	
C-6	Feb. 1	Feb.27	Jun. 4	Jul.18	51	22	424	34.1	5.6	66.4	15.5	24.9	
BG-90	Feb.13	Mar.18	Jun.22	Aug. 2	55	25	584	46.6	9.3	76.5	16.6	26.0	
TCS-103	Feb.13	Mar.18	Jun. 4	Jul.18	42	21	435	33.2	6.5	83.2	10.2	23.7	
C-11	Feb.13	Mar.18	May 29	Jul.29	46	20	908	49.3	4.3	42.2	46.9	20.5	
C-13	Feb.13	Mar.18	Jun.25	Aug. 2	56	22	518	39.1	6.4	82.8	10.9	19.8	
IR-36	Feb.13	Mar.18	Jun. 4	Jul. 9	45	20	665	45.3	7.0	81.1	10.2	19.1	
IR-38	Feb.13	Mar.18	Jun. 4	Jul.24	44	18	505	28.3	4.2	69.9	17.1	21.1	
IR-30	Feb.13	Mar.18	May 29	Jul.29	47	21	1509	45.9	5.7	65.0	31.5	19.0	
IR-22	Feb.13	Mar.16	Jun. 4	Jul.24	50	19	646	34.3	5.5	78.8	16.9	20.3	
SLM-18	Feb.13	Mar.16	Jun. 3	Jul.29	61	22	758	20.6	1.0	15.9	77.7	31.8	
Toitsu	Feb.13	Mar.18	Jun. 4	Jul.15	46	21	433	31.9	4.2	59.5	20.9	22.3	
Taichung 65	Feb.13	Mar.18	May 29	Jul.29	58	18	606	16.8	1.1	26.0	58.8	25.9	
IR-28	Feb.13	Mar.18	May 28	Jul.24	51	20	945	19.2	3.1	76.3	18.1	21.3	
IR-24	Feb.13	Mar.18	Jun.23	Aug. 2	49	21	470	34.8	6.6	84.4	10.7	22.7	
IR-29	Feb.13	Mar.18	Jun.12	Jul.28	50	20	1469	48.4	5.0	50.7	48.3	20.2	
HINO	Feb.13	Mar.16	May 31	Jul.24	50	19	756	35.7	4.6	65.1	28.7	20.0	
BG-34-8	Feb.13	Mar.18	May 28	Jun.22	54	21	454	41.3	4.8	61.4	28.8	19.0	
IR-40	Feb.13	Mar.16	Jun. 3	Jul.10	50	22	638	38.3	4.7	66.7	23.2	18.3	
IR-298-12-1-1-1	Feb.13	Mar.18	Jun. 4	Jul.18	44	21	473	32.4	5.9	87.9	7.6	20.7	
Ishin	Feb.13	Mar.18	Jun. 6	Jul.15	50	21	441	39.0	5.0	61.1	21.7	21.0	
C-6	Feb.15	Mar.16	Jun.27	Jul.29	54	22	441	34.2	6.7	74.4	13.4	26.5	
IR-8	Feb.15	Mar.16	Jul. 3	Aug. 9	51	21	502	42.7	8.2	73.4	20.4	26.1	
IR-20	Feb.15	Mar.16	Jun. 4	Jul.10	46	22	451	42.1	5.9	80.6	5.2	17.4	
BG-34-8	Mar.11	Apr.22	Jun.30	Aug. 5	52	22	318	32.7	4.6	65.1	26.9	21.4	
IR-22	Mar.25	May 6	Jul.13	Aug.21	50	20	462	26.9	5.3	92.1	5.9	21.2	
C-11	Jun. 1	Jun.17	Aug.17	Set.14	73	25	387	41.0	8.7	87.5	3.5	24.4	
IR-20	Jun. 1	Jul.17	Sep. 4	Oct. 7	68	29	355	51.7	8.4	80.7	7.9	20.2	
C-6	Jun. 1	Jul.17	Sep. 7	Oct.10	68	26	302	36.4	8.8	80.6	5.4	29.9	
IR-8	Jun. 1	Jul.17	Sep.10	Oct.14	62	24	320	34.4	8.7	82.1	7.5	30.6	
C-11	Jun. 1	Jul.17	Aug.17	Sep.14	66	23	342	29.0	6.2	87.4	4.0	24.5	
IR-20	Jun. 1	Jul.17	Sep. 4	Oct. 7	58	24	334	49.5	7.9	81.8	11.0	19.5	
C-6	Jun. 1	Jul.17	Sep. 7	Oct.10	59	25	283	30.7	7.9	84.1	1.4	30.7	
IR-8	Jun. 1	Jul.17	Sep.10	Oct.14	52	21	286	28.1	7.5	87.5	0.6	30.3	
Taichung Native 1	Jul.18	Aug. 7	Sep.26	Oct.26	65	24	326	28.8	5.5	80.2	-	24.0	
IR-5	Jul.18	Aug. 7	Oct. 5		56	24	379	37.2	7.2	84.2	-	23.0	
IR-30	Jul.19	Aug. 7	Sep.29	Oct.28	60	23	344	35.9	5.9	78.9	-	20.7	
Ishin	Jul.21	Aug. 8	Oct. 3		66	24	326	33.4	6.9	85.5	-	24.0	
IR-24	Jul.21	Aug. 8	Oct.15		54	22	267	40.0	7.5	83.0	-	22.5	
C-11	Jul.21	Aug. 8	Sep.25	Oct.26	66	21	339	32.5	6.1	79.9	-	23.5	
BG-34-8	Jul.19	Aug. 8	Oct. 1		69	25	280	39.3	7.6	84.1	-	22.9	
IR-28	Jul.19	Aug. 8	Sep.29	Oct.28	70	23	368	26.2	5.6	91.6	-	23.1	
Taichung Native 1	Jul.18	Aug. 8	Sep.26	Oct.26	63	23	331	34.3	7.0	83.8	-	24.2	
IR-5	Jul.18	Aug. 8	Oct. 5		56	24	409	33.8	6.9	86.3	-	23.8	
IR-30	Jul.19	Aug. 8	Sep.29	Oct.28	60	23	352	32.1	6.3	95.4	-	20.7	
Ishin	Jul.21	Aug. 8	Oct. 3		63	24	344	32.8	7.2	90.7	-	24.3	
IR-24	Jul.21	Aug. 8	Oct.15		55	23	307	44.6	8.0	77.8	-	23.0	
C-11	Jul.21	Aug. 8	Sep.25	Oct.26	64	22	342	34.6	7.2	86.5	-	24.0	
BG-34-8	Jul.19	Aug. 8	Oct. 1		70	25	375	44.0	8.3	82.6	-	22.7	
IR-28	Jul.19	Aug. 8	Sep.27	Oct.28	65	22	443	32.4	6.7	90.3	-	22.7	

Table 2-4 Performances of Varieties in Off-Season (Jan. - Aug.) and in the Main Season (1978)

	Seeding date	Trans-planting date	Heading date	Maturity date	Culm length (cm)	Panicle length (cm)	No. of penciles per m^2	No. of grains per m^2 ($x10^3$)	Yield (ton/ha)	Percentage ripened grains	Percentage of non fertilized grains	1,000 grains weight (g)	Quality of Brown Rice
Taichung Native 1	Jul.18	Aug. 9	Sept.26	Oct.26			344	32.6	6.5	85.2	-	23.6	
IR-5	Jul.18	Aug. 9	Oct. 5				403	39.1	7.7	85.2	-	23.0	
IR-30	Jul.19	Aug. 9	Sep.29	Oct.28			392	39.0	5.9	77.0	-	19.6	
Ishin	Jul.21	Aug. 9	Oct. 3		57	24	307	30.1	6.2	85.1	-	24.0	
IR-24	Jul.21	Aug. 9	Oct.15				286	39.9	6.6	74.9	-	22.0	
C-11	Jul.21	Aug. 9	Sep.25	Oct.26	58	22	326	25.0	5.2	91.4	-	22.8	
BG-34-8	Jul.19	Aug. 9	Oct. 1		61	23	301	38.9	6.6	76.1	-	22.4	
IR-28	Jul.19	Aug. 9	Sep.29	Oct.28	58	21	398	33.6	5.6	74.8	-	22.2	
Toitsu	Jul.30	Aug.23	Oct.15				318	33.3	6.7	75.8	-	26.4	
C-11	Jul.3	Jul.26	Sep.14	Oct. 8	63	22	294	27.7	5.1	72.7	15.0	25.0	
C-11	Jul.3	Jul.26	Sep.14	Oct. 8	59	23	259	25.7	4.5	71.5	4.6	24.3	
BG-34-11	Jul.30	Aug.22	Oct.11		65	23	288	39.4	7.5	82.7	-	23.0	
BG-33-2	Jul.30	Aug.22	Oct.11		61	25	288	49.3	9.2	84.3	-	22.2	
BG-34-12	Jul.30	Aug.22	Oct.11		66	23	368	48.7	8.5	72.3	-	24.0	
BG-34-8	Jul.30	Aug.22	Oct.11		69	25	331	46.9	8.3	73.8	-	23.9	
BG-34-6	Jul.30	Aug.22	Oct.11		68	26	334	41.2	8.0	77.3	-	25.1	
IR-36	Jul.30	Aug.22	Oct.13				475	53.1	8.6	74.9	-	21.5	
C-11	Aug. 1	Aug.23	Oct.13				401	40.6	8.0	81.6	-	24.1	
C-11	Aug. 1	Aug.23	Oct.13				446	46.8	9.8	87.3	-	24.0	
IR-20	Jul. 3	Jul.26	Oct. 4	Nov. 6	62	22	312	36.9	5.9	83.3		19.3	
C-6	Jul. 3	Jul.26	Oct.10	Nov.14			251	30.7	7.6	88.7		27.8	
IR-8	Jul. 3	Jul.26	Oct.10	Nov.14			264	25.5	5.3	76.2		27.2	
IR-20	Jul. 3	Jul.26	Oct. 4	Oct. 6			352	37.0	6.3	89.2		19.2	
C-6	Jul. 3	Jul.26	Oct.10	Nov.14			259	29.4	7.0	82.9		28.7	
IR-8	Jul.3	Jul.26	Oct.10	Nov.14			238	23.7	5.8	87.7		27.9	

Remark: Blank cells will be filled later when the data will be obtained

Table 3. Yields of Varieties in Main Season (Jun., - Dec.,)



Note: Numbers in parenthesis mean sowing dates, i.e. (6.17) means June 17.

