EGYPT–JAPAN TECHNICAL COOPERATION

RICE MECHANIZATION PILOT PROJECT IN ARAB REPUBLIC OF EGYPT

GENERAL REPORT 1982–1986

AGRICULTURAL MECHANIZATION RESEARCH INSTITUTE, MINISTRY OF AGRICULTURE, A.R. EGYPT

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA), GOVERNMENT OF JAPAN

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P R E F A C E

The increasing gap between food consumption and production in Egypt is a major concern to agricultural policy makers. Therefore, His Excellency the Deputy Prime Minister and the Minister of Agriculture and Land Reclamation, has instructed that special attention should be given to all projects and programs designed to promote the vertical and horizontal expansion of cereal production. First priority is to be given to increase production through, improved varieties, and adapting and transferring appropriate technologies to the farmers. Self-sufficiency in grain production may be better realized with new technological inputs in agricultural mechanization which are designed, to optimize operational timeliness, and to promote improved tillage, and harvesting practices.

The Rice Mechanization Pilot Project, being implemented by the Agricultural Mechanization Research Institute, with the assistance and technical cooperation of the Japanese Government, is currently introducing an alternative technological approach. Taking into consideration project inputs, we are thoroughly examining those proven technological methods used in other countries, and modifying them to be suitable for the local conditions. Following the current period of adaptation, the successful techniques will then be replicated on a larger scale.

The Rice Mechanization Pilot Project has been extended for three years and seven months for further technical cooperation of verifying experiments on mechanical transplanting and harvesting methods, in order to determine which methods are the most suitable for the Egyptian conditions. These techniques will then be demonstrated to the participating agronomists, agricultural engineers, farmers, and local manufacturers. The training program of the project has been expended by including participant training in Japan. Through the combination of practical field experience, on-site training, and direct exposure to expertise, we plan to meet our objective of developing a capacity to plan, and execute mechanization programs, and to keep this momentum untill self-sufficiency in grain production will be accomplished.

Prof.Dr. Ahmed F.El-Sahrigi

Director, Agricultural Mechanization Research Institute and Agricultural Mechanization Projects

INTRODUCTION

The Government of the Arab Republic of Egypt and Japan have been cooperating with each other in the implementation of a Rice Mechanization Pilot Project (RMPP) for the purpose of introducing a mechanized rice farming system in order to contribute toward increasing rice production and improving the agricultural labour shortage problem, based on the Egyptian Food Security Plan.

The Project has been carried out over a five-year period since its commencement in August 1981. It gives me great pleasure to advise that the joint strenuous efforts of the Japanese experts and the Egyptian counterparts have produced satisfacoty results in the accomplishment of the Project's objectives.

The report on the technical cooperation for the Rice Mechanization Pilot Project has been prepared by the Japanese experts and the Egyptian counterparts and covers the results of the five years' activities of the Project. I hope that this report will be useful for further implementation of the Project in the future.

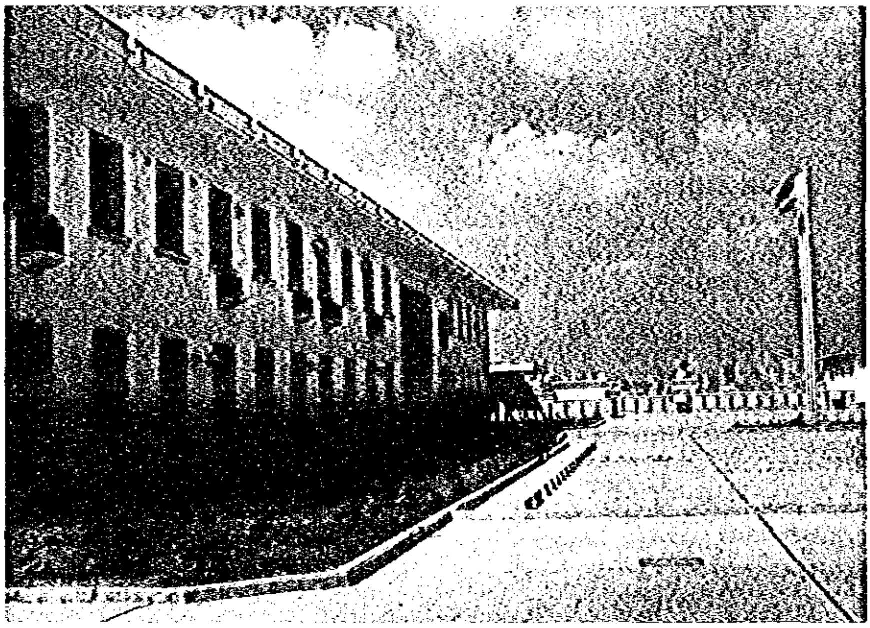
I wish to extend my sincere appreciation to Dr. Ahmed F. El Sahrigi, Director General for Agricultural Mechanization Projects; Dr. Osama Kamel, Site Manager of the Rice Mechanization Center; and to the colleagues of the Egyptian counterparts who have extended to us their assistance and courtesies during our stay in Egypt.

Finally, I would like to express my sincere hope that this Project will result in further developments in the future.

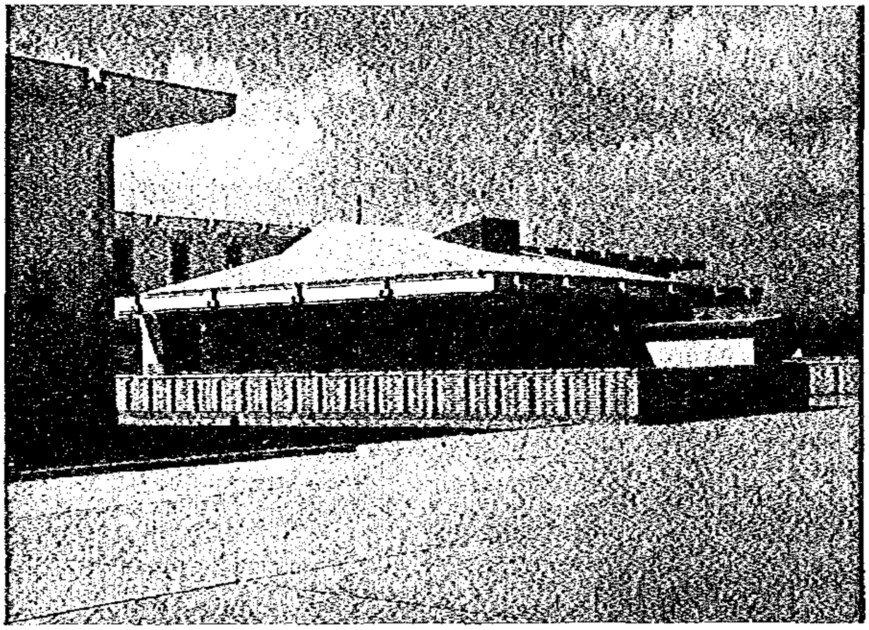
August 12, 1986

Dr. TAKAYUKI TANAKA
Team Leader,
Japanese Experts on the
Rice Mechanization Pilot Project
(RMPP)

Ministry of Agriculture,
A.R. of Egypt (MOA) - JICA



Main Building of Rice Mechanization Center (R M C)



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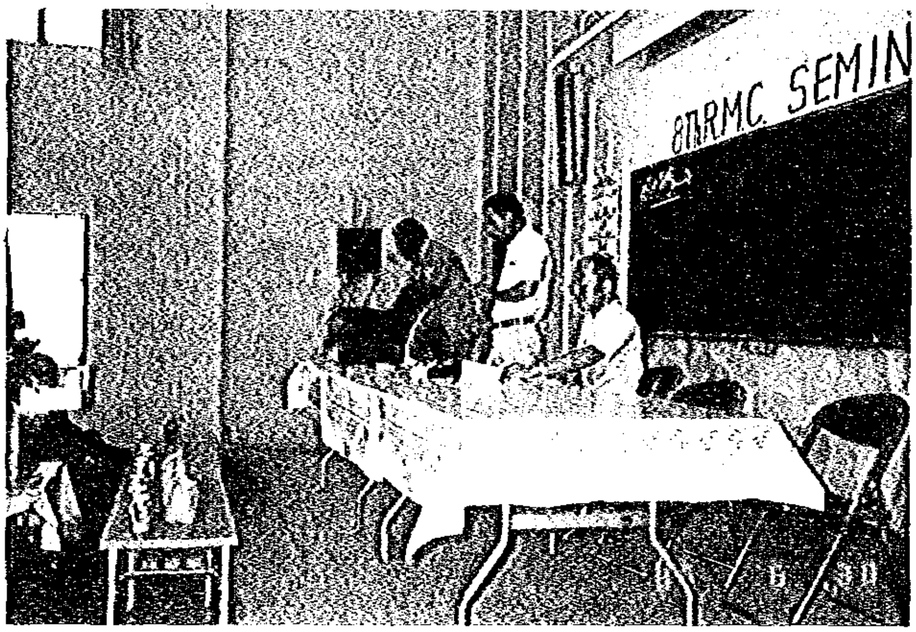
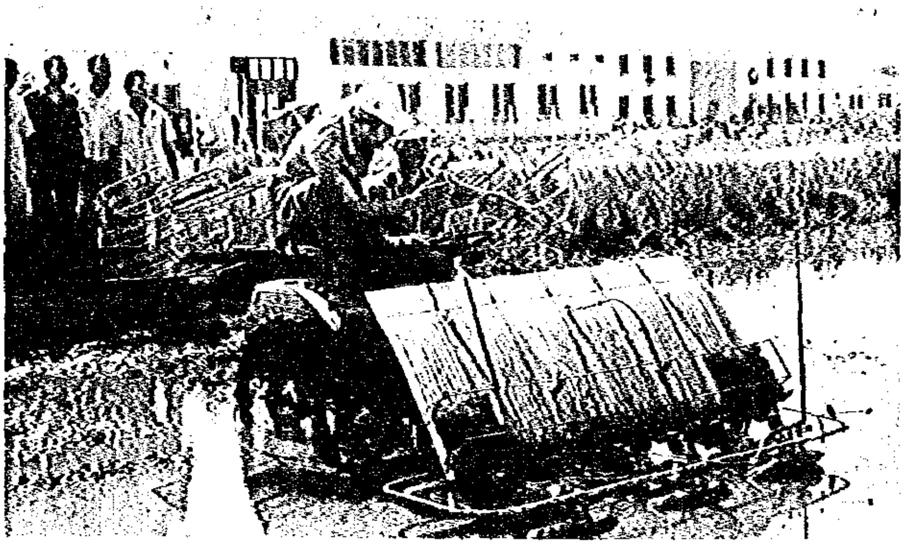


R M C Seminar

Training Activities



Mechanical Transplanting

REPORT ON THE TECHNICAL COOPERATION FOR THE RICE MECHANIZATION PILOT PROJECT

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1. Improvement of Experimental Field

(1) Kallin Experimental Field (11 Feddans)

Improvement of the experimental field by model infrastructure was completed in may, 1982, and the verifying experiment on mechanized rice farming for Phase I was conducted twice in 1982 and 1983. The results showed high yields (Akihikari:12.0 tons per h.a.; and Nipponbare:11.8 tons per h.a.) and suggested the possibility of mechanized rice farming.

(2) Meet El Dyba Experimental Field (100 Feddans)

Improvement of the experimental field was completed with pilot infrastructure in 1983. Uniform cultivation was implemented in 30 feddans in the same year and a full scale verifying experiment was started in April 1984.

However, soil conditions showed a high pH (8.0 - 9.1) value and salt concentration. In addition, a shortage of irrigation water caused a considerable obstacle in the implementation of experiments. Therefore, experts on water utilization and desalination were recruited and joined the Team in August 1984. Experiments, for the improvement of water utilization and desalination, based on countermeasures, and using model infrastructure, were conducted during the period December 1984 to April 1985.

As a nucleus of Phase II activities, the field is utilizing for the verifying experiment, training, demonstrations and others.

2. Verifying Experiment on Mechanization

The object of this Project was to establish a satisfactory mechanized rice cultivation system within the framework of both the

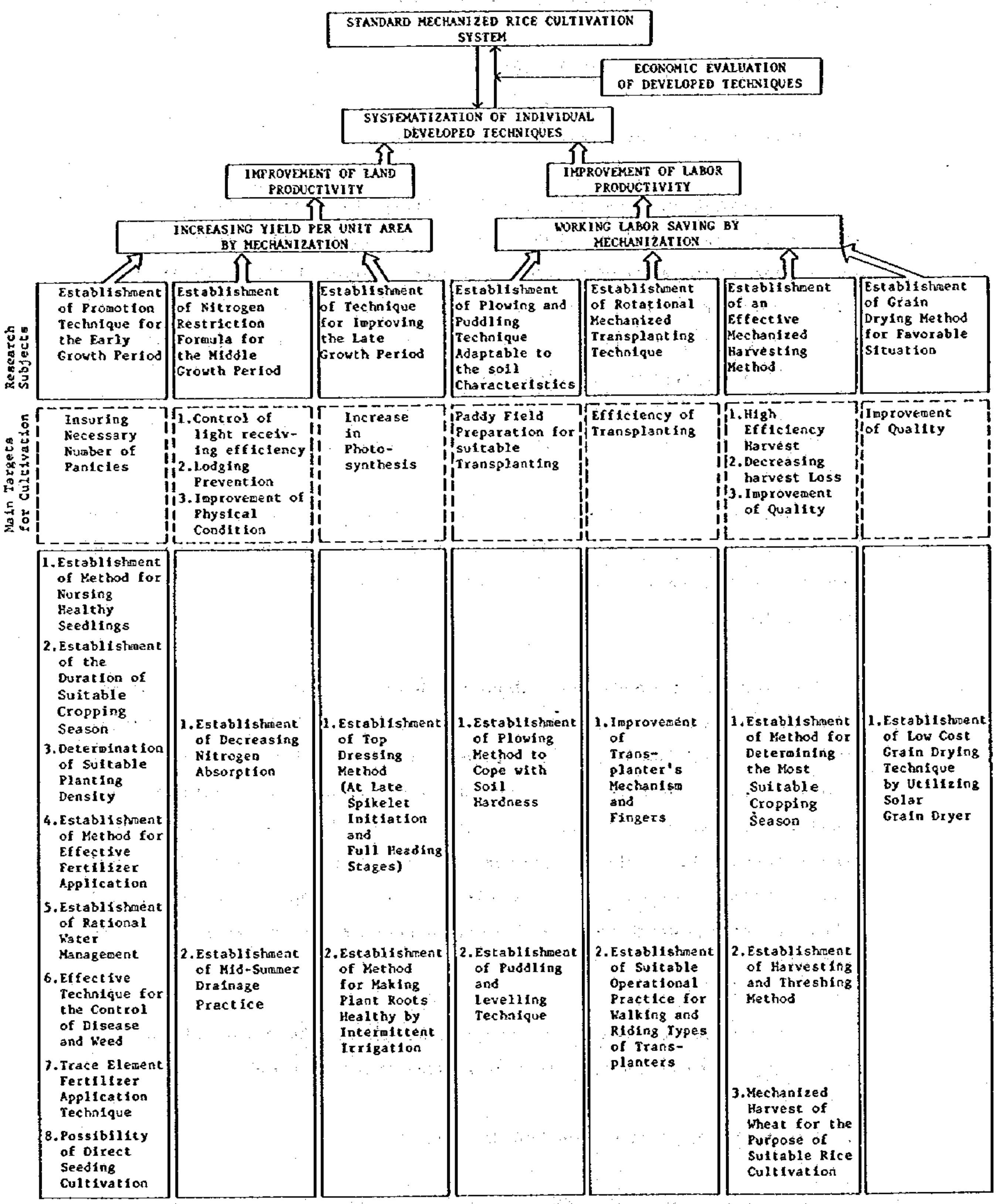


Fig. 1 TECHNICAL DEVELOPMENT FOR THE MECHANIZED RICE CULTIVATION SYSTEM

"Food Security Plan" and the agricultural labour shortage problem. Aspects of the "Food Security Plan" were taken into consideration in order to increase the land yield and the problems caused by the shortage in agricultural labour were studied so that improved productivity could be achieved through the utilization of mechanized techniques.

It was required, therefore, that certain verifying experiments be conducted covering various research subjects (shown in Fig. 1) on the basis of the overall objectives of the two Phases of the Project.

The summary of the results are as follows:

2.1. Increasing Yield per Unit Area by Mechanization

In order to obtain a high grain yield per unit area, utilizing the mechanical transplanting method, various improved cultivation techniques are necessary, such as: raising healthy seedlings; establishing ideal method for both the application of fertilizer and the management of irrigation water; securing the optimum planting density; and the inauguration of an effective system for the control of weeds.

On the other hand, the Egyptian weather provides the best conditions in the world for rice cultivation. In this respect, the exceptional abundance of solar radiation should be utilized more effectively. In pointing out the dominant factors of rice cultivation in the Nile Delta, consideration should be given to the following: (i) solar energy; (ii) no natural disasters (such as damaging cool weather; heavy rainfalls, floods, typhoons, etc.); and (iii) well controlled irrigation water; and others.

The paddy yield can be determined by two factors, namely: (i) "Yield Capacity" (number of panicles per unit area multiplied by the number of spikelets per panicle); and (ii) "Yield Contents" (about 90% photosynthetic products after heading, equals the ripening ratio and 1000 grain weight). Accordingly, the relation between the number of spikelets per M^2 and paddy yield (based on the data collected from the experiments carried out by the Project) is shown in Figs. 2 and 3.

It was made clear from the experiments conducted that rice cultivation in the Nile Delta has a remarkably high productivity due to the great yield capacity supported by the abundant solar radiation, as mentioned above.

It was evident that the yield capacity (such as the number of spikelets per unit area) and the yield contents (such as the ripening ratio and 1000 grain weight) has no correlation with the paddy yield, as shown in Fig. 2.

It was necessary, therefore, to establish a technique whereby the yield capacity could be expanded in order to increase the paddy production but at the same time avoid any decrease in the ripening ratio and 1000 grain weight.

The life of the rice plant can be divided into three parts, i.e. (i) the early stage (after germination up to 45 days before heading); (ii) the middle stage (20 to 45 days before heading); and (iii) the late stage (20 days before heading to maturity).

According to these periods, studies were conducted to accomplish the targets of each growth stage.

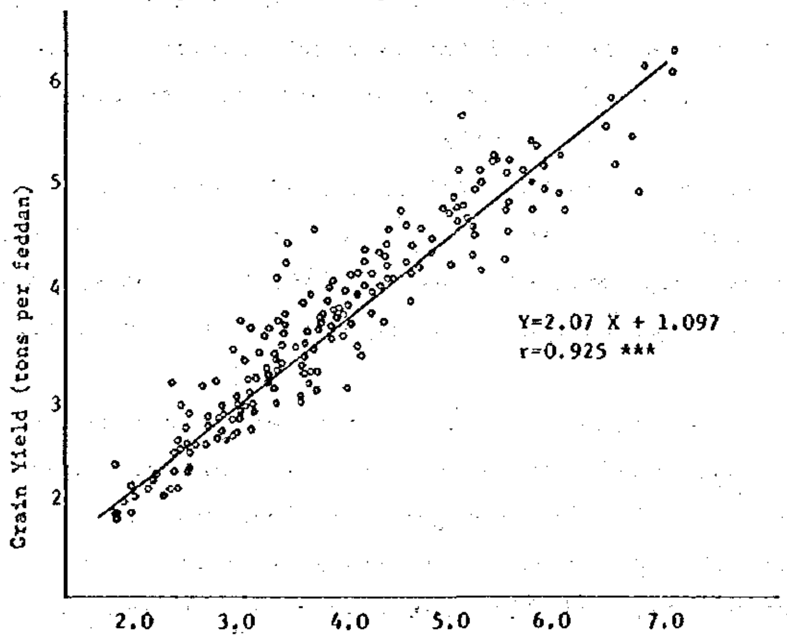
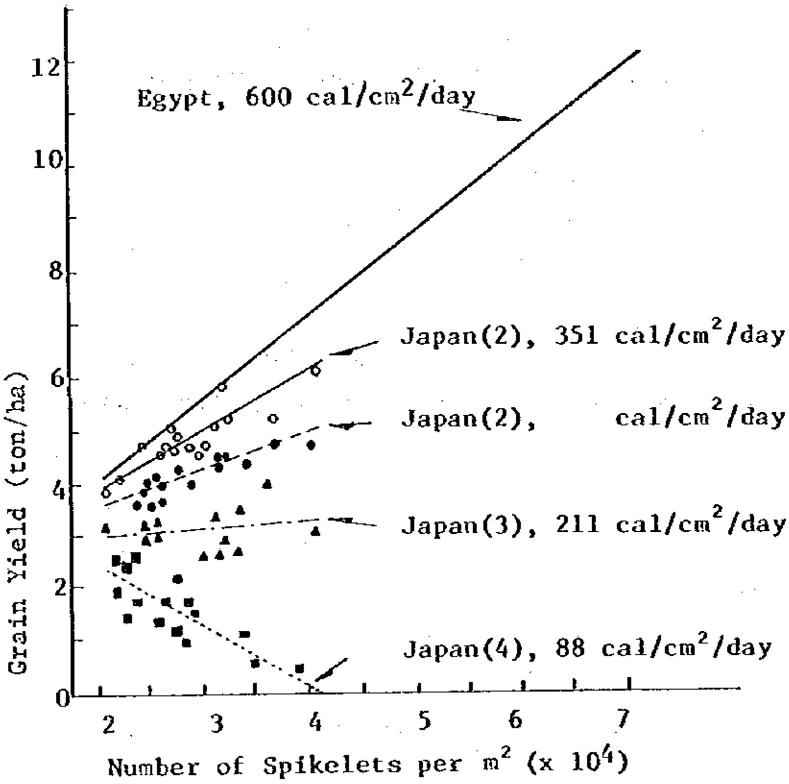


Fig. 2 Correlation between the Number of Spikelets per m^2 and Grain Yield



Note: Egypt ... 1982-1985 at Kallin and Meet El Dyba, RMC

Japan (1)-(4) ... T.TANAKA, G. NAGAO, M.NAMIOKA, 1975.

Fig. 3 Relation Between the Number of Spikelets per m^2 and Grain Yield for each solar radiation during main Ripening Period (35 days after heading)

2.1.1. Establishment of Technique for Promoting Plant Growth in the Early Growth Period

Generally, the soil in the Nile Delat shows high pH and salinity properties. These conditions, under traditional rice cultivation, tend to retard the emergence of tillers and to deter the rooting activities in the early stage of growth, making it difficult to ensure yield capacity (number of spikelets per unit area).

In order to ensure the growth of a sufficient number of panicles in the early growth period, the following cultivation practices are required:

a. Raising of healthy and strong seedlings;
b. Early seasonal transplanting;
c. Encouraging plant growth by the application of sufficient nitrogenous fertilizer in tillering;

d. Narrow spacing by transplanter;

e. Preventing rooting damage by rational water management after transplanting;

f. Controlling weeds effectively;

g. Applying zinc sulphate at the middle stage of the seedling nursing period.

The following chapter shows the various experiments which were conducted at the Rice Mechanization Project to encourage plant growth in the early growth period.

2.1.1.1.(1) Selection of a Suitable Variety for Mechanized Rice Cultivation

The standards required in the selection of a suitable variety for Mechanized Rice Cultivation are outlined as follows:

i) Paddy yield capacity;

ii) Total growth duration ;

iii) Suitability for mechanical harvesting (especially plant height, lodging resistance, shattering tendency); and

iv) Disease and insect resistance.

The trial for the selection of a suitable variety for Mechanized Rice Cultivation began when the Rice Mechanization Project was launched in 1982. Throughout this period, various varieties were introduced, mainly from Japan, and studies were conducted at the Kallin Agricultural Station and Meet El Dyba Center for four years.

Regarding the yield, in tons per feddan, of these newly-introduced types, the Nipponbare variety obtained the maximum of 4.78; the Akihikary 4.44 and Toyonishiki 4.36 as shown in Table 1.

The total growth duration (the second standard, point ii) above, was 135, 130 and 133 days respectively for the three highest varieties: Nipponbare, Akihikari and Toyonisike. The difference in the total growth duration between the medium and the late-maturing variety is around 30 days, as shown in Fig. 4. The total irrigation water can be reduced when using the medium-maturing variety which is very advantageous.

The third standard, that of plant height, is applicable to both the panicle-number and long-culm weight varieties. The harvesting work as well as the labour entailed in transplanting is very important in Mechanized Rice Cultivation in order to reduce manpower and harvesting losses. The effectiveness of harvesting work by the use of head-feeding type combines is strongly related to the height of the plant (culm length). The most possible and suitable plant height ranges between 70cm (minimum) and 120cm (maximum). However, according to the results, as shown in Fig. 5, the highest paddy yield of the three Japanese varieties (short culm types) was 100 to 110 cm (total average height), compared to more than 120 cm of the Giza-171 and 172 varieties (long culm types). Furthermore, these three Japanese varieties are advantageous for head-feeding type combines.

Unfortunately, the recently introduced Giza-173 variety (short culm type) although very adaptable to head-feeding type combines, was affected by Blast Disease in 1984 in Kafr El Sheikh and was, therefore, restricted from growth in that area.

From the result obtained, the advantages of the medium-maturing variety can be summarized as follows:

(i) Economization of irrigation water due to the shortening of the total growth duration by 25 to 30 days;
(ii) Guaranteed high paddy yield compared with long culm varieties;
(iii) These varieties do not suffer lodging and can guarantee high working efficiency with a low ratio of harvesting losses;
(iv) The shattering habit runs very low in these three Japanese varieties as compared with the IR-28 type.

It is envisaged in the near future, that along with the introduction of mechanized rice cultivation, the short culm type varieties will become indispensable to the increase of paddy yield per unit area and efficiency of the combine harvester in the Nile Delta.

Table 1 The Yield of Different Varieties during 1982-'85 in RMP

(Ton per feddan)

	YEAR				
Variety	1982	1983	1984	1985	Av.
Akihikari	5.05	4.43	3.86	--	4.44
Nipponbare	4.94	6.01	3.39	--	4.78
Reiho	4.74	3.73*	2.87	--	3.78
Giza-172	4.73	2.18*	2.65	--	3.18
Yukara	--	1.89**	--	--	1.89
Hayakogane	--	1.60**	--	--	1.60
Ishikari	--	1.90**	--	--	1.90
Toyonishiki	--	--	--	4.36	4.36
Nokei No. 4	--	--	--	4.23	4.23
IR-28	--	--	--	3.86	3.86
Akiyutaka	--	--	--	3.81	3.81
Giza-171	--	--	--	3.75	3.75
Nong Kyo-11	--	--	--	3.70	3.70
Koshihikary	--	--	--	3.60	3.60
Koganemasari	--	--	--	3.53	3.53
Todoroki Wase	--	--	--	3.47	3.47
Oseto	--	--	--	3.39	3.39
Nagoyutaka	--	--	--	3.32	3.32
Nishihomare	--	--	--	3.15	3.15
Shinrei	--	--	--	3.06	3.06
Ogonbare	--	--	--	2.88	2.88
Mizuho	--	--	--	2.84	2.84
Asominori	--	--	--	2.71	2.71