Table 4. Yields of Varieties in Off-season (Oct., 1977 - Aug., 1978)

Yield (ton/ha)

10.0

9.5 BG-90(2.13),

9.0

8.5 IR-8(2.15),

8.0

7.5 IR-36(2.13),

7.0 Taichung Native 1(11.3), IR-8(2.1), ToS-103(2.13), IR-24(2.13), C-6(2.15),

6.5 IR-30(11.3), IR-8(11.6), C-15(2.13),

6.0 Ishin(11.3), C-15(11.3), BG-34-8(11.5), C-6(2.1), IR-30(2.13), IR-22(2.13), IR-40(2.13), IR-298(2.13), IR-20(2.15),

5.5 C-11(11.3), IR-5(11.4), IR-8(1.16), IR-29(2.13), Ishin(2.13), IR-22(3.25)

5.0 IR-24(11.4), C-6(11.15), C-6(12.1), IR-8(12.1), C-6(1.16), HINO(2.13), BG-34-8(2.13), BG-34-8(3.11),

4.5 IR-20(12.15), IR-8(1.2), C-11(2.13), IR-38(2.13), Toitsu(2.13),

4.0 IR-298(10.9), Waikyakunantoku(11.3), Toitsu(11.4), IR-8(11.16), IR-20(11.22), IR-20(1.16), IR-20(2.1),

3.5 C-11(10.10), IR-40(11.4), Reimei(11.15), C-6(12.15), IR-20(3.4), IR-28(2.13), Reimei(2.15),

3.0 IR-22(11.3), IR-38(11.3), HINO(11.4), IR-8(12.15), C-6(1.2),

2.5 Taichung-65(11.4), C-6(11.5), Reimei(2.1),

2.0 IR-36(11.3),

1.5 Reimei(11.3), Matsumai(11.3), IR-28(11.4), SLM-18(2.13), Taichung 65 (2.13),

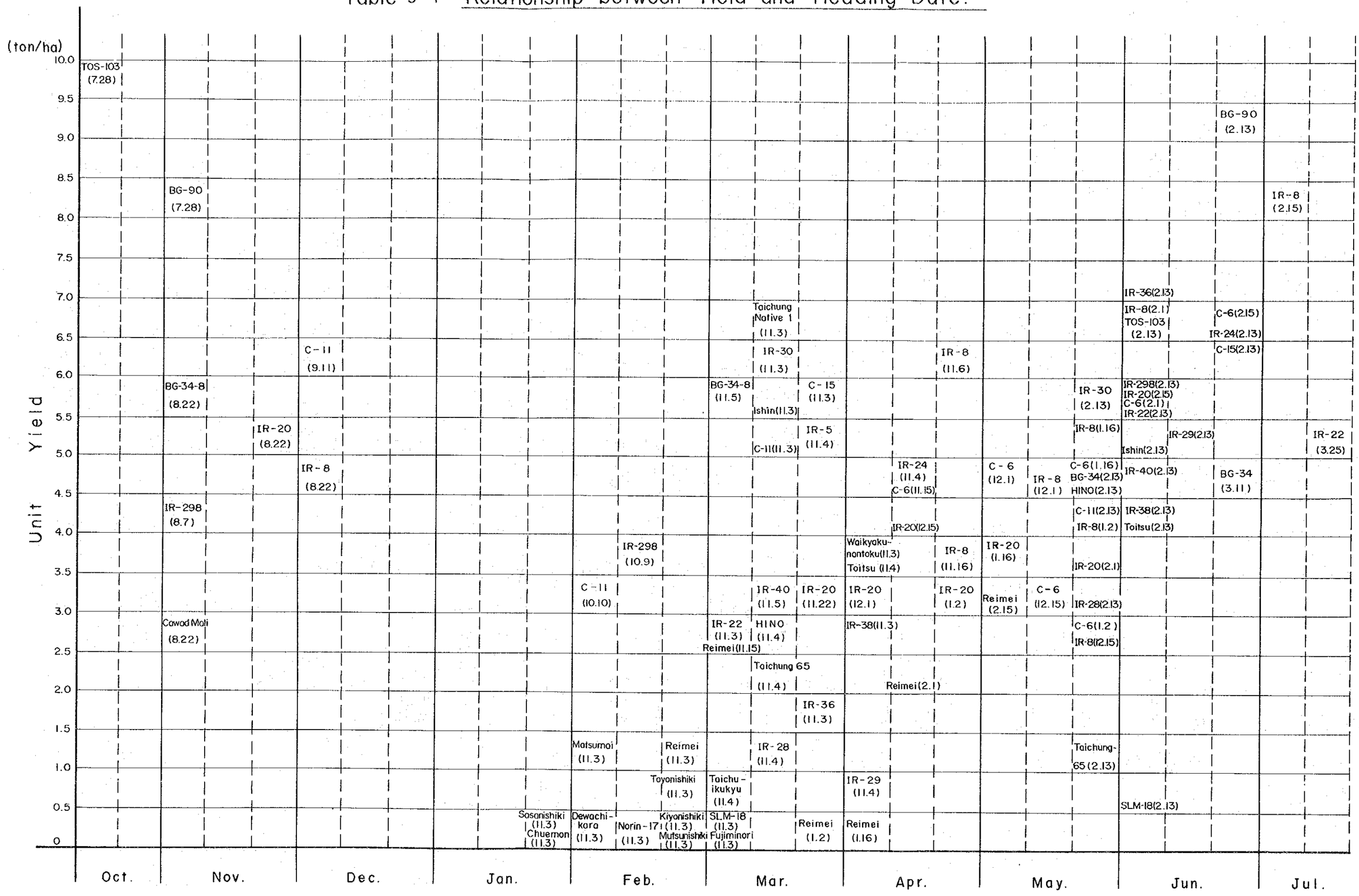
1.0 Toyonishiki(11.3), Taichuikukyu(11.4), IR-29(11.4),

0.5 Fujiminori(11.3), Norin-17(11.3), Dewachikara(11.3), Mutsunishiki (11.3), SLM-18(11.3), Sasanishiki(11.3), Chuemon(11.3), Kiyonishiki (11.4), Reimei(1.2), Reimei(1.16),

0

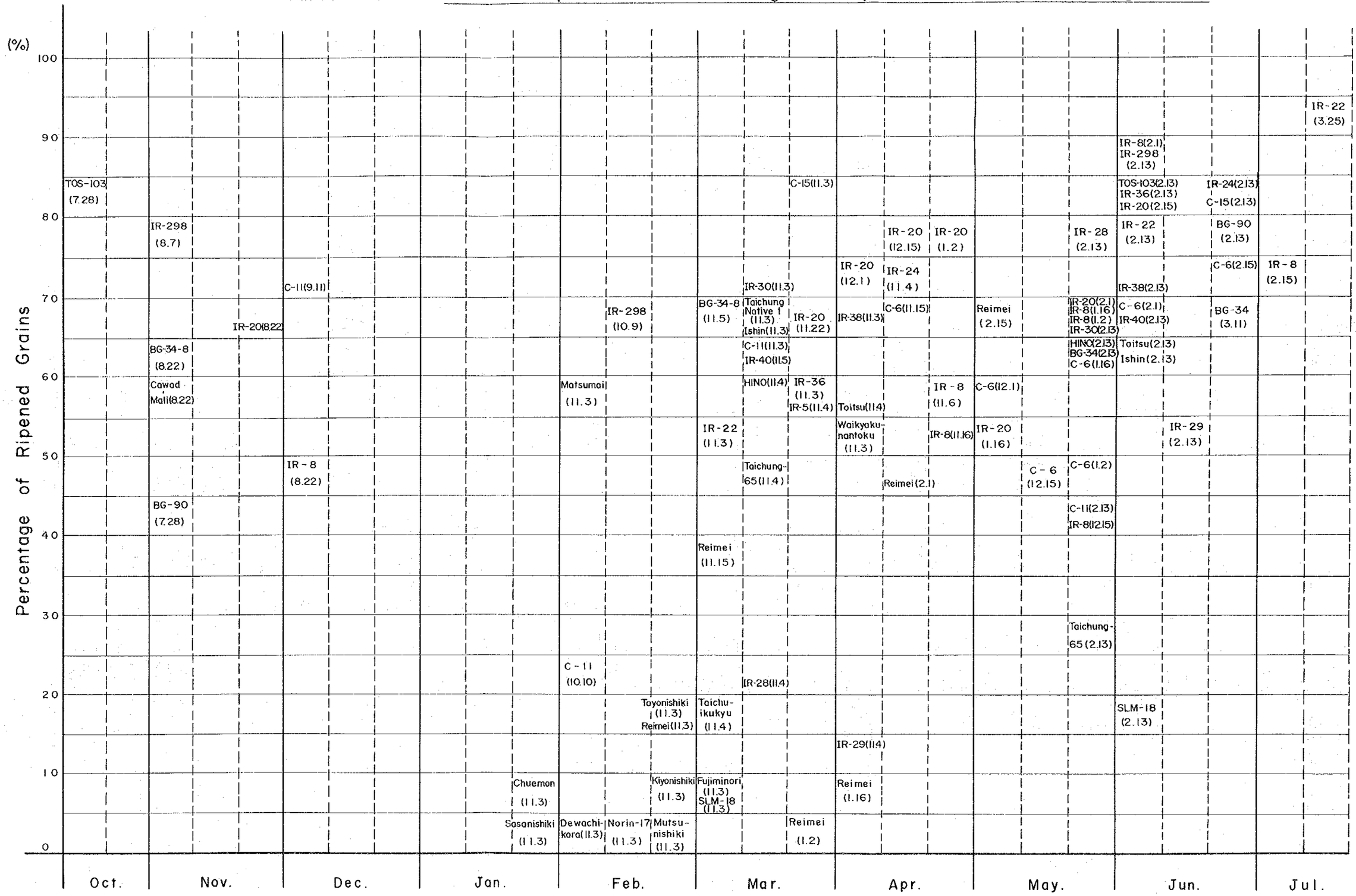
Note: Numbers in parenthesis mean sowing dates, i.e. (2.3) means February 3.

Table 5-1 Relationship between Yield and Heading Date.



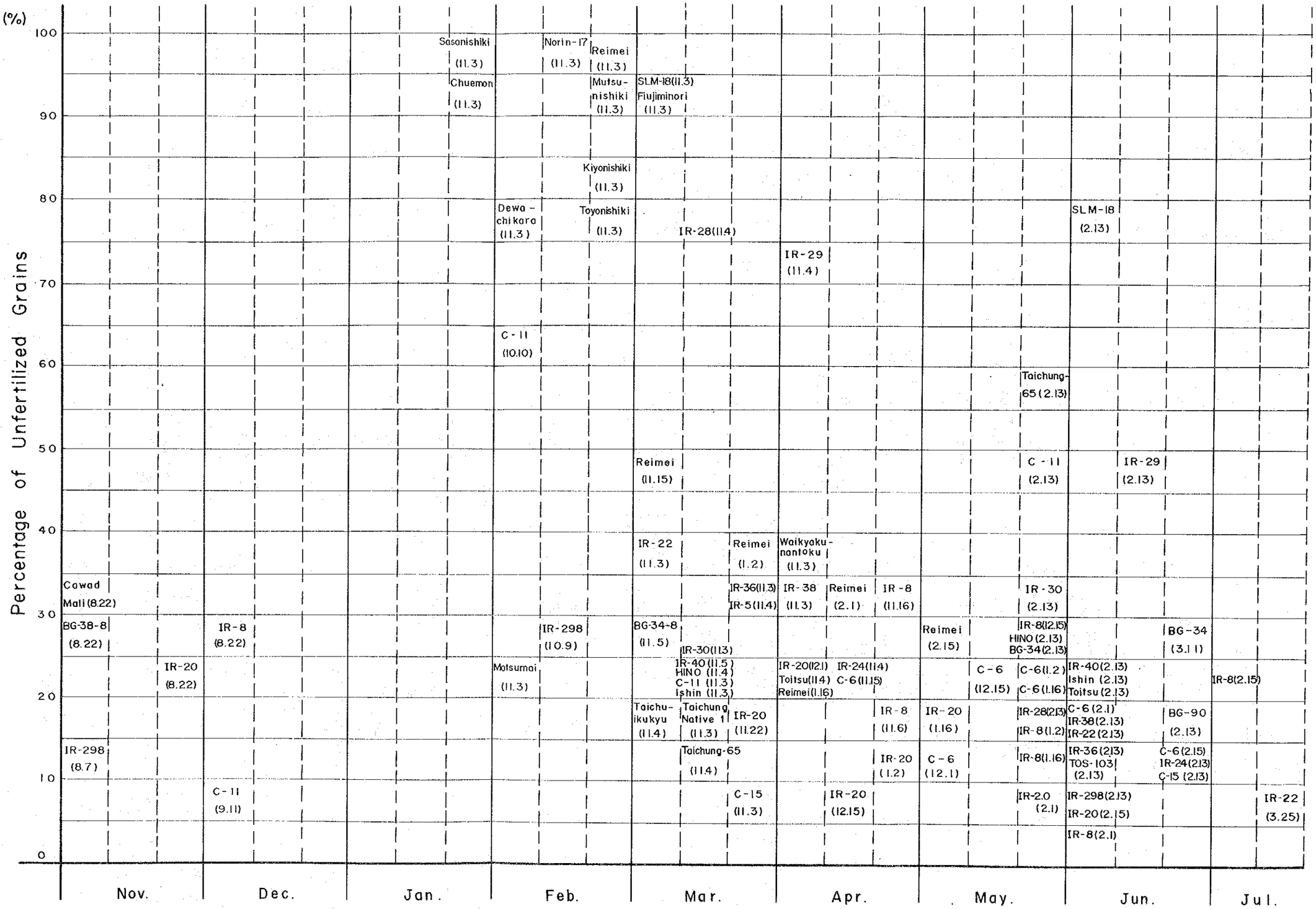
Remark : The number in parenthesis means a sowing date . (7.28) means July 28.

Table 5-2 Relationship between Percentage of Ripened Grains and Heading Date



Remark : The number in parenthesis means a sowing date . (7.28) means July 28.

Table 5-3 Relationship between Percentage of Unfertilized Grains and Heading Date



Remark : The number in parenthesis means a sowing date . (8.22) means July 28.

Table 6. Results of Fertilizer Element Test

Treatment	Block Number	Culm Length (cm)	Panicle Length (cm)	No. of Panicles per m^2	No. of Grains per m^2 (x1000)	Yield (ton/ha)	Percentage of Unfertilized Grains (%)	Percentage of Ripened Grains (%)	1000 Grains Weight (g)
Non-N	1	52	20	206	20.5	3.5	7.1	81.2	21.1
	2	52	23	248	sample missing	4.2	sample missing	sample missing	21.1
	3	54	23	211	38.8	6.7	5.7	81.3	21.2
	Mean	53	22	222	29.7	4.8	6.4	81.3	21.1
Non-P	1	69	24	312	40.2	7.7	5.3	86.8	22.1
	2	69	25	363	47.9	9.7	1.2	90.8	22.2
	3	69	23	315	35.6	7.2	2.2	93.5	21.7
	Mean	69	24	330	41.2	8.2	2.9	90.4	22.0
Non-K	1	70	23	401	53.8	8.9	5.3	75.8	21.7
	2	66	25	382	50.3	9.4	3.5	86.7	21.6
	3	65	24	379	44.2	7.5	6.2	81.0	20.8
	Mean	67	24	387	49.4	8.6	5.0	81.2	21.4
Noting	1	52	21	203	18.1	2.8	7.4	76.2	20.5
	2	53	22	166	17.8	3.0	8.7	80.7	20.7
	3	55	23	192	20.0	3.5	0.7	86.0	20.0
	Mean	53	22	187	18.6	3.1	5.6	81.0	20.5
Everything	1-1	60	24	395	sample missing	9.4	sample missing		22.1
	1-2	65	24	376	47.7	9.5	4.1	88.8	22.3
	2-1	68	25	336	42.5	7.9	2.8	84.6	21.9
	2-2	65	24	379	41.5	6.6	6.2	74.3	21.5
	3-1	65	24	352	41.3	7.7	4.3	87.7	21.9
	3-2	62	24	320	38.2	7.3	4.2	88.6	21.5
	Mean	64	24	360	42.2	8.1	4.3	84.2	21.9

Remak. : Variety C-15
Sowing date, June 8
Transplanting date, June 25
Heading date, September 7
Standard fertilization, 150 kg N,
100 kg P_2O_5
100 kg K_2O/ha

Table 7. Results of Nitrogen Amount Test

Treatment	Block Number	Culm Length (cm)	Panicle Length (cm)	No. of Panicles per m^2	No. of Grains per m^2 (x1000)	Yield (ton/ha)	Percentage of Unfertilized Grains (%)	Percentage of Ripened Grains (%)	1000 Grains Weight (g)
50 kg	1	52	22	211	23.9	4.3	1.9	92.0	19.7
N/ha	2	55	24	224	22.9	4.2	2.1	90.4	20.4
	3	56	23	222	23.4	4.1	3.9	88.6	19.7
	Mean	54	23	219	23.4	4.2	2.6	90.3	19.9
100 kg	1	57	22	280	28.3	5.5	2.0	89.4	21.7
N/ha	2	59	24	280	30.3	5.4	5.7	86.7	20.5
	3	57	23	286	31.9	5.7	4.6	87.2	20.6
	Mean	58	23	282	30.2	5.5	4.1	87.8	20.9
150 kg	1	62	24	350	40.4	7.4	4.8	84.8	21.6
N/ha	2	65	25	334	38.3	7.1	5.6	86.3	21.6
	3	65	25	350	43.2	6.8	14.4	73.0	21.4
	Mean	64	25	345	40.6	7.1	8.3	81.4	21.5
200 kg	1	67	26	376	36.7	6.3	5.0	80.7	21.4
N/ha	2	67	25	328	45.7	8.4	3.9	84.9	21.7
	3	70	25	344	42.6	7.6	8.0	79.4	22.5
	Mean	68	25	349	41.7	7.4	5.6	81.7	21.9
250 kg	1	68	26	350	47.3	7.9	5.6	76.6	21.7
N/ha	2	65	26	358	50.8	10.0	1.0	87.6	22.4
	3	68	26	371	42.8	7.0	5.9	74.3	21.9
	Mean	67	26	360	47.0	8.3	4.2	79.5	22.0

Remarks: Variety, C-15
Sowing date, June 17, 1978
Transplanting date, July 5
Heading date, September 11
Maturity date, October 15

Table 8. Results of Spacing Test for Transplanted Rice

Treatment	Block Number	Culm Length (cm)	Panicle Length (cm)	No. of panicles per m^2	No. of Grains per m^2 (x1000)	Yield (ton/ha)	Percentage of Unfertilized Grains (%)	Percentage of Ripened Grains (%)	1000 Grains Weight (g)
30x30 cm	1	72	27	283	37.8	7.3	2.9	84.3	23.0
(11.1 hills/m^2)	2	68	24	273	35.2	5.8	9.1	77.6	21.1
	3	65	26	240	29.5	6.1	2.9	94.1	22.1
	Mean	68	26	265	34.2	6.4	5.0	85.3	22.1
30x20 cm	1	66	26	356	42.1	7.4	5.5	81.6	21.6
(16.7 hills/m^2)	2	65	25	337	41.6	6.5	14.3	72.1	21.6
	3	64	25	319	40.5	7.0	6.4	80.7	21.4
	Mean	65	25	337	41.4	7.0	8.7	78.1	21.5
30x15 cm	1	74	27	364	39.8	7.6	0.6	85.7	22.4
(22.2 hills/m^2)	2	67	25	320	36.4	7.6	0.7	95.8	21.8
	3	65	26	326	41.7	7.3	5.1	83.3	21.0
	Mean	69	26	337	39.3	7.5	2.1	88.3	21.7
25x15 cm	1	71	27	395	56.2	10.4	6.7	81.1	22.7
(26.7 hills/m^2)	2	68	26	470	60.9	9.7	8.1	74.2	21.5
	3	66	24	323	32.9	6.3	1.0	91.6	21.0
	Mean	68	26	396	50.0	8.8	5.3	82.3	21.7
30x10 cm	1	71	27	446	51.8	8.8	8.1	75.9	22.4
(33.3 hills/m^2)	2	65	25	313	41.8	8.7	0.7	94.5	22.1
	3	61	25	356	40.3	7.8	0.7	90.4	21.3
	Mean	66	26	372	44.6	8.4	3.2	86.9	21.9

Remarks: Variety, C-15
Sowing date, June 17
Transplanting date, July 6
Heading date, September 10
Maturity date, October 15
Fertilization, 150 kg N/ha, 75 kg P_2O_5/ha

Table 9. Effect of Herbicides for Soil Application

Herbicide	Block No.	Survived Weeds	
		Cyperaceae (hills/m^2)	Echinochloa crus-galli (hills/m^2)
	1	62	5
Control	2	70	9
	3	74	15
Average		69	10
	1	4	0
MO	2	2	4
	3	7	3
Average		4	2
	1	0	0
Saturn	2	0	0
	3	0	0
Average		0	0
	1	2	0
X-52	2	0	0
	3	1	3
Average		1	1
	1	0	0
Ronstar	2	0	0
	3	0	0
Average		0	0

Remarks: Sever phytotoxicity was found on the plants applied by Ronstar, i.e., a low percentage of established seedlings and stunted plants. Treatment and investigation were carried out on Oct., 4 and Oct., 24, respectively.

Fig. 1–1 Diurnal Change of Water Temperature in a Paddy Field, Air Temperature and Relative Humidity.