Note: * = Serious lodging observed

** = Very early cultivation started from Feb.

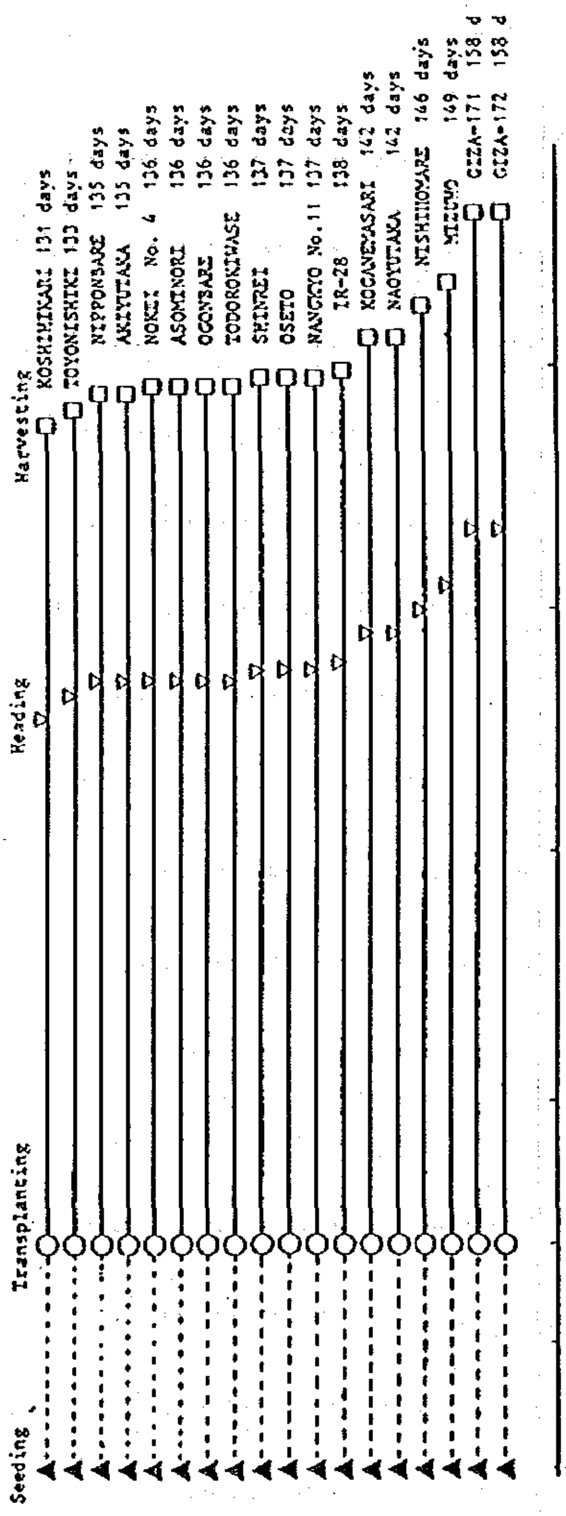


Fig.4 Total Duration of Different Varieties

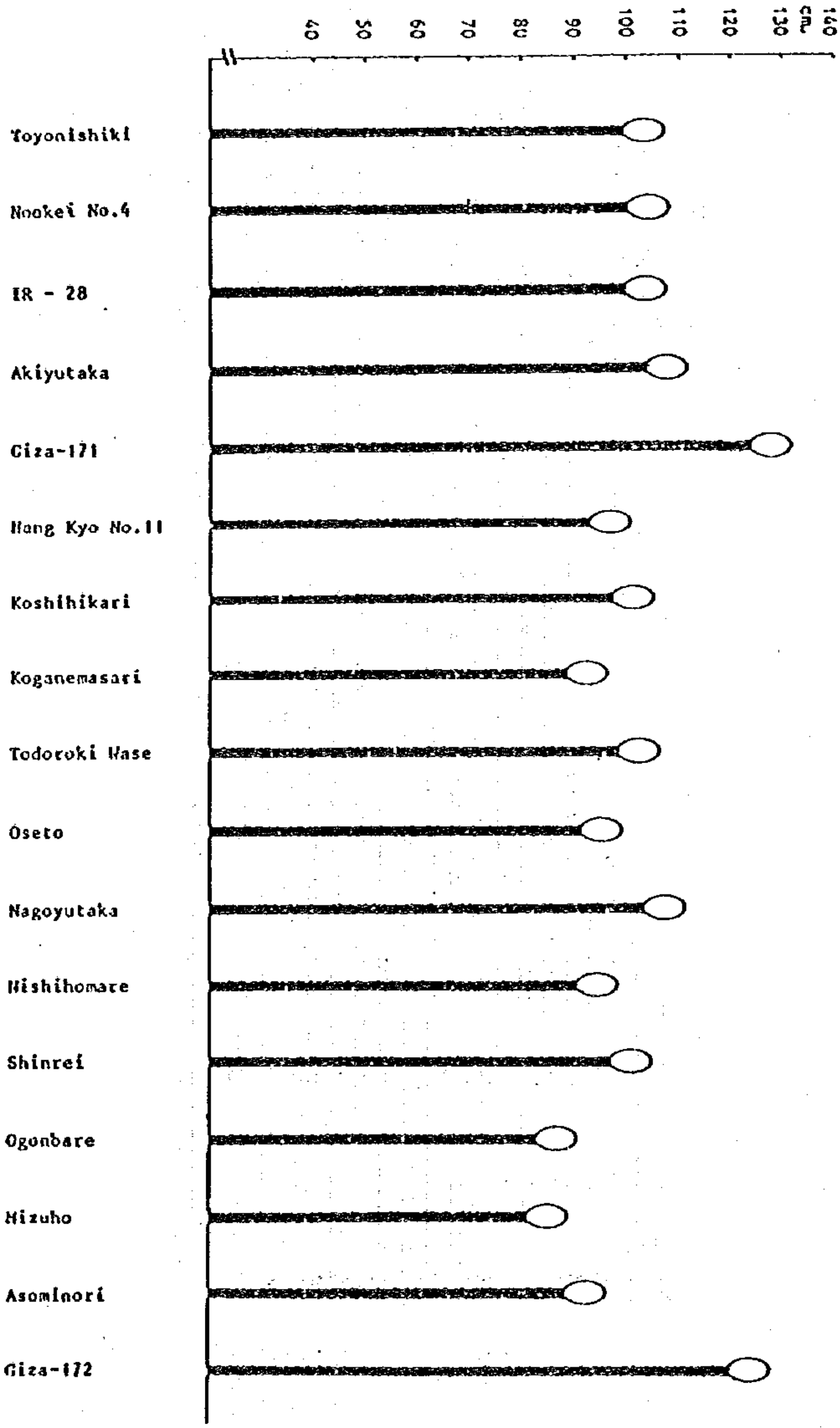


Fig.5 Height of Different Rice Varieties

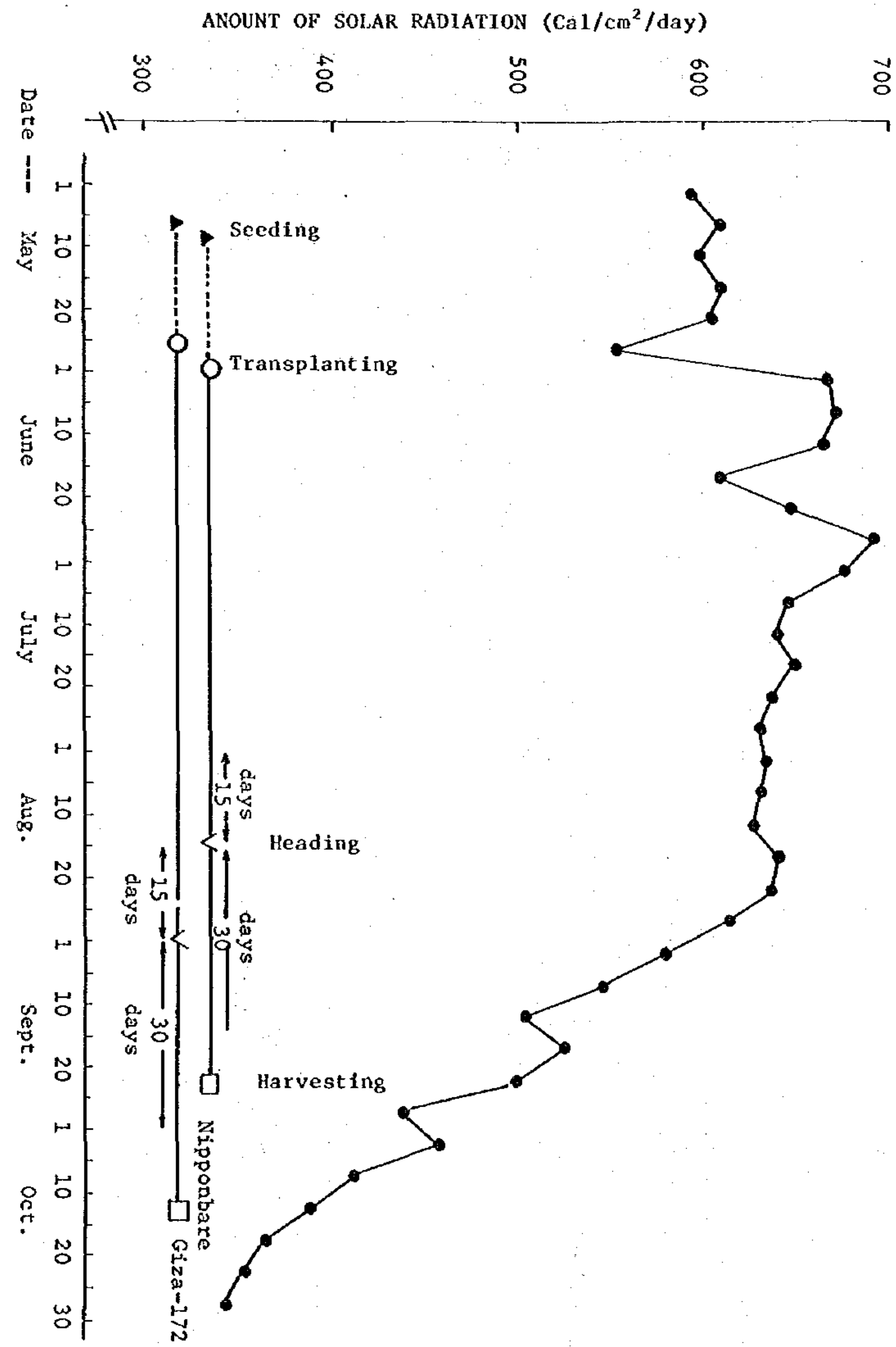


Fig. 6 Amount of Solar Radiation during Rice Cultivation Season

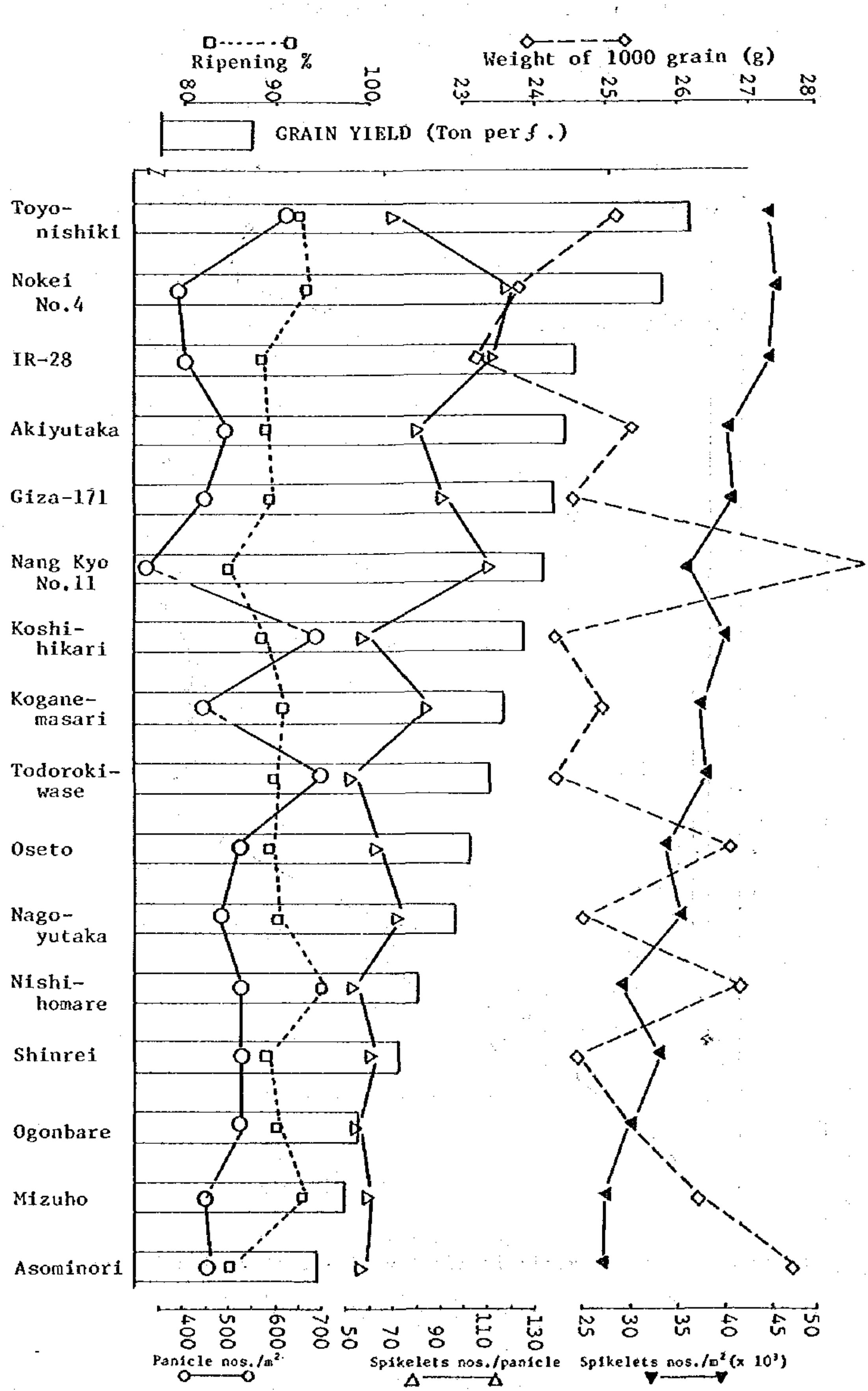


Fig. 7 Paddy Yield and Yield Components in Different Varieties

2.1.1.(2) Establishment of method for Nursing Healthy Seedlings

(a) Collection and Preparation of Soil for Seedling Tray

Soil in the Nile Delta has a very heavy and sticky consistency when it contains water and at the time of transplanting tends to cling to the planting fingers of the rice transplanter. In the beginning this resulted in the appearance of vacant hills in a ratio reaching around 20%. Therefore, an applied technique of adding a 50% mixture of Tameiya (dredged soil of the main irrigation canal) was employed. Later on, the planting finger push rod was modified from the crank to the spring type which enabled the clinging soil to be forcibly separated from the seedlings. As a result, perfect planting became possible even when the normal soil with heavy stickness was used as bed soil. Therefore, further studies on the kinds of bed soil were made in order to find suitable types for the raising of seedlings.

The textures of each experimental soil used and the relevant seedling conditions are shown in table 2. In particular, it was noted that the growth which took place during the latter period in heavy clay plots was characteristically great. Tests were also conducted for dry matter weight of seedlings using Tameiya, normal, mixed (Tameiya 50% with normal soil 50%) and heavy clay soils. A tabulation of the above results proved it desirable to use as bed soil for the seedling box, that of normal fields where Birsim (Egyptian clover) and wheat show good growth, as it is most easily obtainable; and, it was not found necessary to use a special kind (Tameiya).

The soil for the seedling box should be selected from sources containing a low pH value and low salinity quality; taken from well planted fields showing good growth patterns; and be fully dried.

Table 2 Relationship between Different Kinds of Bed Soils for Seedling Box and Seedling Condition

Kinds of bed soil Items	Tameiya (dredged soil from irrigation canal)	Normal soil (soil from normal field)	Mixed soil (Tameiya 50% & normal soil 50%)	Heavy clay soil
Content of soil (%)				
Silt	40	13	23	8.5
Clay	60	87	77	91.5
Height of seedling after sowing (cm)				
7 days	8.04	6.63	6.14	6.96
15 days	9.35	9.53	6.14	6.96
21 days	9.37	10.66	11.92	13.66
Dry matter weight of seedling (g/20 Nos. of seedling)	0.19	0.22	0.22	0.23

Note: Variety, Giza-172. Sowing Q'ty per box, 200 g.
Leaf age, 2.5, without fertilizer application condition.

After the soil is collected from the paddy field, sieves of 5mm and 3mm mesh, respectively, should be used for preparing the bed and cover soil of the seedling tray.

(b)Determining the Quantity of Seeds per Tray

Respecting the nursing of the seedling tray, the seed quantity appears to have a strong influence on the seedling quality, its setting (rooting) duration, as well as missing hill occurrences, tiller development and the paddy yield. Thus, with a lesser seed quantity per tray, the seedling shortage per hill will occur with a high ratio of missing hills. On the other hand, a larger seed quantity per tray will produce a poor quality of seedling and the following troubles could occur:

i) Seedling injury at transplanting time;
ii) Delay of rooting after transplanting;
iii) Occurrence of competition in a hill due to the large number of seeds contained therein.

The results on plant height and dry matter weight for the different sowing quantities used for each seedling box were recorder two weeks after settling in the greening bed (17 days after sowing) and are shown in Fig. 8. The results revealed that the seedling dry matter weight showed a tendency to decrease as the sowing quantity was increased. Plant height seemed to be influenced very little when the sowing quantity was increased from 120g to 200g. However, it tended to increase when the sowing quantity was increased to over 200g and the seedlings became spindly.

Generally, there is a large amount of solar radiation in the Nile Delta, and it is unlikely that dense sowing to some degree will cause any decline in the seedling character. However, special attention should be paid in order that the sowing quantity of 200g (dry seed weight) per seedling box is not exceeded.

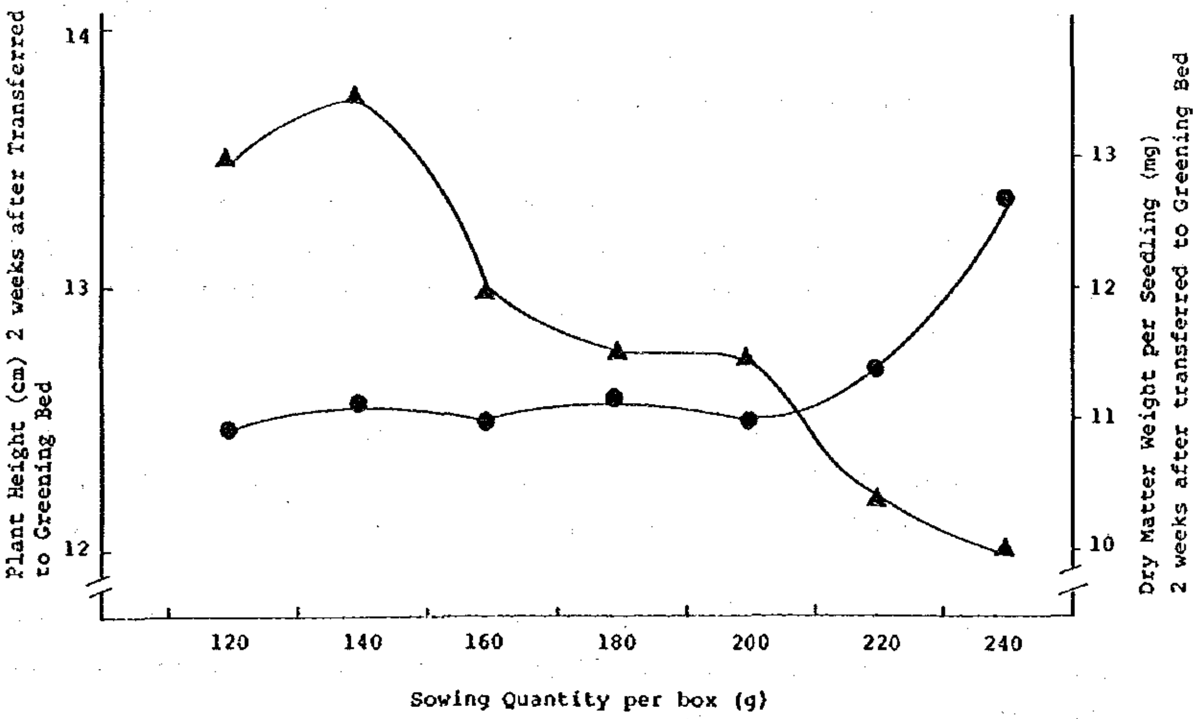


Fig. 8 Relation between Sowing Quantity per Seedling Box and Dry Matter Weight per Seedling (2 weeks after transferred to greening bed)
Note: ● Plant Height ▲ Dry Matter Weight

Trial to assess the effect of seed quantity on the grain yield were conducted, using the method outlined herein. Seed quantities of 150g, 200g and 300g per tray were used with an application of fertilizer made up in the formula of 50kg for N, 25kg for P_2O_5 and 13kg for K_2O per feddan (the same as that used in the main field). It should be noted that when using the transplanting machine for picking seedlings, the setting on it is at 10mm by 13mm, with 27.7 hills per square meter. However, in these trials, the seeding work was done by hand in order to deepen the exact seeding position.

According to the data, the 200g seed tray produced the maximum paddy yield of 3.81 tons per feddan, and the number of spikelets per unit area also greatly influenced the maximum yield. However, the 150g seed tray obtained a lesser number of spikelets per panicle and square meter compared with the other trays of 200 and 250gs seed quantity. The reason may be assumed to be: (i) lesser number of seedlings per hill; and (ii) high ratio of missing hills. Under such conditions, tillers occurred up to the latter half of the tillering period, and the panicles became small.

On the other hand, the 250g and 300g seed quantities produced a less number of spikelets due to the larger number of seedlings per hill, and/or, the delay in rooting caused by serious transplanting and salinous injuries.

The 250g quantity produced 490 panicles per M^2 which was the maximum obtained, followed by 463 from the 300g trial. However, the average number of spikelets per panicle was less in the 200g quantity.

From the results, experiments using more than 200g seed quantity produced very weak seedlings and many obstacles, such as the following, were encountered:

(i) Spindly growth condition;
(ii) Transplanting injury;
(iii) Heavy competition in a hill; and
(iv) Salinous injury.

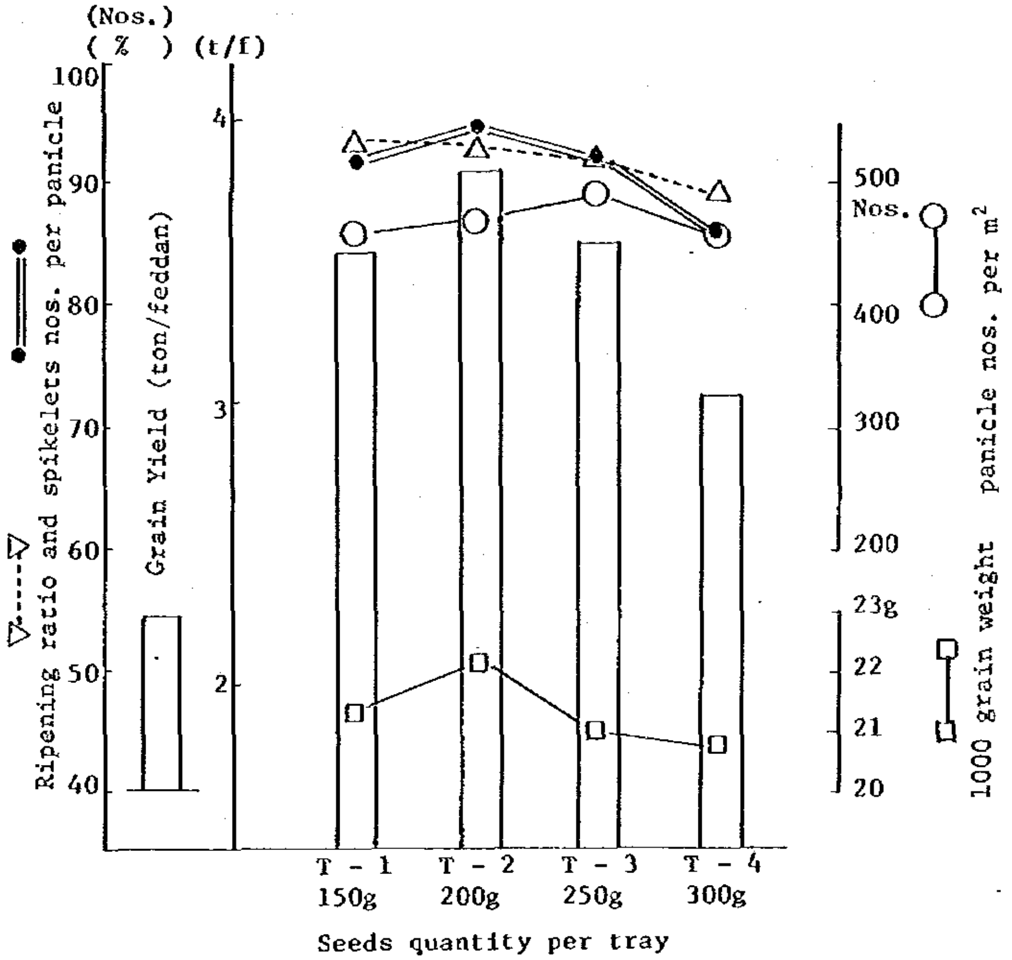


Fig. 9 Effects of seed quantity per tray on grain yield (Variety: Giza-172)

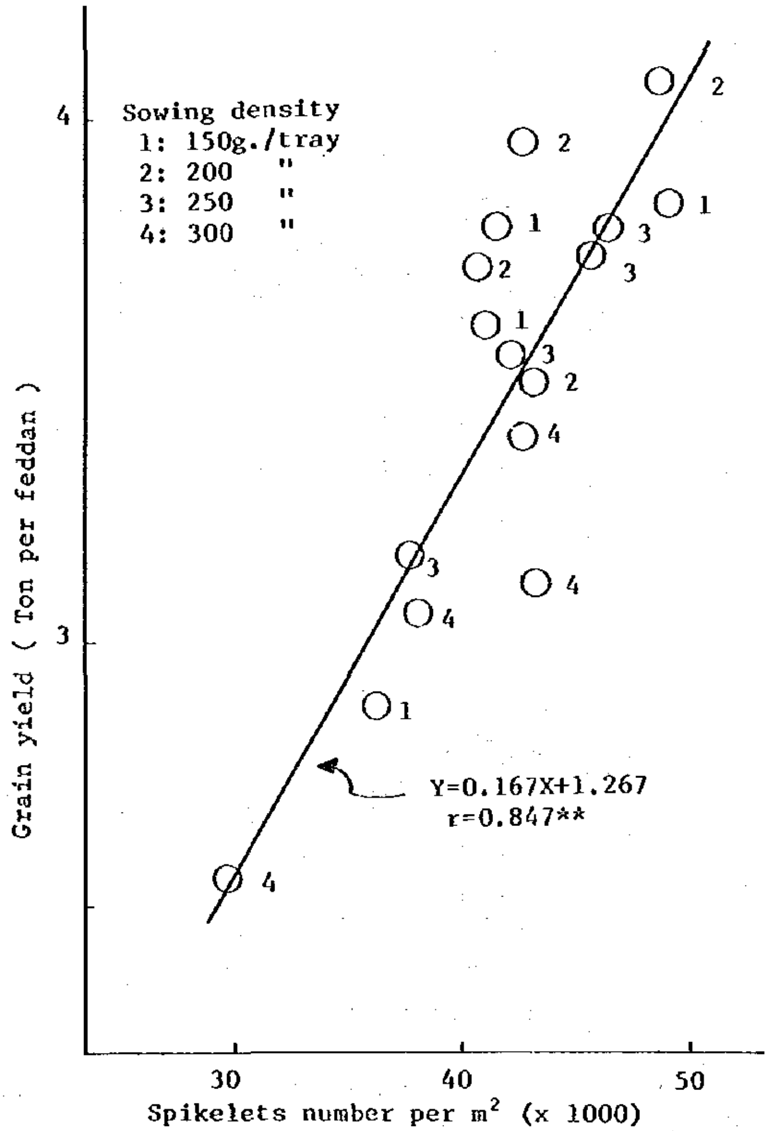


Fig. 10 Relation of sowing densities, number of spikelets per m^2 and paddy yields

Conversely, trays containing a lesser seed quantity, should have the required measure for the transplanter setting for the picking quantity. However, the number of seedlings per hill became less and many missing hills occurred. It can be concluded from the above results, that the optimum seed quantity, when using very young seedlings, would be under 200g of dry seeds per tray, with about 20 days nursing duration.

(c)Seed Pre-Treatment

The following work entailed in the pre-treatment of seeds is indispensable in obtaining uniform germination and seedling growth:

(i) Awning;
(ii) Seed selection;
(iii) Seed disinfection;
(iv) Seed soaking;
(v) Hastening of germination.

Awning work is the first step and is an absolute requirement for obtaining a uniform seedling for each tray, regardless of whether the seedling machine is hand or power operated. Without awning work, the accuracy of the seedling quantity could become greatly reduced.

The second step is seed selection to ensure uniform germination and plant, by the elimination of seeds affected by disease and insects, and imperfectly ripened grain. However, this seed selection exercise is not commonly practised in the conventional rice cultivation in the Nile Delta. For the mechanical transplanting by trays seed selection is an absolute requisite for accuracy in deepening the seedling and to encourage the rooting after transplanting. The method used in seed selection is obtained by the use of a salt solution of 1.13 specific gravity.

The process of seed disinfection (the third step) must be carried out in order to eliminate seeds carrying infections such as blast, brown spot, or bakanae (Gibberella f.) diseases. Benrate-T, or a chemical performing the same function, are commonly utilized and are available in the market. The solution should be prepared by using 100g of Benrate-T, mixed with 20 litres of water. The seeds should be soaked in this solution for 24 hours.

In order to absorb sufficient water, seed soaking (the fourth step) is an important factor in obtaining uniform germination. The normal duration of soaking during the first half of May is around 36 to 48 hours. When soaking seeds in buckets, the water must be changed every morning and evening, and the upper layers of seeds rotated downwards as oxygen is required during soaking and uneven water absorption must be avoided.

The fifth step is hastening of germination and the achievement of uniformity in it. The seeds, having been sufficiently soaked, should be removed from the water and wrapped with wet hemp bags on top of which a sheet of vinyl should be placed. From time to time the boxes should be checked in order to monitor the germination condition. The appearance of the white bud indicates the optimum time for sowing. Care should be taken not of over-hasten the germination as it will bring about a drop in seedling accuracy and cause damage to the seed buds.

(d) Soil Filling for Seedling Tray

The seedling trays, after being lined with paper at the bottom, are filled with sifted soil which has been collected. However, as the collected soil is in a dried-up condition, it must be considered that it has expanded. Most of the soil which has been collected from the paddy fields will be found to have expanded around 20 to 30 percent as compared with the volume of dry soil. The most suitable condition for germination after piling up has been determined to be a thickness measuring about 1.5cm of bed soil. If more than 1,5cm of bed soil is used, it will hamper the germination during piling up, and should less than this amount be used, it will cause the shortage of water during piling up and produce an imperfect seedling mat formation.

(e) Adjustment of pH, Mix of Tachigaren and Method of Watering

The adjustment of pH in the irrigation water; the mixture of tachigaren; and, the method of watering the seedling trays just prior to the commencement of seedling work are very important if good germination and uniform seedlings are to be obtained.