(Dueim, June 17, 1977)

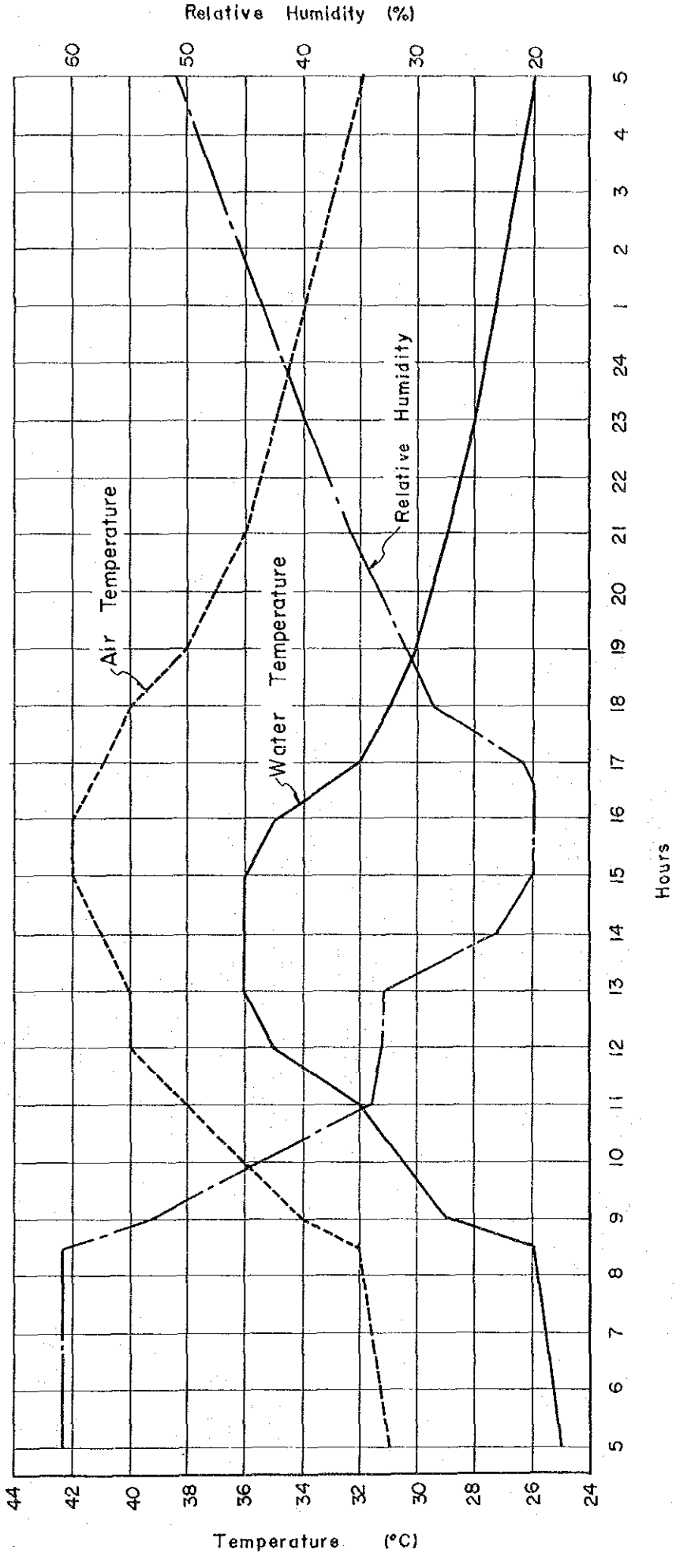
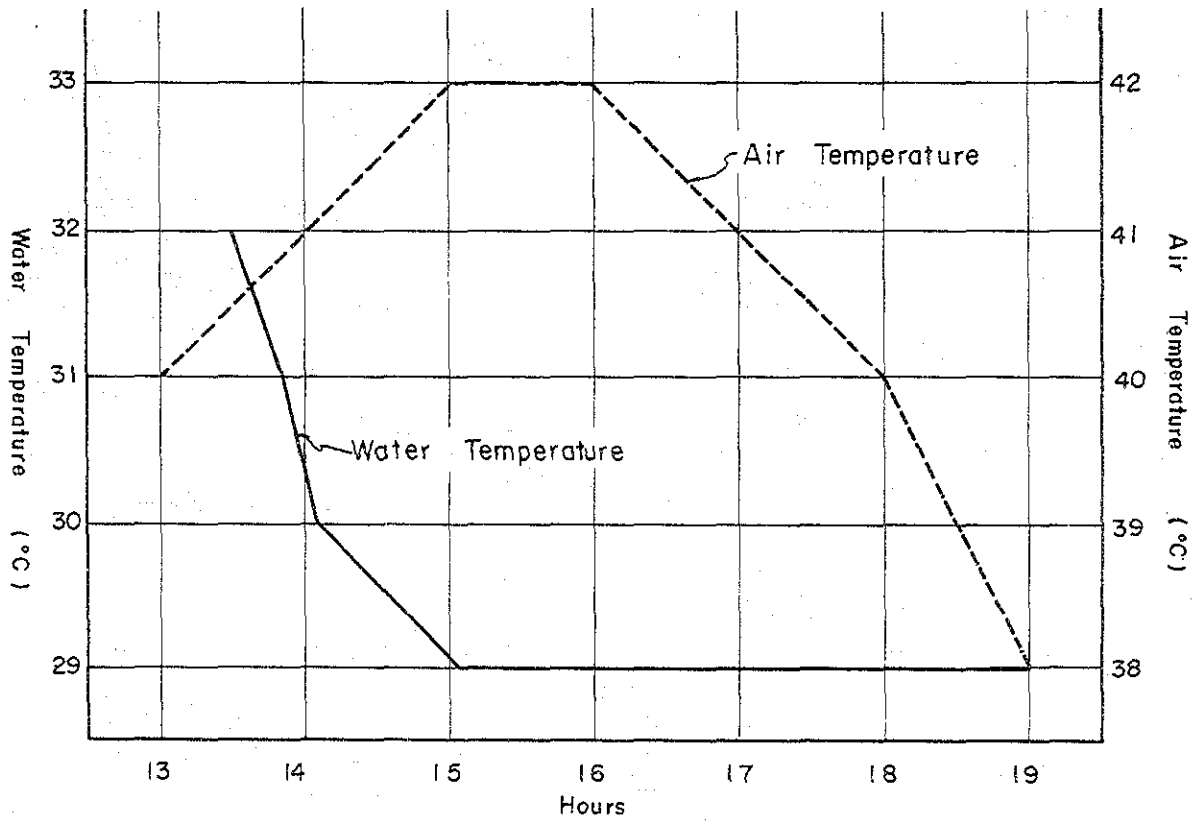
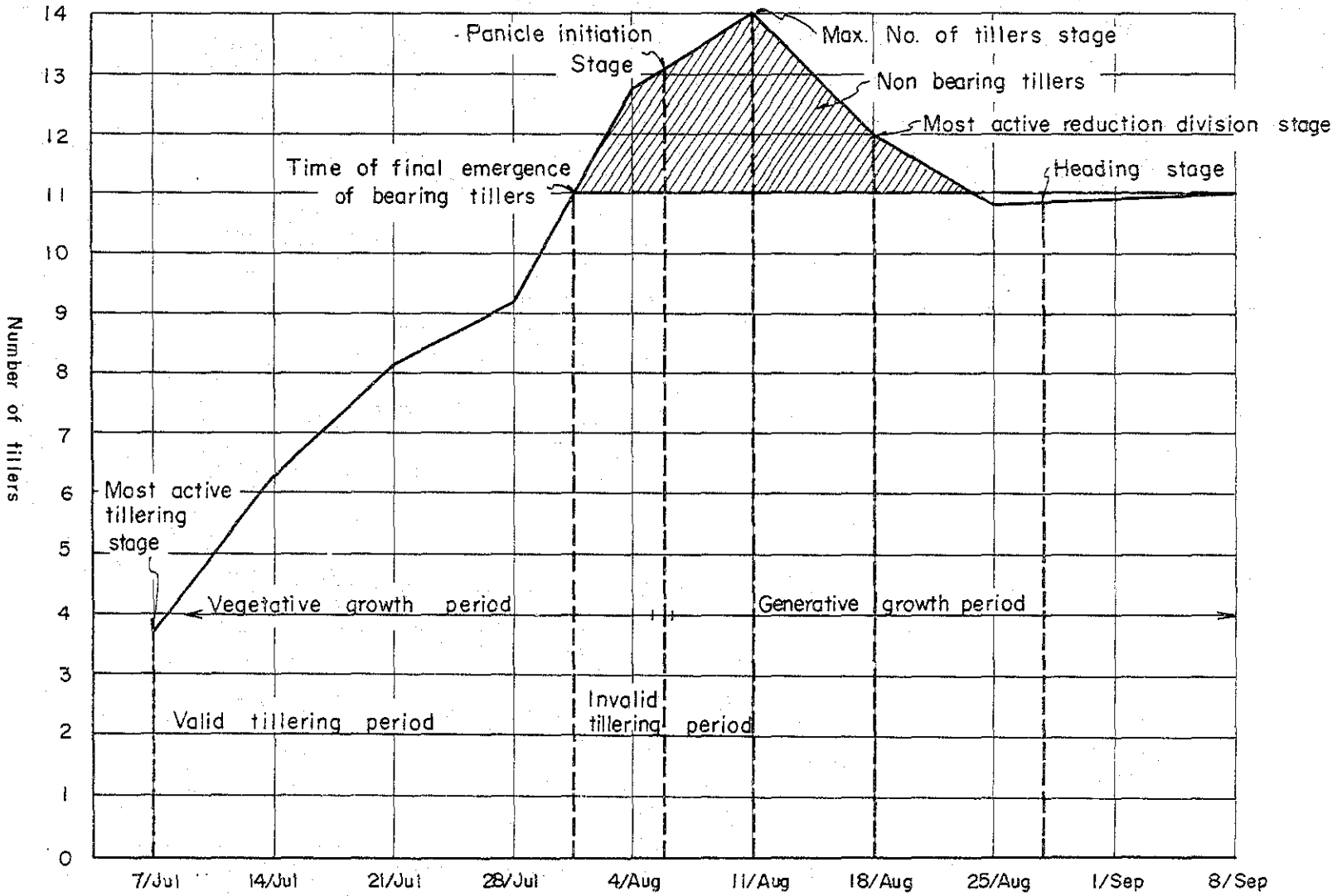


Fig. 1—2 Decreasing Process of Water Temperature inside the Room



Note : City water was taken in a tinned vessel at 1.30 in the afternoon on June 17 and it was kept indoors thereafter.

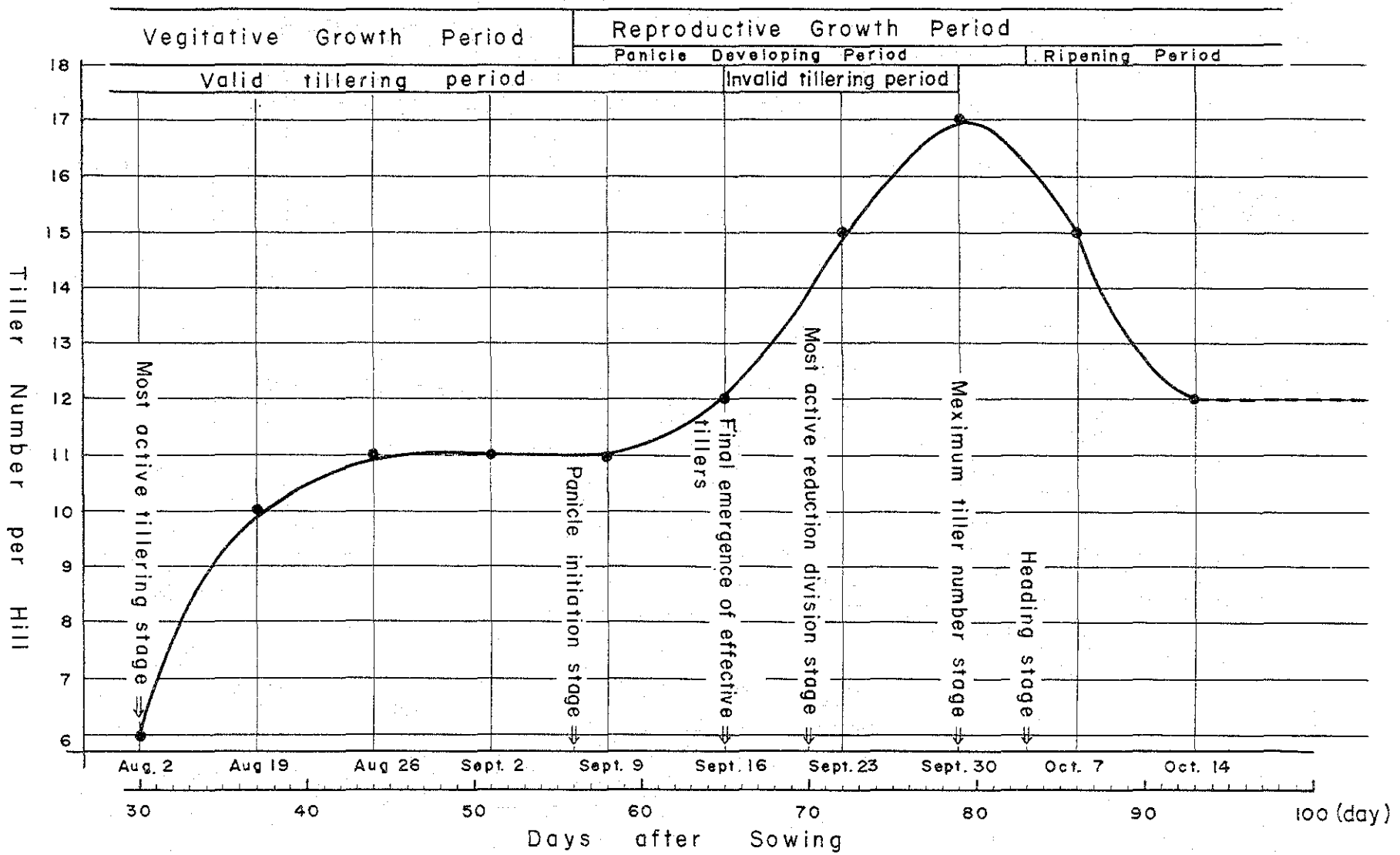
Fig. 1—3 Growth Process of a Medium Term Variety (Taichung-65)