(i) Investigation on the effect of pH value adjustment by sulphuric acid in bed soil of seedling box

Establishment of a good method for nursing seedlings is one of the most important tasks for mechanized rice transplanting in Egypt. Although an optimum pH value of 4-5 is required for growth from germination to emergence of seedling and greening, soil of the Nile Delta has a pH content of around 8. Therefore, an adjustment of the pH value with additional sulphuric acid was made and found to be the most suitable method of treating the dry soil condition which is essential to seedling growth. Tests were carried out to determine the most suitable additional quantity of sulphuric acid required for optimum seedling growth.

Figure 11 shows dry matter weight of the seedling and plant height at 21 days after sowing. According to the experiments conducted, as indicated in Fig. 11, both the dry matter weight and plant height showed the highest results at the point of pH4.5 to 5.5. Also, both the dry matter weight and plant height of the seedling revealed a noticeable decrease at pH reading under 4.5 and over 5.5.

In view of the above results, in order to obtain healthy seedlings it was proven necessary to adjust the pH value by adding sulphuric acid to the bed soil (taken from normal wheat and Egyptian clover fields). The effect of pH value adjustment by sulphuric acid was recognized with remarkably clear results. As already confirmed, the initial stage of growth, after transplanting, induced an incredible increase in the number of tillers produced when healthy seedlings were used. However, attention must be drawn to the fact that over dosages of sulphuric acid should be avoided in order to prevent any obstructions that might hinder the emergence of seedlings

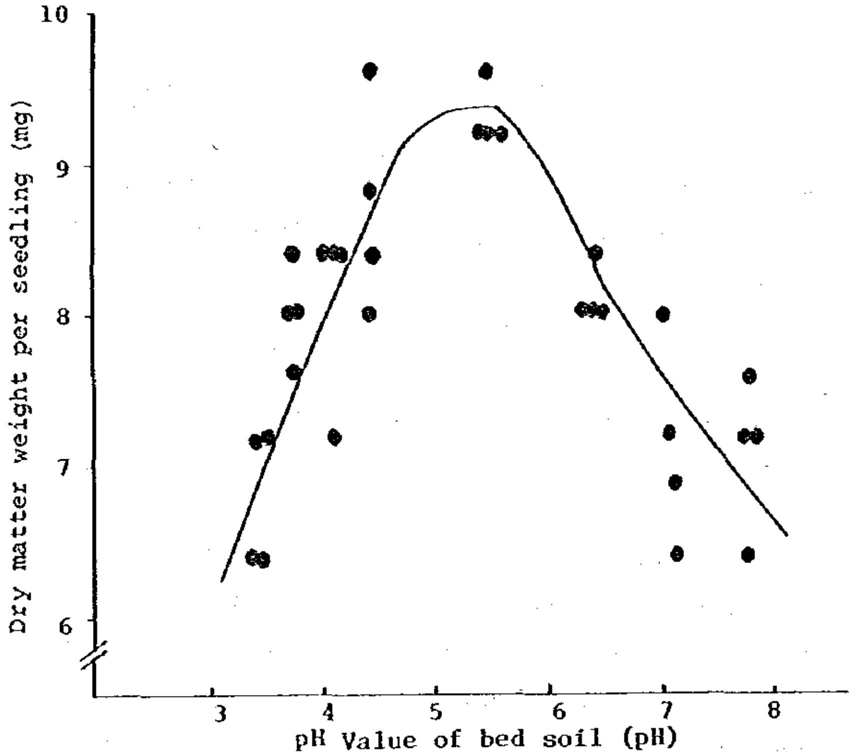


Fig. 11 Relation between pH value and dry matter weight per seedling, 21 days after sowing

Note: pH values of bed soils were checked just after ajustment by sulphuric acid (H_2SO_4, 97%) before sowing

by Trichoderma viride (Tachigare disease). This disease occurred around PH4 reading when a high value of EC was present. The EC value rose with the addition of sulphuric acid causing obstructions which severely hindered the emergence of seedlings. According to the trial results, the optimum sulphuric acid portions and application method for increased allotments can be achieved as follows:

i) Determining optimum additional sulphuric quantity: The optimum additional quantity (c.c) of sulphuric = 11.013 x (bed soil pH - 5.5) acid (H_2SO_4, 97%) per liter of soaking water

ii) Method to follow for the application of additional sulphuric acid:

- Measure the exact amount of soaking water;
- Use syringe to measure sulphuric acid;
- Mix solution well;
- Soak seedling box with mixture;
- Plant the seedlings.

(Utilize mixture for the first irrigation of bed soil of seedling box)

(Note: According to experiments carried out, one liter of irrigation water is required for the first irrigation of a seedling box filled with bed soil to a depth of 1.5 cm in order to reach the saturation condition.)

Precaution: High precaution is required when measuring the sulphuric acid and mixing it to the water in order to avoid injury. Therefore, rubber gloves should be used throughout this procedure.

(ii) The Effects of Chemical Application in the Control of Seedling Disease

An excellent effect was achieved by the application of Hymexazol and Metalaxyl chemicals in the treatment and control of seedling disease. Other treatments tested, except Isoprothiolane, indicated disease occurrence with end results similar to plots where no treatments were administered. However, etiolation appeared in the greening bed stage when Isoprothiolane was used and the seedling gradually died. On the other hand, when Hymexazol and Metalaxyl treatments were used, the seedlings showed remarkable growth (in plant height and dry matter weight) when compared with the other remaining treatments.

According to the observations at the nursery site of the Kafr El-Sheikh Governorate, the severe damage to seedlings was caused by said disease. The damaged ratio sometimes reached over 50% at the site because of non-application of Hymexazol and Metalaxyl. It was further noted that no occurrence appeared from the end of April to around the first week of May during low air temperature during the days. However, heavy occurrence appeared after the middle of May which indicated the peak of nursery preparation with raised temperatures. It is considered that this seedling disease, which appears to be Pythium spp, is recognized as the largest deterrent in raising healthy seedlings and in the utilization of mechanized rice transplanting in this Region. In the verifying experiments of trail results, it was proven that this disease can be completely controlled by Hymexazol and Metalaxyl. These chemicals, therefore, should be introduced as early as possible. In connection with the above tests, other seedling diseases such as Fusarium spp, Rhizoctonia solani, and Cochliobolus miyabeanus, etc., were observed at certain nursery sites. Countermeasures for their control should be implemented urgently and consideration to the introduction of chemicals such as Chlorothalonil for Rhizopus spp and Benomyl thiram for seed disinfection.

The watering work of the seedling box just before seedling is very important and full attention must be paid while doing it in order to obtain good germination after the piling up work is completed. During piling up, should there be a water shortage, floating seeds will occur. Two methods may be used for irrigating the seedling tray before seedling: (i) surface; and (ii) penetration.

The penetration method or irrigation is more safe and is considered to be better than the surface method because the latter destroys the single-grained structure of the surface soil of the tray causing rooting difficulties. A larger percentage of floating seeds will occur with surface irrigation than when using the penetration method.

(f) Sowing, Covering and Piling Up Work

When manually-operated machines are used, the seeding speed should be kept slow and should be constant. If the seeding speed is uneven, the quantity of seeds will not be uniform. The grouping of personnel around the seeding machine, in readiness to quickly spot difficulties, is also beneficial for smooth seeding work.

The seedling trays should be piled up after seeding for uniform germination. It normally takes from two to three days for piling up work to be completed. Attention should be paid to the following points in piling up work:

(i) The seedling trays should be piled up correctly;
(ii) The piling height should not exceed one meter. (Should the stacks reach more than one meter, the lower trays may be transformed and germination may also be damaged).
(iii) When piling is finished, cover the top tray with an empty one, then cover the entire pile completely with a plastic sheet.

(g) Preparation of Greening Bed

The preparation of the greening bed is very important in order to obtain uniform seedlings. The method of preparing the greening bed is as follows:

(i) Pace out the necessary area;
(ii) Manually, level surface roughly;
(iii) Water, then level;
(iv) Let water settle and dry up then make the bed compact;
(v) Water again and make final levelling;
(vi) Leave bed to dry up.

Meticulous care must be exercized to ensure that the greening bed surface is level. If the trays are not placed evenly throughout the entire area, the seedlings may grow to different heights reflecting quick growth patterns at the bottom of the tray where it touches and stagnated growth where it does not.

(h) Transfer to Greening Bed and First Irrigation of Seedling Tray

When the buds have reached a height of 5 to 10 cms., the seedling trays should be transferred to the greening bed. These seedling trays are then carefully placed onto the greening bed. When this is done it is imperative to make certain that the entire bottom of each seedling tray touches the surface of the greening bed.

(i) Irrigation Water Management during Raising of Seedlings

A very vital factor in the achievement of satisfactory germination depends upon the first irrigation to the seedling trays. This is done just after transferring and laying the trays on the greening bed. The cover soil and insufficient germinated portions on the buds should be washed out in order to expose the buds. The exposed seeds are then recovered just slightly with soil. This surface irrigation, by either watering can or power sprayer, must be continued for a minimum of three days until enough elongation of the bud appears. Afterwards, the flood method of irrigation water supply can be introduced and drained after sufficient absorption.

Additionally, intermittent irrigation, such as one-day-irrigation and three-days-dry-up, is very important. It was found that when irrigation water was kept on continuously, many troubles such as imperfect seedling mat formation, occurrence of disease, wake rooting after transplanting, and so on, resulted.

(j) Top Dressing of Nitrogenous Fertilizer to Seedling Tray Just Before Transplanting

In cases of transplanting with very young seedlings, rooting and tiller development were sometimes delayed as a result of very small plants and root systems. Therefore, it is very important to encourage the rooting of seedlings in the initial growth stage in order to expand the yield capacity when mechanically transplanting with very young seedlings. In pursuing the encouragement to the initial growth after transplanting, the carry over effects of nitrogen and zinc were studied.

(i) Carry Over Effects of Nitrogen Treatment

The following method of treatment was used:

Treatment: 5 g. of nitrogen per tray.

Plot	T-0	T-1	T-2	T-3	T-4	T-5	T-6
Days after transp-lanting	Cont.	Same day	2	4	6	8	10

Variety: Giza-173

Fertilizer Doses: N = 120 kg. per ha.
P = 80 kg. per ha.
K = 30 kg. per ha.

Split Application Method:

Basal	=	50% of total N, and 100% of P and K
1st Top Dressing	=	25% of total N : at 10 days after transplanting
2nd Top Dressing	=	25% of total N : at 7 days before the panicle initiation stage.
Planting Density	=	30cm X 12cm with 4 to 6 seedlings
Seeding Date	=	26 April 1984
Date of Transplanting	=	24 May 1984
Date of Harvesting	=	6 October 1984

Treatment given two and four days before transplanting produced the second highest yield of 3.11 tons per feddan. Further experiments were conducted at both eight and ten days before transplanting. No difference in grain yield resulted nor was transplanting affected because of nitrogen application on the same day as the transplanting took place.

Cases where the 6 to 10 day treatment was followed, revealed the nitrogen effect on the nursery bed and it's encouragement of overgrowth there and subsequent transplanting injuries. This resulted in delays in setting and the occurrence of tillers after transplanting.

As for the yield components, the number of panicles per M^2 stood at 550 to 600 when the application was made in the period two to eight days before transplanting compared with 470 to 480 when administered on the same day. However, a larger number of spikelets per panicle was obtained in the plots where the application was made two and four days before transplanting. This could be attributed to smooth setting and aiding of initial growth by the addition of nitrogen top-dressing at the seedling stage. The 6 to 10 day plots produced a smaller number of spikelets per panicle compared with the 2 to 4 day plots, due to transplanting injuries.

From these trials, the nitrogen application to seedling trays at 2 to 4 days before the transplanting date, tends to support the initial growth of the rice plant after transplanting, as well as to increase the grain yield.

(k) Nursing Duration

According to the results of the survey of mechanical transplanting in Kafr El-Sheikh, some observations were noted concerning the senescented condition of some seedlings at transplanting time. For this reason, trials were conducted covering the nursing duration of the seedlings and subsequent yield.

Using the Akihikari variety, trials were scheduled for 20, 28 and 35-day periods. To total fertilizer quantities per feddan were 42 kg N, 25kg P_2O_5 and 13kg K_2O.

Results indicated that the 20 day nursing duration plot produced the maximum grain yield of 3.41 tons per feddan which became lower as the seedlings became older. Additionally, the number of panicles and spikelets per square meter, a strong determining factor on the grain yield, was highest in the above period, running at 541 and 37 thousand respectively. These recordings decreased gradually as the seedlings became older.

Differences in other yield components, such as the ripening ratio and 1000 grain weight were never observed during treatment.

A strong relationship between the nursing duration and the initial growth of the rice plants after transplanting was observed. When the seedlings were kept for long periods, such as 35 days, with high planting density (200g of dry seeds per box), overgrowth occurred along with a very low quality of seedling. This long nursing period hampered the setting of the seedling and the development of new tillers was delayed after transplanting. Together, these factors reduced the number of panicles per unit area. Seedlings of 28 days nursing duration also revealed the same tendencies as the 35 day ones.

The seed quantity of 200g per tray was found to lack the flexibility required for the transplanting phase and consequently was done around the 20-day nursing period.

Should irrigation water or some other reason cause a transplanting delay of more than 30 days, a suitable quantity of seeds per tray would be around 150g. However, consideration must be given to the picking quantity and the number of seedlings per tray.

(1) Nitrogen Application, mixed with bed soil of Seedling Box

In the mechanized rice transplanting area being developed by the Kafr El-Sheikh Governorate, there were some cases where high yields could not be expected due to obstruction of rooting and delays in the initial stage of growth of the seedlings. It appeared that a very large amount of nitrogen application would be required in order to improve the seedling growth and development. Therefore, investigation were made to determine the compatibility and relationship of factors such as the dry weight, plant height, leaf age, number of tillers and the quantity of the nitrogen applications.

Fig.14 shows the relation between the quantity of the nitrogen applications and the seedling characteristics. The remarkable effects of nitrogen applications are recognized clearly when used in 1g. treatment formulas for healthy seedlings in the initial growth stage. However, when amounts over 1 g. were applied, the seedling had a tendency to become spindly which caused stagnation in the initial growth stage. Therefore, nitrogen application quantities should not in any case exceed 1g. per seedling box. In conjunction with this, the transplanting date should be controlled well in order to avoid elongation of seedlings. Furthermore, experiments including major elements should be conducted in order to obtain good, healthy seedlings and promote the initial stage growth. However, for the standard mechanized rice cultivation system, bed soil was collected and, as a safety measure at the farmers' level at this time, no application of fertilizer was administered.