Note : Sowing date ----- Jun. 7 Transplanting date ----- Jun.23

Values on Aug.11 and 18 are presumed ones, because of missing date.

Fig.1-4 Growth pattern of IR-20 in Main Cultivation Season



Remark : Sowing date, July. 3 ; Transplanting date, July 26.

Fig. 1-5 Growth pattern of IR-8 in Off Cultivation Season

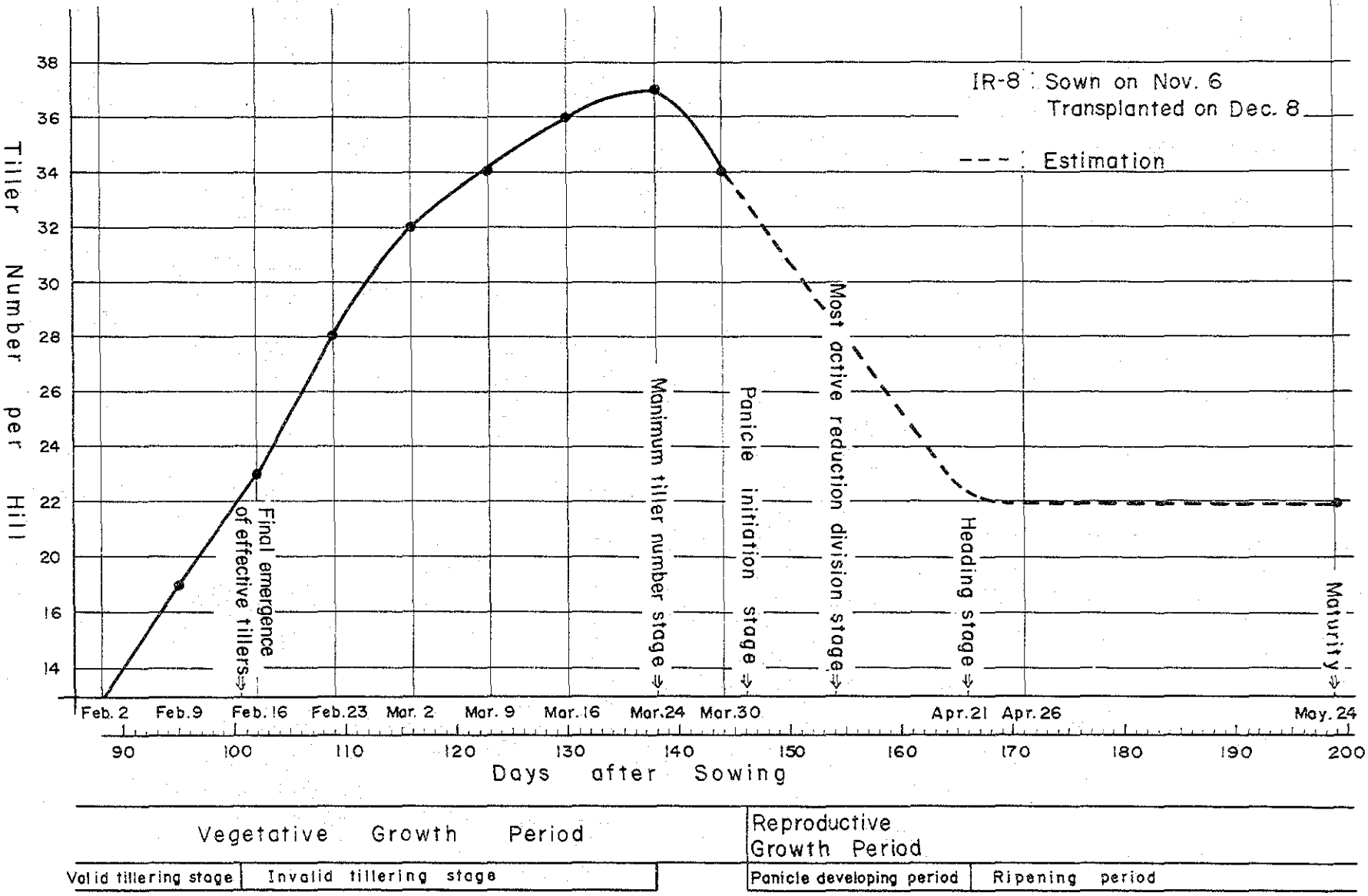
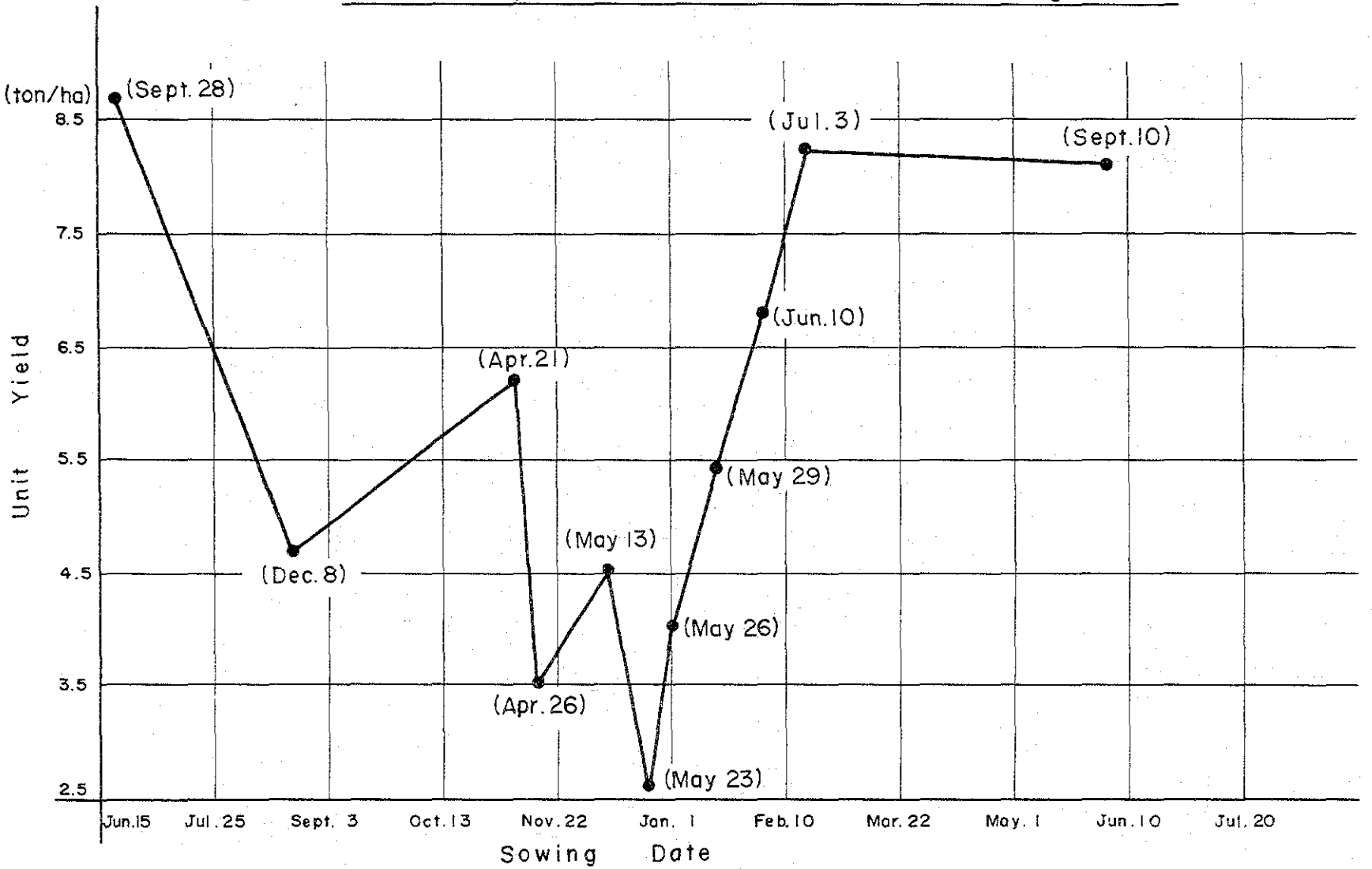


Fig. 2 Relationship between Unit Yield and Sowing Date



Remark : Variety used was IR-8. Date in parenthesis means a heading date.