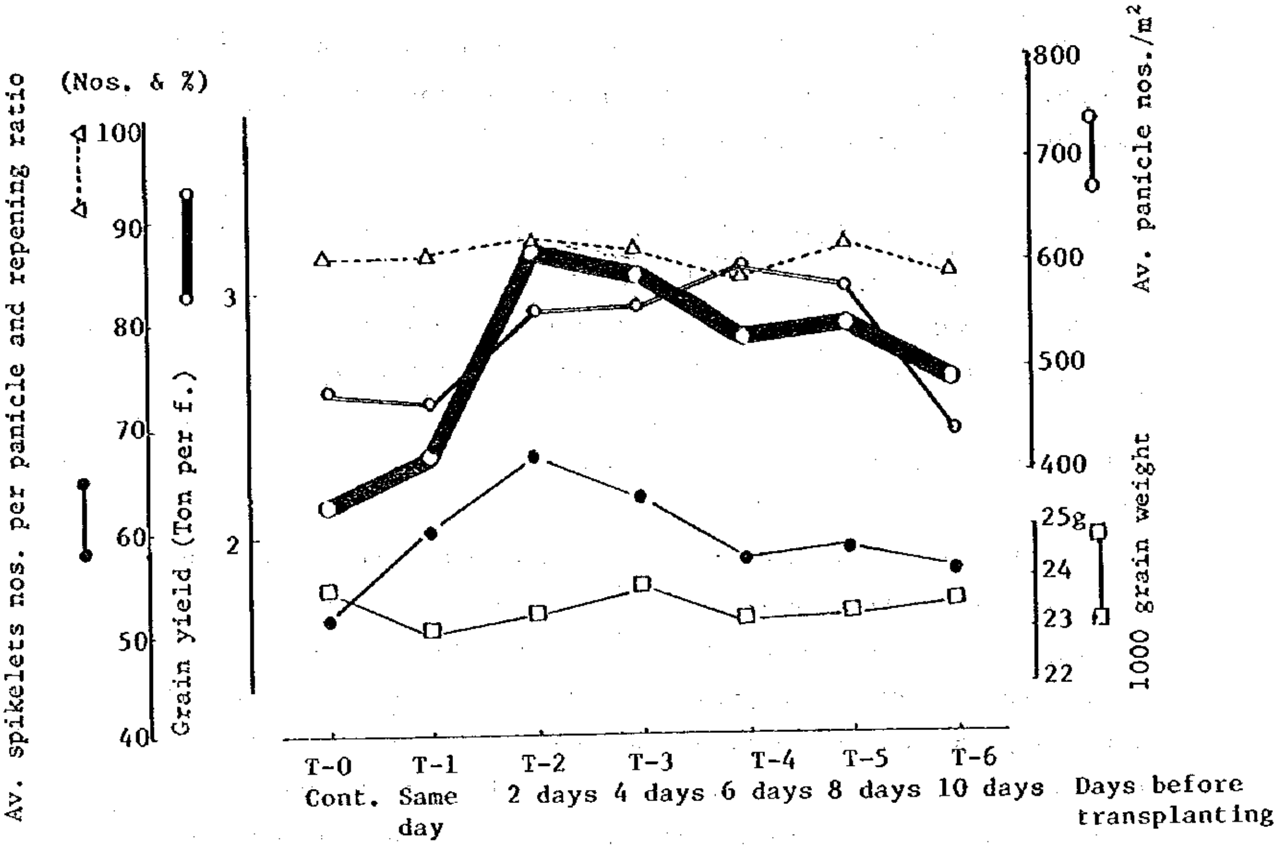


Fig. 12 Trial of Carry Over Effect of Nitrogen from Nursery Bed to Main Field (Variety: Giza-173)

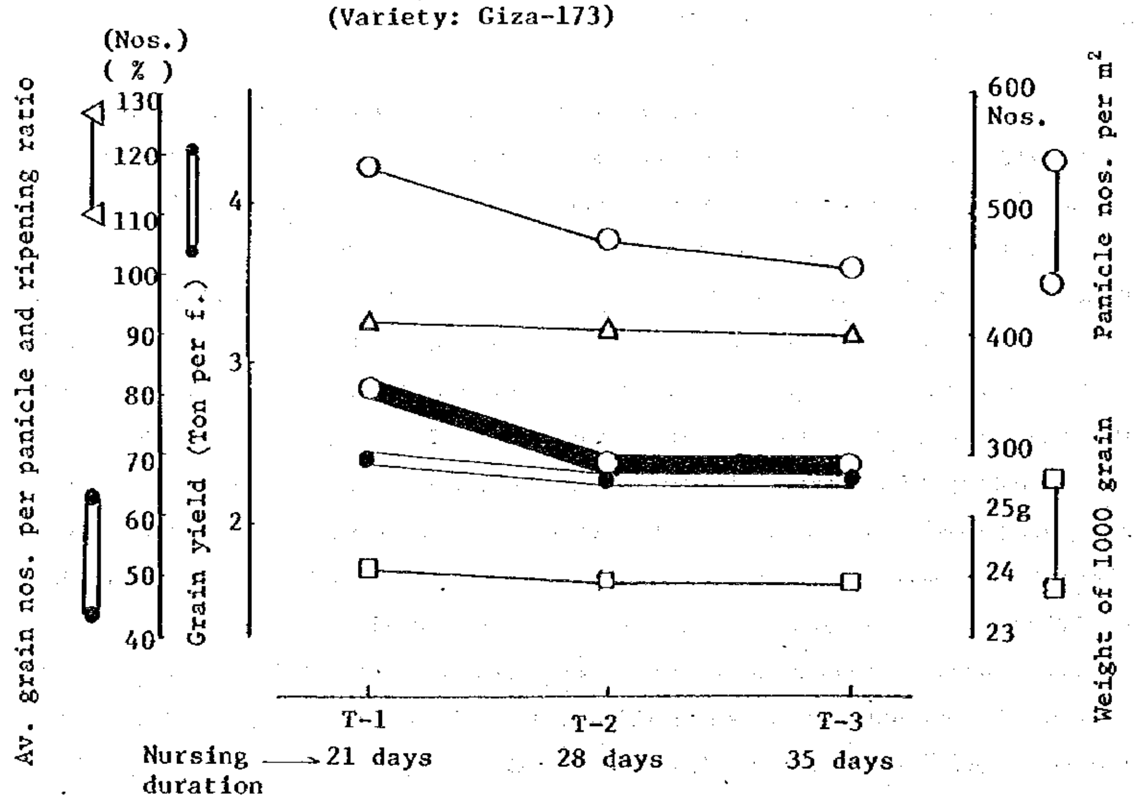


Fig. 13 Comparative Trial of Different Nursing Durations (Variety : Akihikari)

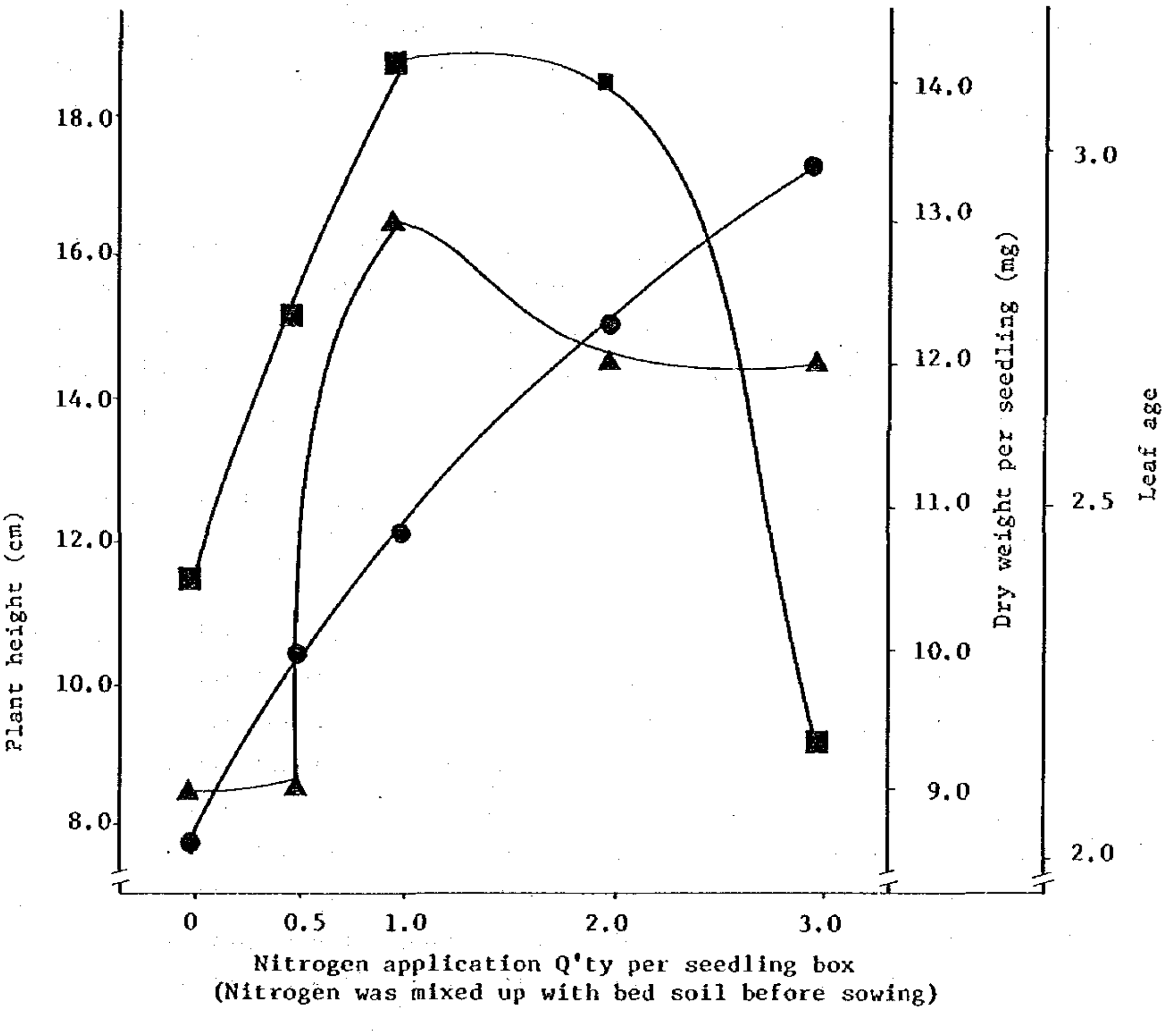


Fig. 14 Dry Weight, Plant Height, Leaf Age and Nitrogen Application Quantity Relationships

Note: ● Plant Height ▲ Dry Weight ■ Leaf Age

Seedling were checked 2 weeks after transferred to greening bed (just before transplanting)

2.1.1.(3) Determination of Suitable Cropping Season

(a) Effects of Cultivation Season on Grain Yield and Yield Components

In the local cultivation method, seedling work is started at around the middle of May with transplanting in June under normal weather conditions. However, sometimes transplanting work has to be carried over to July because of the delays by farmers in the harvesting of the Egyptian clover.

Generally, grain yields to not reach the maximum peak due to late cultivation practices in the Nile Delta. Using this reason as a prime factor, trials were conducted to elucidate the transition of grain yields under different cultivation methodology, and to discover the most suitable cultivation time to ensure the highest grain yields.

Tests using the following Seeding/Transplanting Schedules were conducted:

T-1:	1st	April	seeding	and	11th May	transplanting
T-2:	15th	April	seeding	and	16th May	transplanting
T-3:	1st	May	seeding	and	23rd May	transplanting
T-4:	15th	May	seeding	and	7th June	transplanting
T-5:	1st	June	seeding	and	20th June	transplanting
T-6:	15th	June	seeding	and	4th July	transplanting
T-7:	1st	July	seeding	and	23rd July	transplanting
T-8:	15th	July	seeding	and	8th August	transplanting
&-9:	1st	August	seeding	and	24th August	transplanting

The fertilizer quantity per feddan for the main field was applied, using the following formula:

"N" : for 42 kg.
"P_2O_5 : for 25 kg.
"K_2O" : for 13 kg.

The split application method of nitrogen was 50% of the total quantity for basal with full quantities of "P" and "K". In the first application for top dressing, 25% of the total nitrogen solution was used seven days after transplanting and the remaining 25% just before the reduction division stage. The Giza-172 variety was used.

According to the results, maximum grain yield was obtained in cases where the seeding date was the first of May and the transplanting date was the 23rd. of May. Early transplanting in Plot Numbers T-1 and T-2 did not achieve high grain yields in comparison with Plot T-3, attributable to the low temperatures during May (just after transplanting) and the outbreak of both insect and bird attacks at that time.

Should a basic yield of, say 3.36 tons per feddan, be set, grain yields above this point would be in plots sown between the period of 20th April to 20th May and transplanted in the period of 20th May to 15th June.

Yield capacity (panicle number per M^2 and number of spikelets per panicle) among the four yield components showed a very strong correlation with grain yield, as mentioned in the beginning of this Chapter. Furthermore, in this trial, the number of panicles per M^2 was a far stronger influence on yield capacity than that of spikelet numbers per panicle (see Fig. 19).

Plot T-3 obtained the maximum number of panicles per M^2 at 511. This gradually decreased along with late sowing dates. The exception to this case was found when plots were seeded early, such as on the 1st and 15th of April. The cause of fewer numbers per panicles in plots that were sown early was known to be the occurrence of insect infection (Rice Leaf Beetle: Culma oryzae) and bird attacks, as mentioned above.

The attainment of the maximum number of panicles in the first of May's plot can be attributed to the big difference between maximum and minimum temperatures which encouraged the tiller development; and low mean temperatures which maintained strong tiller growth throughout the duration (see Fig. 15).