Fig.3-1 Relationship between Unit Yield and Heading Date

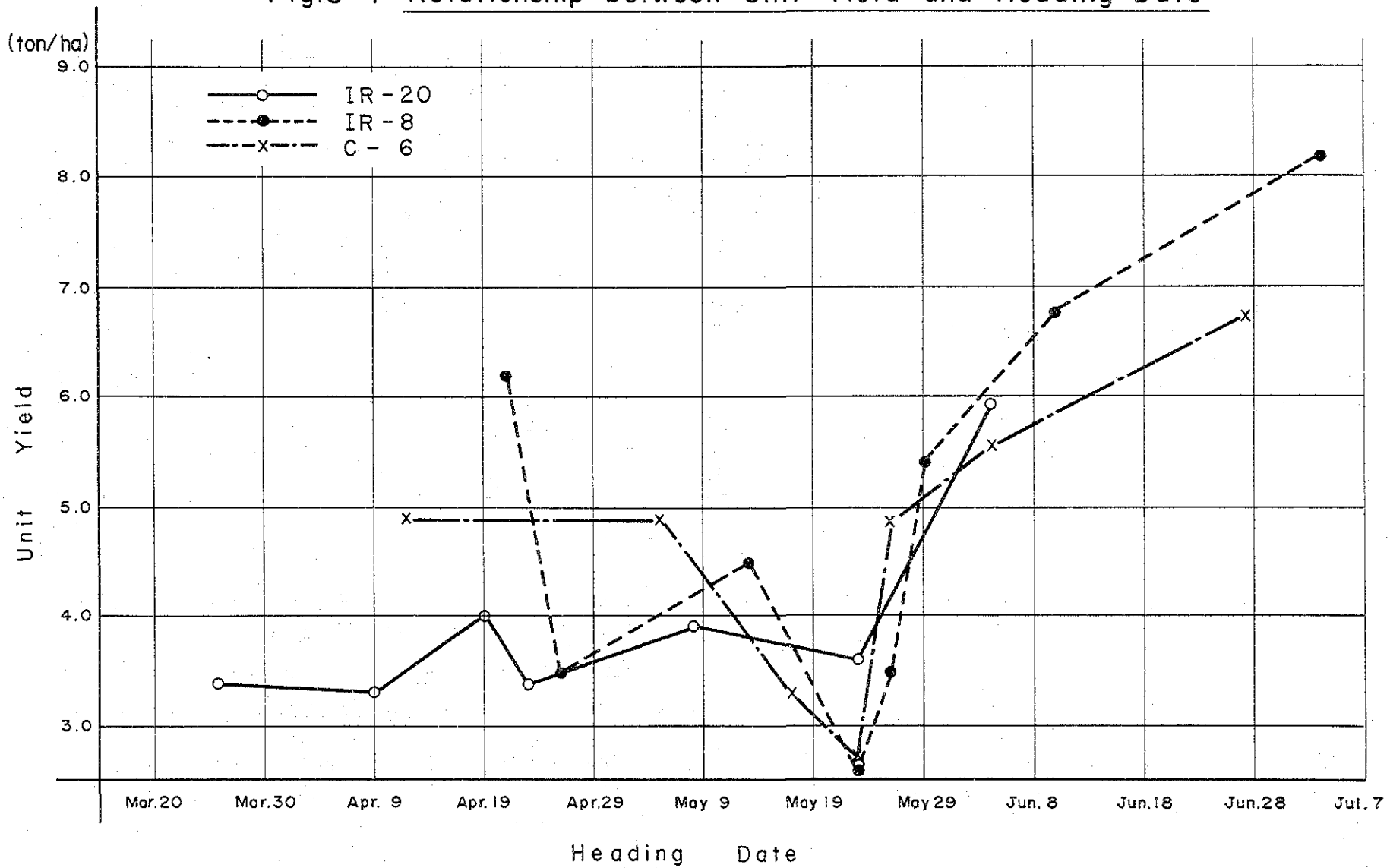


Fig. 3-2 Relationship between percentage of Ripened Grains and Heading Date

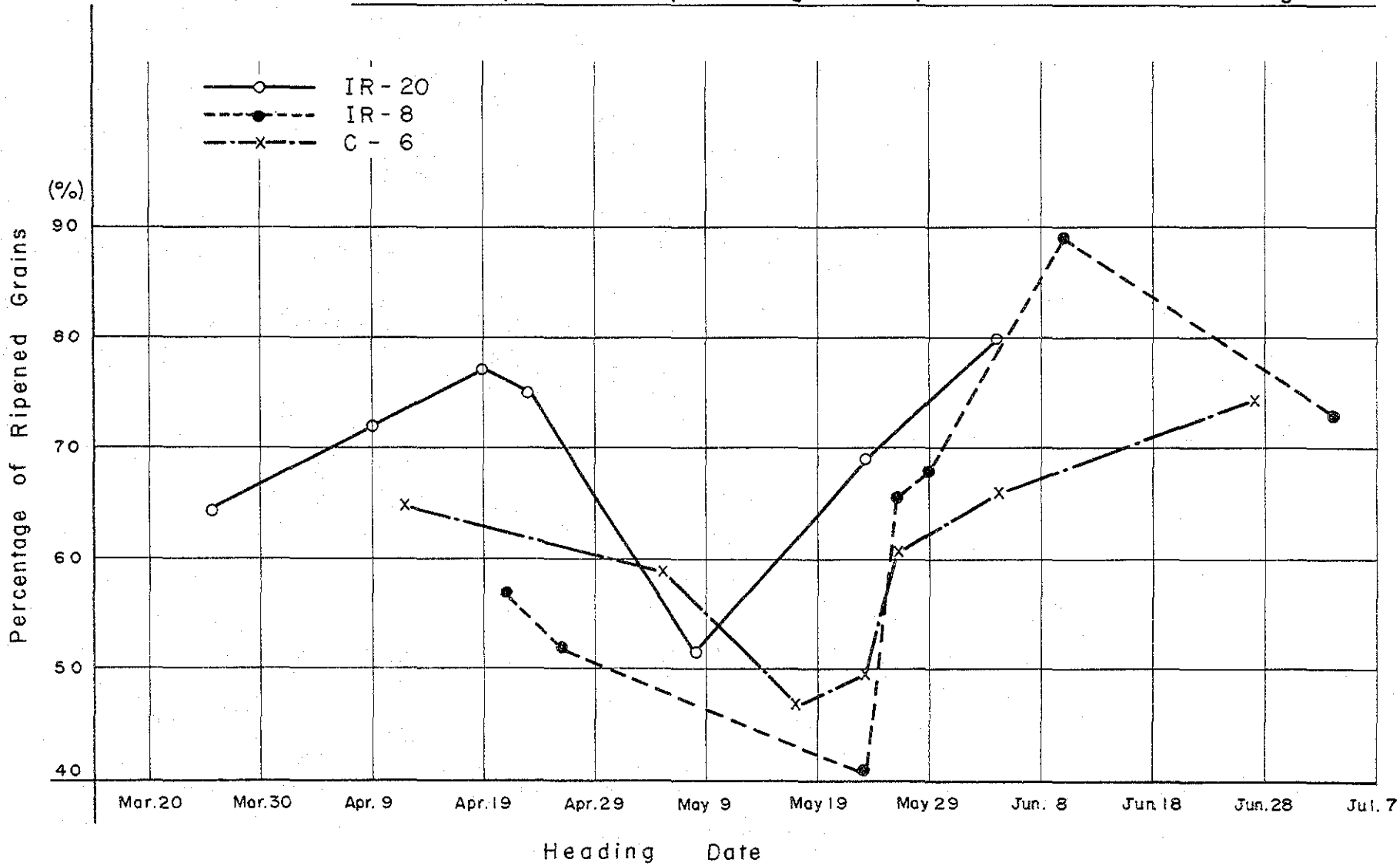


Fig. 3-3 Relationship between percentage of unfertilized Grains and Heading Date

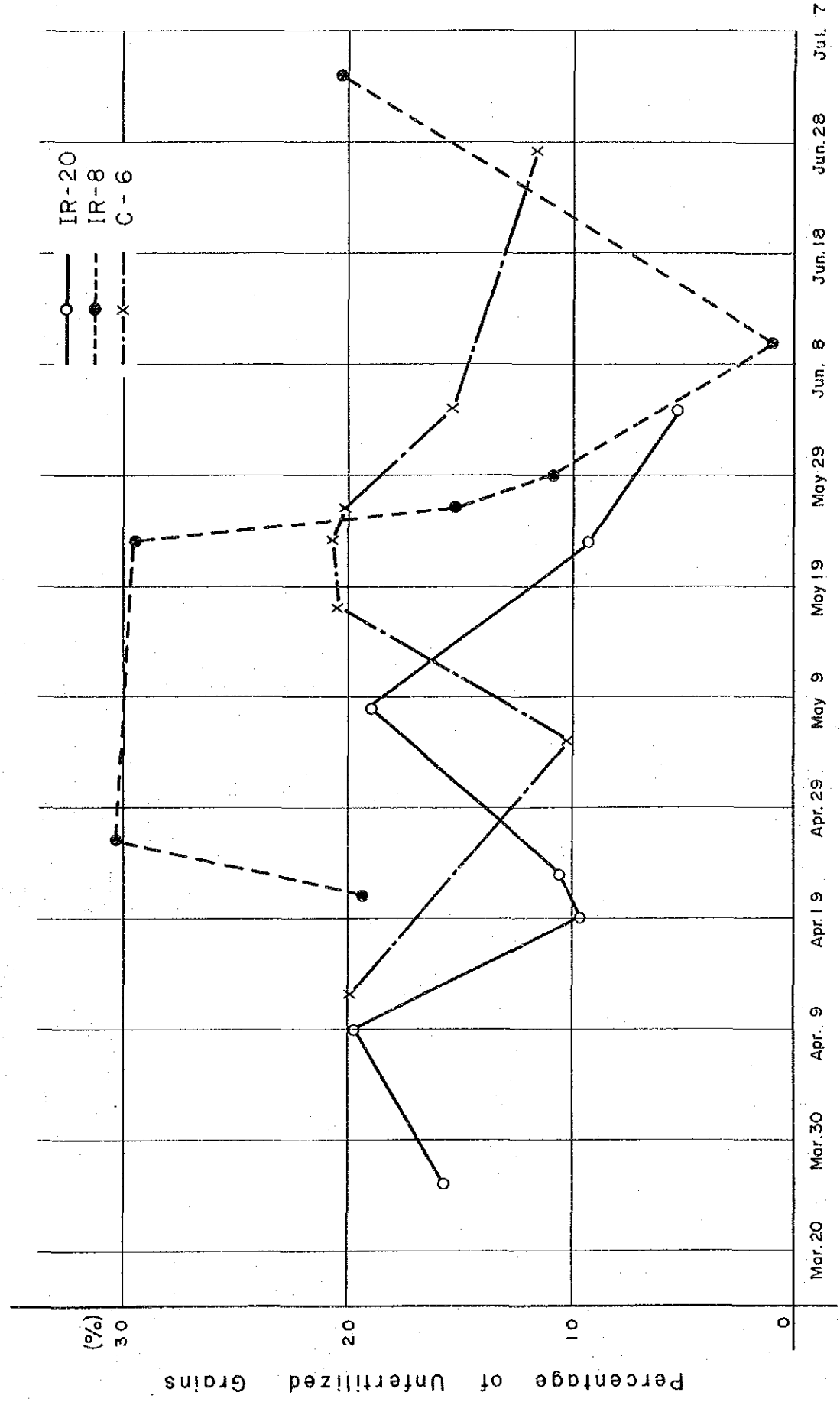


Fig. 3-4 Relationship between percentage of Imperfectly Ripened Grains and Heading Date