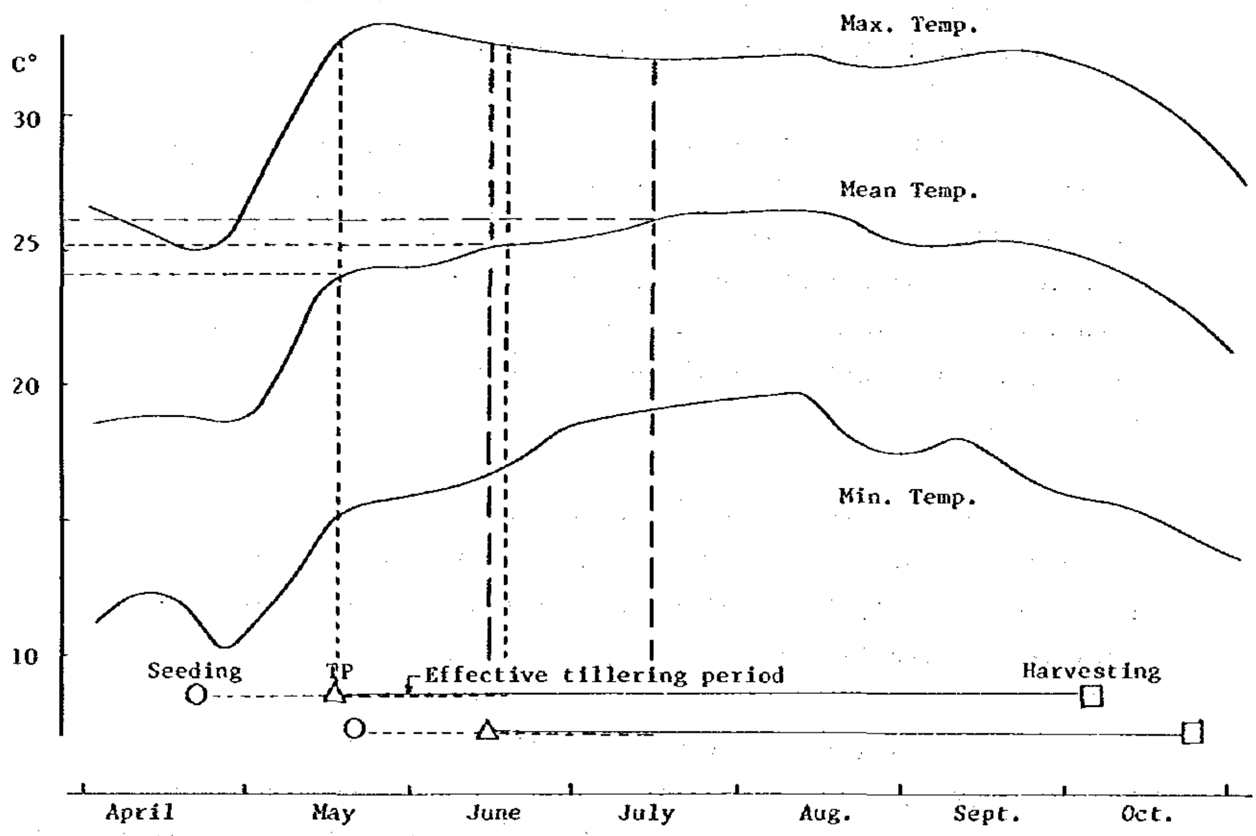


Fig. 15 Meteorological Data During Three Years - 1983-1985, in RMP and Most Suitable Cultivation Season (Giza-172)

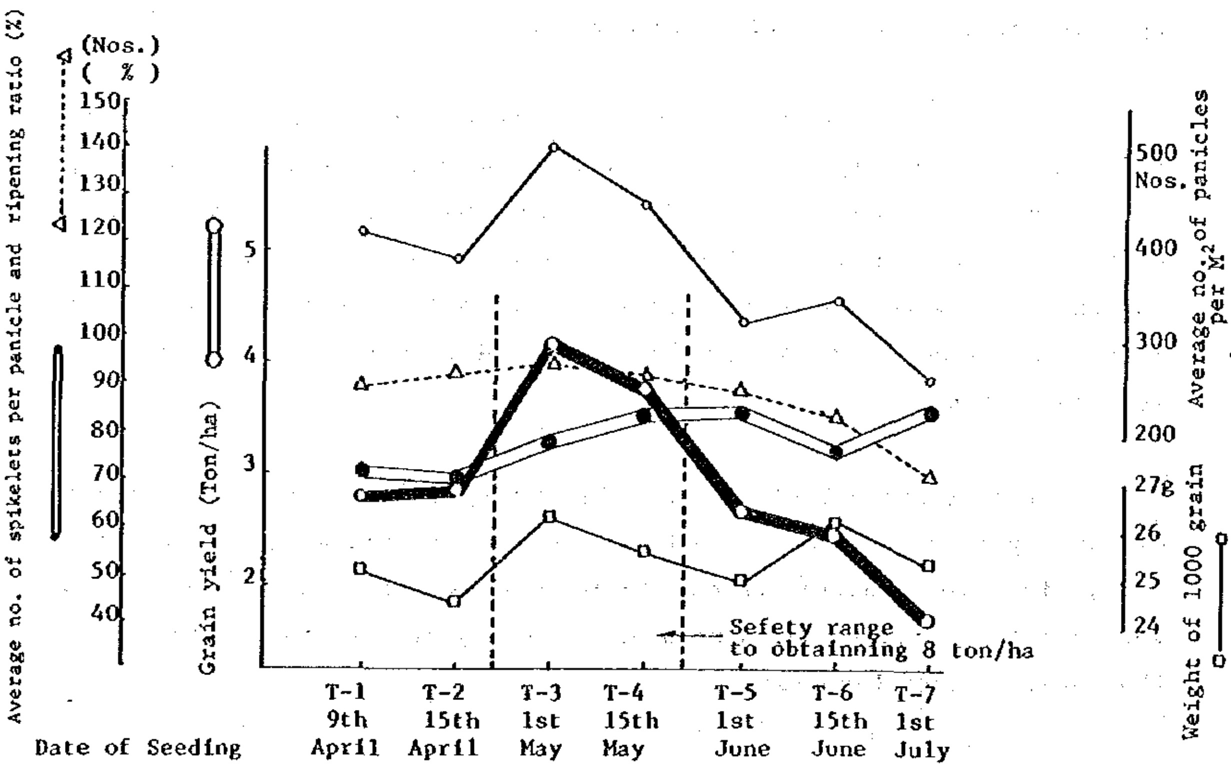


Fig. 16 Effects of Different Cultivation Periods and their Grain Yields (Giza-172)

If the transplanting date is delayed beyond the 15th of June, mean temperatures will increase and the effective tiller duration will become shorter. Finally, the number will decrease and the total growth duration will also become shorter.

The number of spikelets per panicle also decreased along with late sowing or transplanting. Furthermore, other components, such as the ripening ratio and 1000 grain weight, showed little difference among the various cultivation seasons, as shown in Fig. 16.

It was noted, therefore, that with the strong influential factor of the two components (number of panicles per unit area and number of spikelets per panicle) which constitute the "Yield capacity" (as shown in Fig. 17) the number of panicles per m^2 was more strongly influenced than the number of spikelets per panicle. However, the number of spikelets also decreased along with late sowing and transplanting.

Finally, it can be said that seeding should be started during the period of April 20th to May 20th, and transplanting done during the time between the 25th of May and the 15th of June, in order to secure the highest grain yield.

In cases of either very early or very late seeding and transplanting, the following measures are considered essential:

(i) Seeding before the 20th of May;

- Vinyl sheets should be used for keeping uniform temperature of the nursery bed and to encourage the growth of seedlings;
- Nitrogen fertilizer should be applied to the seedling tray;
- When vinyl sheeting is used, the seedlings must be exposed to sunshine four to five days before the transplanting work is started;
- At times of transplanting and afterwards, required measures should be taken for insect control.

(ii) Seeding after the 20th of May:

- During the nursing period, in order to avoid overgrowth, nitrogen fertilizer should not be applied to the seedlings;
- Seedlings should not be kept in the nursery bed more than 20 to 25 days.

(iii) At and after transplanting times:

- The number of seedlings should be kept to around 6 or more as dense transplanting will be required;
- Nitrogen fertilizer should be applied during the first half of the growth stage and large amounts should not be used during the latter half of the growth stage.

The above factors are considered necessary for early and late cultivation times. According to tests conducted, late seeding and transplanting rapidly decreased the grain yields. Therefore, it was not deemed feasible to attempt seeding after the 15th of July and so statistics covering grain yields are not available for the Giza-72 variety.

(b) Cropping Season Trials of Different Varieties

The paddy-field rice cultivation in the Nile Delta is incorporated into a three-year rotational system of paddy-rice, cotton and maize (winter crops are wheat, Egyptian clover, flax, broad beans, etc.). The cropping season is regulated by the harvesting and sowing of the preceding and succeeding crops, irrigation conditions and other factors.

In mechanized rice cultivation, it is very important to clarify the conditions for expanding the suitable cropping seasons; to improve the working efficiency of the machinery throughout the year; and to establish techniques to increase the yield.

From the above viewpoint, studies were made on the effect of growth and yield of paddy-field rice when seasonal cropping changes were made. The following elements formed the basis for the study:

1)Variety	: Akihikari, Giza-173 (Reiho) and Giza-172;
2)Cropping Season-1984	: May 15, May 20, May 25, May 30;
(Date of transplanting)	: June 5, June 10, June 15, June 20, June 25, June 30;
	: July 5, July 10, July 15, July 20.

Variation of Vegetation Period

Akihikari, an early maturing variety, is almost stable in any cropping season of approximately 70 days. However, the heading periods of a middle maturing variety such as Giza-173, requires 95 days for Cropping Season I (transplanting May 15th) and 88 days for Cropping Season XIV (transplanting July 30th). Thus, the number of heading days become less as the cropping season is delayed.

In the case of Giza-172, a late maturing variety, 103 days is required in Cropping Season I, and becomes less as the transplanting season is delayed, reaching 93 days in Cropping Season XIV, and showing a remarkable reduction in heading time. Ripening periods (from heading to the time of maturity) are regulated by temperatures, and consequently tend to be short for the early maturing kind and long

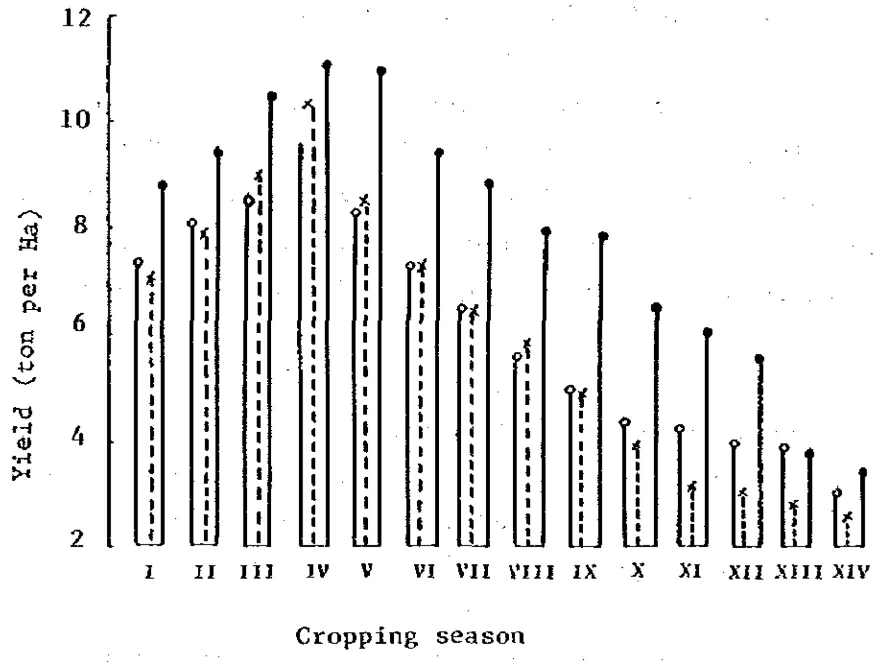


Fig. 17 The Effect of Cropping Seasonal Change on Yield

Note: Relation between cropping season and transplanting date.
I (15th May), II (20th May), III (25th May), IV (30th May), V(5th June), VI (10th June), VII (15th June), VIII (20th June), IX (25th June), X (30th June), XI (5th July), XII (10th, July), XIII (15th July), XIV (20th July)
: Varieties, o Akihikari, × Giza 173, • Giza 172

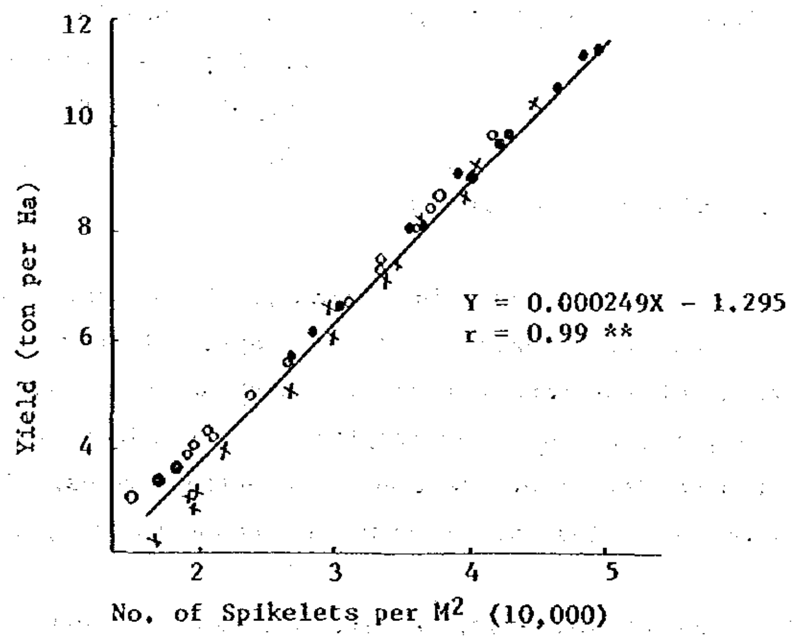


Fig. 18 Relation Between No. of Spikelets per M^2 and Yield under the Condition of Cropping Seasonal Change

Note: o Akihikari, × Giza 173, • Giza 372 for the late maturing varieties. The latter show a tendency toward shorter ripening periods in line with the later cropping season. Experiments concluded that the variation in the total periods due to cropping seasonal change were 6, 7 and 16 days for Akihikari, Giza-173 and Giza-172, respectively, with heading and ripening periods being the two controlling elements.

Variation of plant height and number of tillers by Cropping Seasonal Change

The effect of cropping seasonal change on plant height and the number of tillers showed the fastest growth speed for Cropping Season IV. The growth progress became slower as the cropping season was moved away from Season IV and decreased in both plant height and the number of tillers.

Variation of Yield and Yield Components

The effects of cropping seasonal change on yield, both in the number of panicles and spikelets per panicle, kept increasing up to Cropping Season IV, when the maximum resisting value began to decline as the cropping season progressed. It is clearly recognized that yield per unit area is controlled by these factors. As for the ripening ratio and 1000 grain weight, no significant change was caused by cropping seasonal change. The overall observations of variety characteristics and cropping seasons revealed the very close correlation between the number of spikelets per M_2 and yield; which is considered to be under the complete control of the number of spikelets per M_2, as show in Fig. 18. Thus, a suitable cropping seasonal span was formulated, as follows:

Assuming the yield was over 2.5 ton/feddan

: the suitable cropping seasonal span would be from Cropping Season I (transplanting on May 15) to Season VII (transplanting on June 15) for Akihikari and Giza-173- the early and medium maturing varieties (respectively);

and

: from Season I (May 15) to Season XI (transplanting July 5) for Giza-172-the late maturing varieties.

Furthermore, it became clear that the transplanting period could be extended to 50 days using a combination of early, medium and late maturing varieties. The harvesting periods for these Cropping Seasons would be:

- Akihikari : From Cropping Season I (August 23) to Season VII (September 21);
- Giza-173 : From Cropping Season I (September 24) to Season VII (October 23);
- Giza-172 : From Cropping Season I (October 6) to Season XI (November 15).

Thus, it was confirmed that the possible harvesting period could be extended to 82 days.