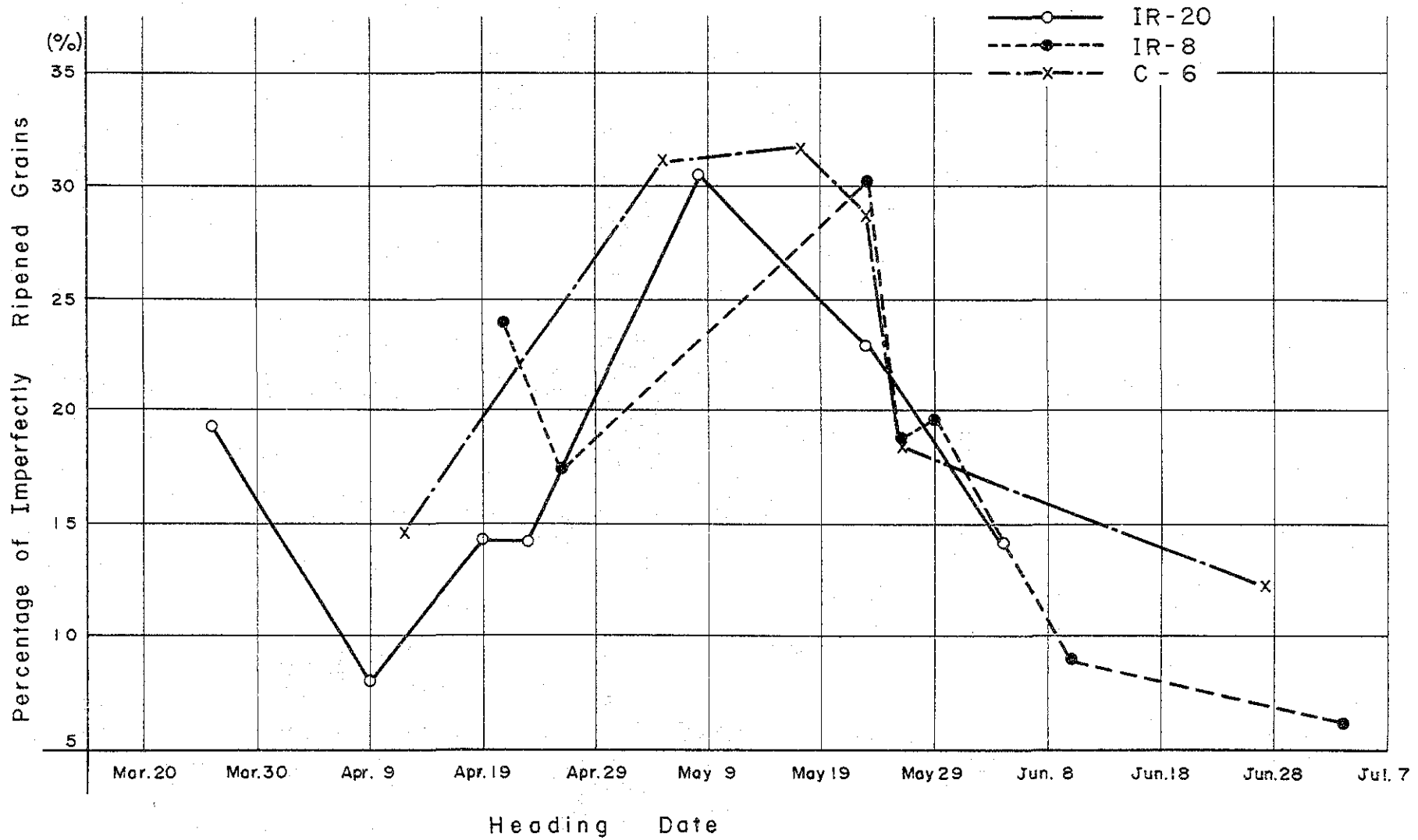
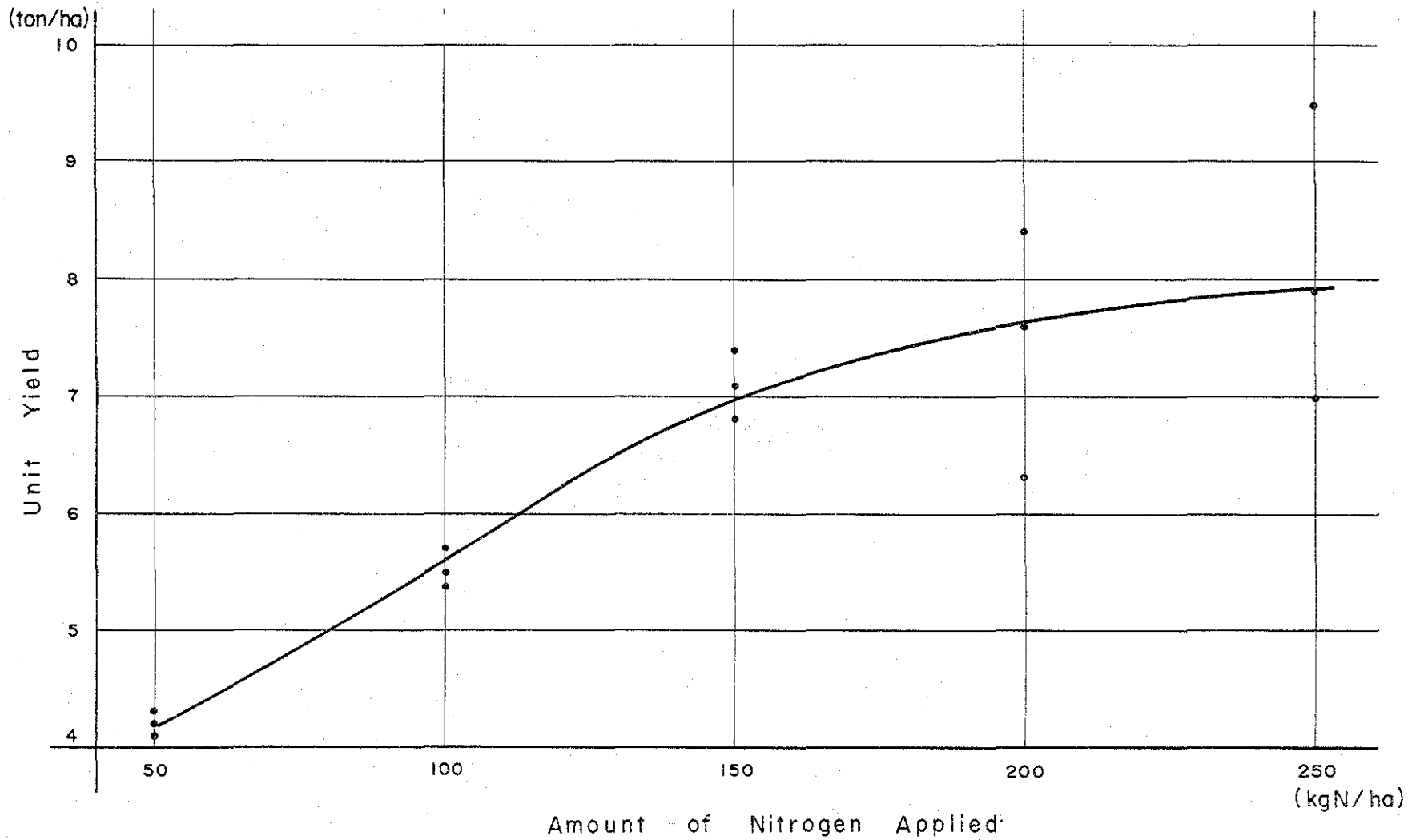
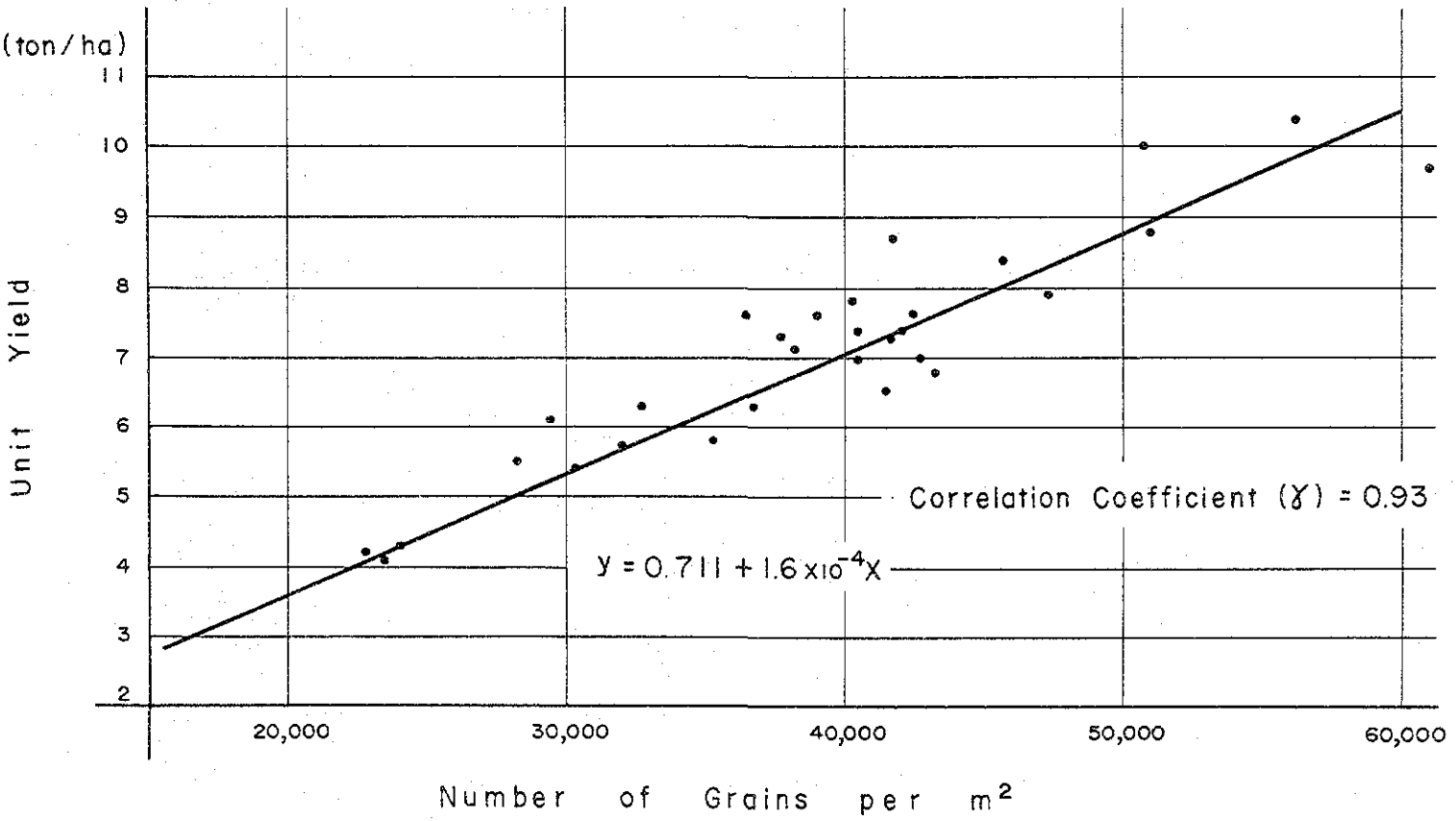


Fig. 4 Relationship between Unit Yield and the Amount of Nitrogen Applied



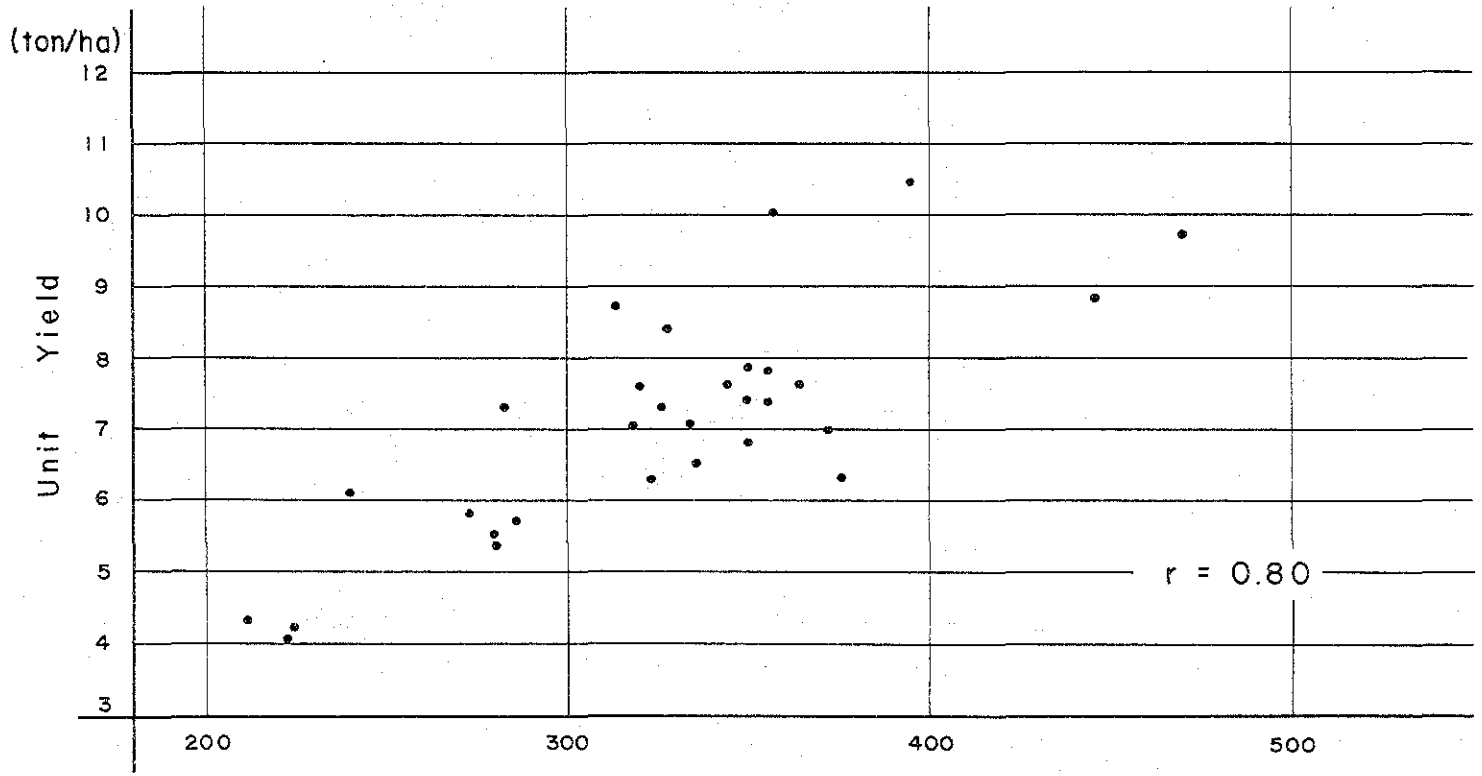
Remark : Variety, C-15 ; Spacing, 25 x 15cm ; Sowing date, June 17.

Fig. 5-1 Correlation between Yield and Number of Grains Produced per m^2



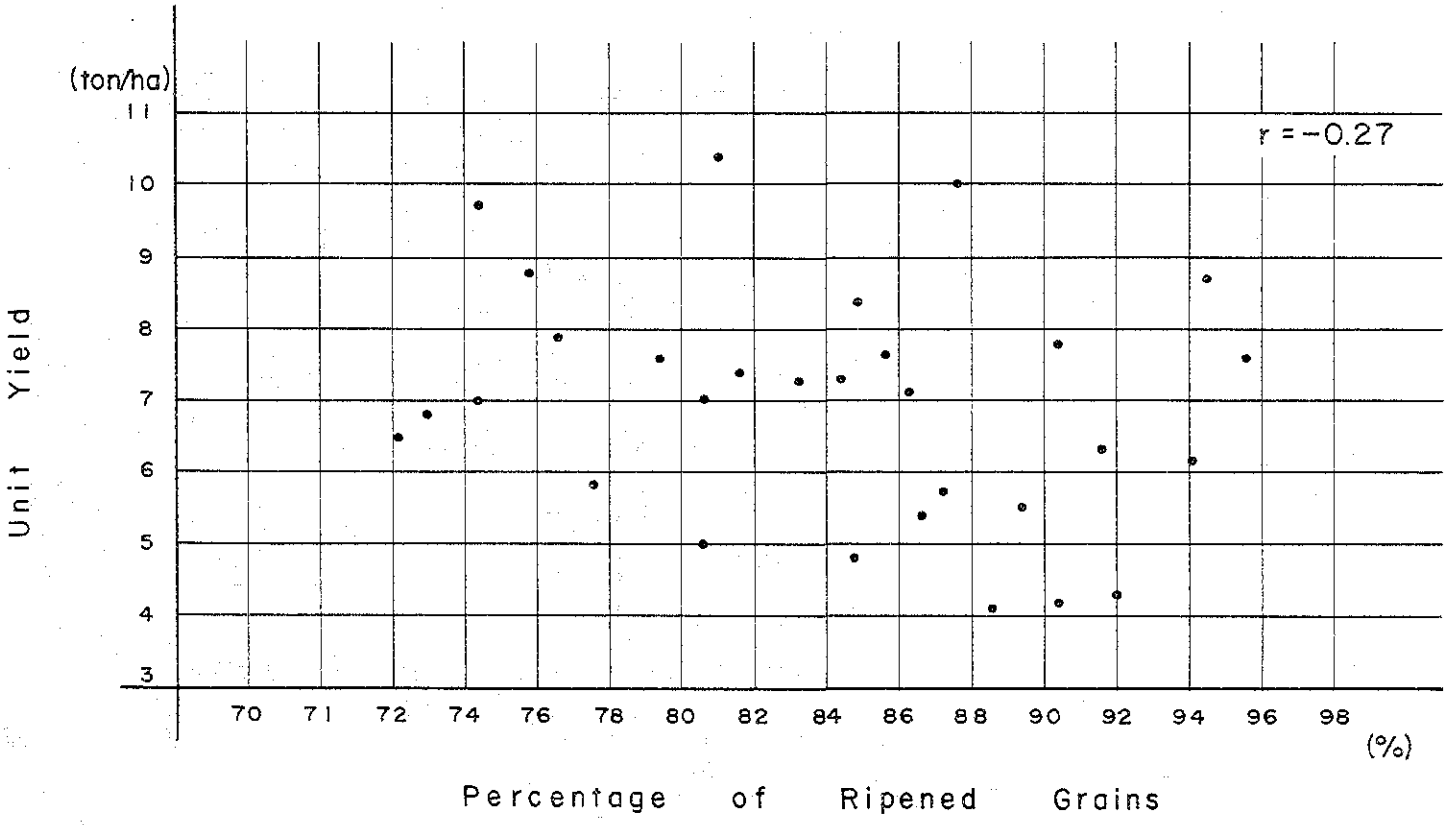
Remark : Variety, C-15 ; Sowing date, June 17.

Fig.5-2 Correlation between Unit Yield and Number of Panicles per m^2



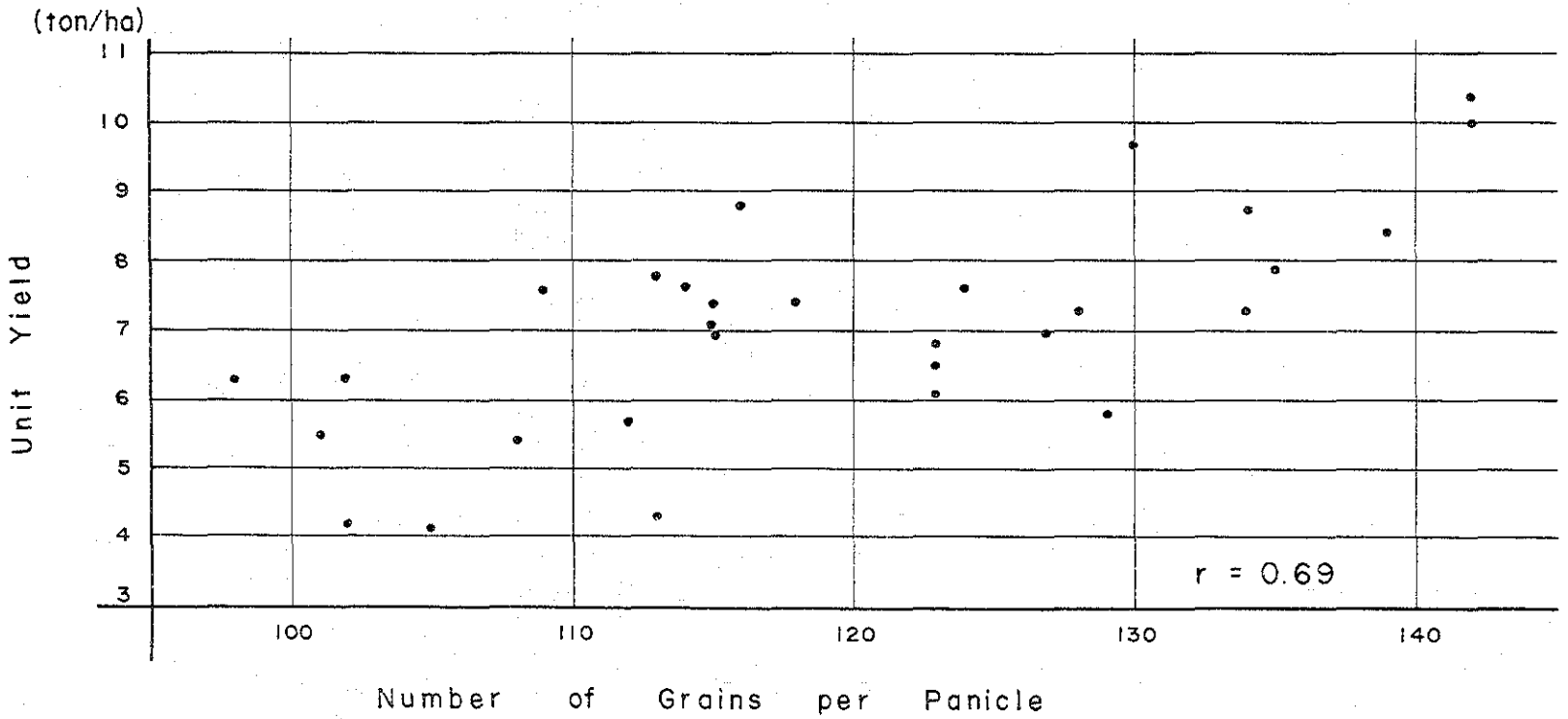
Remark : Variety, C-15 ; Sowing date, June 17

Fig. 5-3 Correlation between Yield and Percentnge of Ripened Grains



Remark : Variety, C-15 ; Sowing date, June 17.

Fig. 5-4 Correlation between Yield and Number of Grains per Panicle



Remark : Variety, C-15 ; Sowing date, June 17.

Annex 1. Sequence of investigation procedure for diagnosing yield