It was found possible to eliminate the working peak of the rice transplanters as well as the harvesting machinery in use, in order to improve the overall working efficiency on an annual basis. Also, it was found to be more economical to systematically use a combination of early, medium and late maturing varieties of seed in the machines in view of the time span between the harvesting of the preceeding crop and of planting the succeeding one. The yield variation by cropping seasonal change is regulated by the number of spikelets per M_2, so by increasing the number of panicles and spikelets when transplanting is late, leads to an increase in yield. This, in turn, makes the utilization of rice transplanters more economical as they are suitable for dense planting.

2.1.1.(4) Determining suitable planting Density

(a) Suitable Number of Seedlings per Hill

Under the conventional rice cultivation method, most of the farmers' fields are transplanted with a large number of seedlings per hill such as 20 to 25. Such an excessive number of seedlings per hill can only encourage competition among the seedlings planted there and consequently prevent tiller development.

For the above reason, trials were conducted to determine the effects of different numbers of seedling per hill on the grain yield and the yield components. It was envisaged that the findings of these experiments would result in the discovery of the proper number of seedlings that should be planted in an hill when using the mechanical transplanting method and taking into account the conditions in Egypt.

The method devised for these experiments was to take a series of seedlings from two upwards: i.e.2 seedlings (T-1); 4 seedlings (T-2), and so on, up to 20 seedlings (T-10) per hill. Seedlings selected were those that were suitable for mechanical transplanting, with leaf age of from 2.5 to 3.5. For the sake of the experiment, they were transplanted by hand in order to keep an accurate account of the number per hill and of the planting density. The kallin Agricultural Station conducted these experiments in 1983 using Giza-172 and Giza-173 varieties.

The total dosages of fertilizer used, per feddan, for these experiments were: N : 42kg; P_2O_5: 26 kg; and K_2O: 13 kg. for both varieties. Basal doses were applied by total layer application method, just before plowing, and contained 50% of the total nitrogen quantity and full quantities of P_2O_5 and K_2O. The first top dressing consisted of 25% nitrogen, and was applied 7 days after transplanting. The second top dressing was given at 7 th 10 days before the panicle initiation stage for the Nipponbare variety and at the beginning of the reduction division stage for Giza-172.

The trial, using 6 seedlings per hill, was conducted with two varieties, and resulted in 4.19 and 4.81 tons per feddan, respectively, for Nipponbare and Giza-172. In plots sown with 2 seedlings, it was found that the Giza-172 variety obtained a higher yield than that of Nipponbare. The major cause of the low yield of the Nipponbare variety, in the two-seedling batch, can be construed in the first instance to be related to its greater panicle weight type; and secondly, to the insufficient seedling population (51.2 nos./hail) for its panicle number type. Should the panicle-number type be continuously developed, under the sparse density conditions, until the latter half of the tillering stage, the resulting tillers would provide very small and poor panicles. Should a comparison be made between the 2 and 6-seedling plots of the Nipponbare variety, the number of spikelets would be found to be less in the former.

Furthermore, for these two varieties, results showed that the grain yield decreased as the number of seedlings per hill increased. This decrease in grain yield can be attributed to the fact that heavy competition amongst the seedlings occurred when more than six per hill were used. It was also proven that the number of spikelets decreased along with the increase in the number of seedlings per hill, in spite of the increase in the number of panicles per M^2. The other components, such as the ripening ratio and 1000 grain weight, were not greatly influenced by the different seed quantities. However, it was found that a strong correlation existed between the "Yield Capacity" - such as the number of spikelets per M^2 and the "Grain Yield", as shown in Fig. This correlation was also apparent between the number of panicles per M^2 and the number of spikelets per panicle; the underlying cause of this being the heavy competition amongst the seedling in a hill.

On the other hand, Fig. 20 shows the relationship among the "Number of Panicles per M^2"; "Number of Spikelets per Panicle"; "Number of Spikelets per M^2"; and the "Grain Yield". According to this Figure, the number of spikelets per M^2, as well as the number of spikelets per panicle, were perfectly synchronized with the grain yield, in spite of the increase in the number of panicles per M^2.

From the foregoing results, it can be concluded that: (i) the most suitable number of seedlings per hill is 4 to 6, in a normal cultivation season; and (ii) more than six seedlings per hill will tend to increase heavy competition among seedling resulting in rapid decrease in the grain yield.

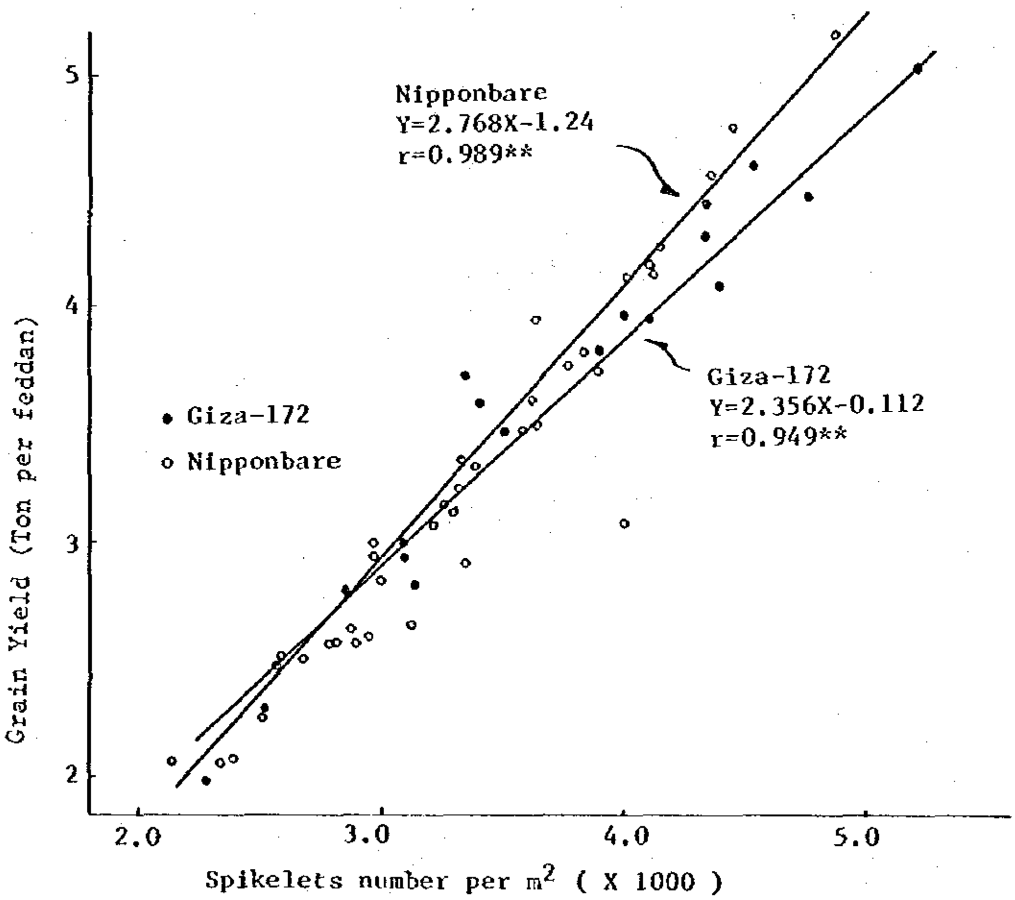


Fig. 19 . Relation Between Number of Spilelets per m^2 and Grain Yield (Giza-172/Nipponbare)

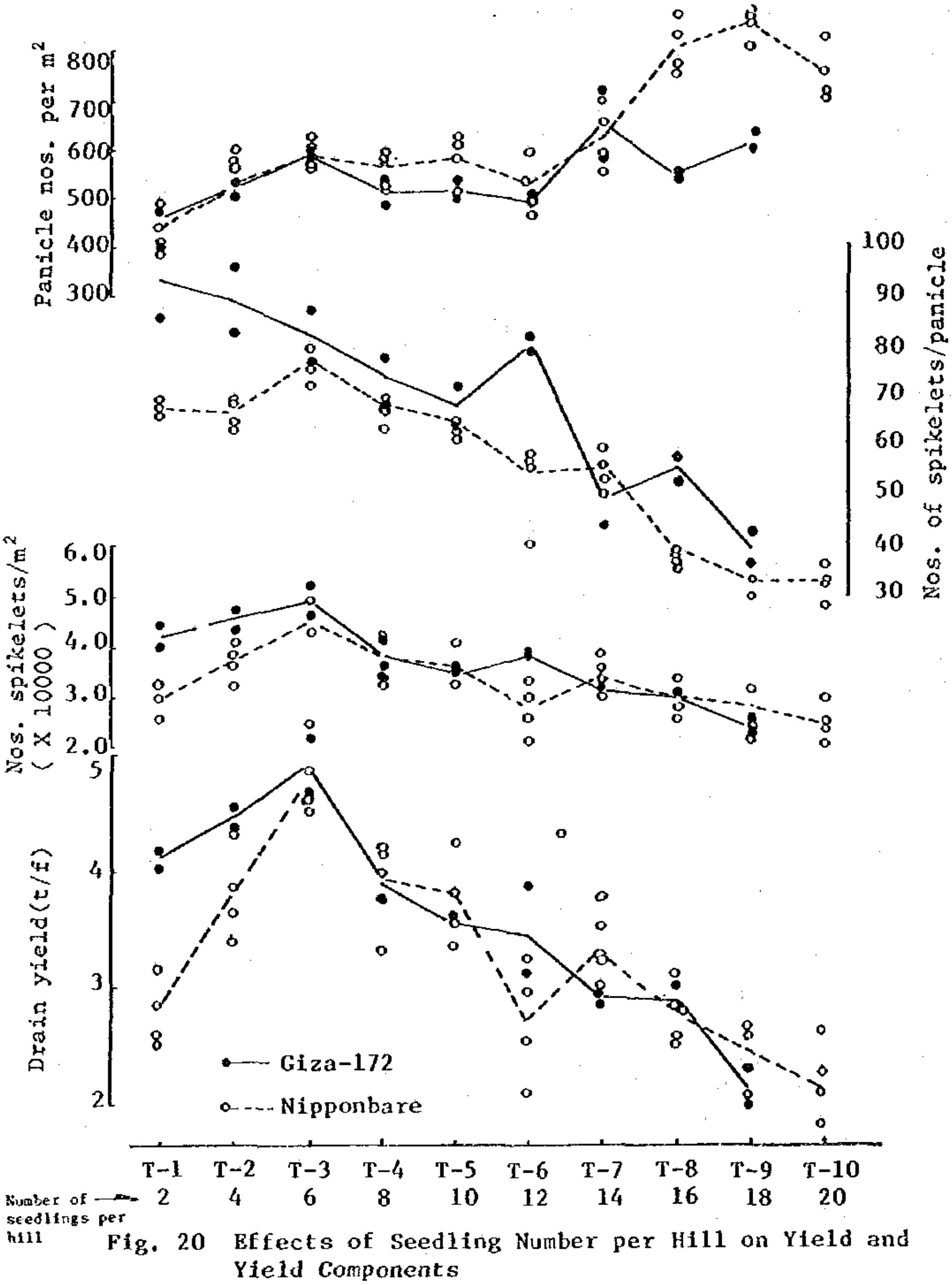


Fig. 20 Effects of Seedling Number per Hill on Yield and Yield Components

(b) Suitable Planting Density

Under the conventional rice cultivation method, sparse transplanting of 15 to 18 hills per M^2, is commonly practised. Under such conditions, it is difficult to ensure the necessary number of spikelets due to delayed development of the leaf area and absorption of ample solar radiation in the initial growth stage is insufficient.

On an average, about 600 to 700 $cal/cm^2/day$ of solar radiation during the rice cultivation season affords an extremely high potential for productivity. By increasing the leaf area through dense transplanting enhances the utilization ratio of solar radiation and its advantages in ensuring yield capacity.

In Japan, the number of spikelets per M^2 is usually 30,000 to 35,000 grains when the highest yield is obtained, but the ripening ratio tends to decline conversely due to limited solar radiation.

The results of the experiments conducted over the past four years indicated the relationship between the number of spikelets per M^2 and yield; and an extremely high positive correlation between the two has been confirmed. As the number of spikelets become larger - up to 60,000 per M^2 - the yield increases in a straight line, as shown in Fig. 19

The experiments on planting densities have been conducted for four years, from 1982 to 1985, at the Kallin Agricultural Station and at the Rice Mechanization Center, Meet el Dyba. In particular, during 1985 trials pertaining to two factors were conducted: (i) different nitrogen levels; and (ii) various planting densities. The experiments were conducted using the following methodology:

Treatment Method:

a. Planting Density = D-1 : 24.24 hills/M^2

D-2 : 21.21 ''

D-3 : 18.18 ''

b. Nitrogen Quantity = N-0 : Cont.

N-1 : 21Kg/feddan

N-2 : 42 ''

N-3 : 63 ''

N-4 : 84 ''

Note: For basal doses, P_2O_5 and K_2O were applied in quantities of 34 Kg and 17Kg respectively.

The split application method of nitrogen was given in accordance with quantities of 50% for basal with 20% administered at 7 days after transplanting, 20% at just before the reduction division stage and 10% at the heading stage. The Giza-172 variety was used.

The experiments showed a change in paddy yield of each different planting density, based on different quantities of nitrogen and the yield increased along with the increased quantities of nitrogen. Hills per M^2 rapidly increased to reach 24.24 compared with 21.21 and 18.18. However, paddy yield in N-3 (63kg N/feddan) and N-4 (84kg N/feddan) with 24.24 hills per M^2, were considered slow when compared with N-1 and N-2, as shown in Fig. 21. It is clear from the experimental data that high planting density is advantageous in obtaining a high paddy yield.

Regarding the panicle number, 500 per M^2 are required in order to secure a high yield. More than 500 was obtained with planting densities of 21.21 and 24.24 hills per M^2 (D-1 and D-2), using the 42kg. per feddan nitrogen level (N-2) and for 18.18 hill/M^2 with 63kg per feddan nitrogen quantity (D-3 : N-3). The paddy yield of these lots was only 3.88 tons per feddan in the 18.18 hills per M^2 with 63kg. nitrogen per feddan (D-3 : N-3), against 4.75 and 4.46 tons per feddan in D-1 : N-2 :and D-2 : N-2 respectively. The low paddy yield of 3.88 tons per feddan, in spite of 500 panicles per

M^2, can be attributed to the low number of spikelets caused by late tiller development under the sparse planting conditions of 18.18 hill/M^2. Against the sparse planting condition, there was as high density effect in 21.21 and 21.24 hills per M^2 and from these plots big and healthy tillers were obtained in the early stage of the tillering period.

With respect to the ''Yield Capacity'', the yield contents such as the ripening ratio and 1000 grain weight, showed no large differences among the various treatments rendered.

From the results, the following points were made clear: (i) dense planting can obtain a sufficient number of panicles per unit area in the early tillering stage; (ii) tillers bearing a large quantity of panicles represent a large number of spikelets per panicle; and (iii) the most suitable nitrogen quantity was found to be in the formula of 42 to 63kg nitrogen per feddan, with 21 to 24 hills per M^2.

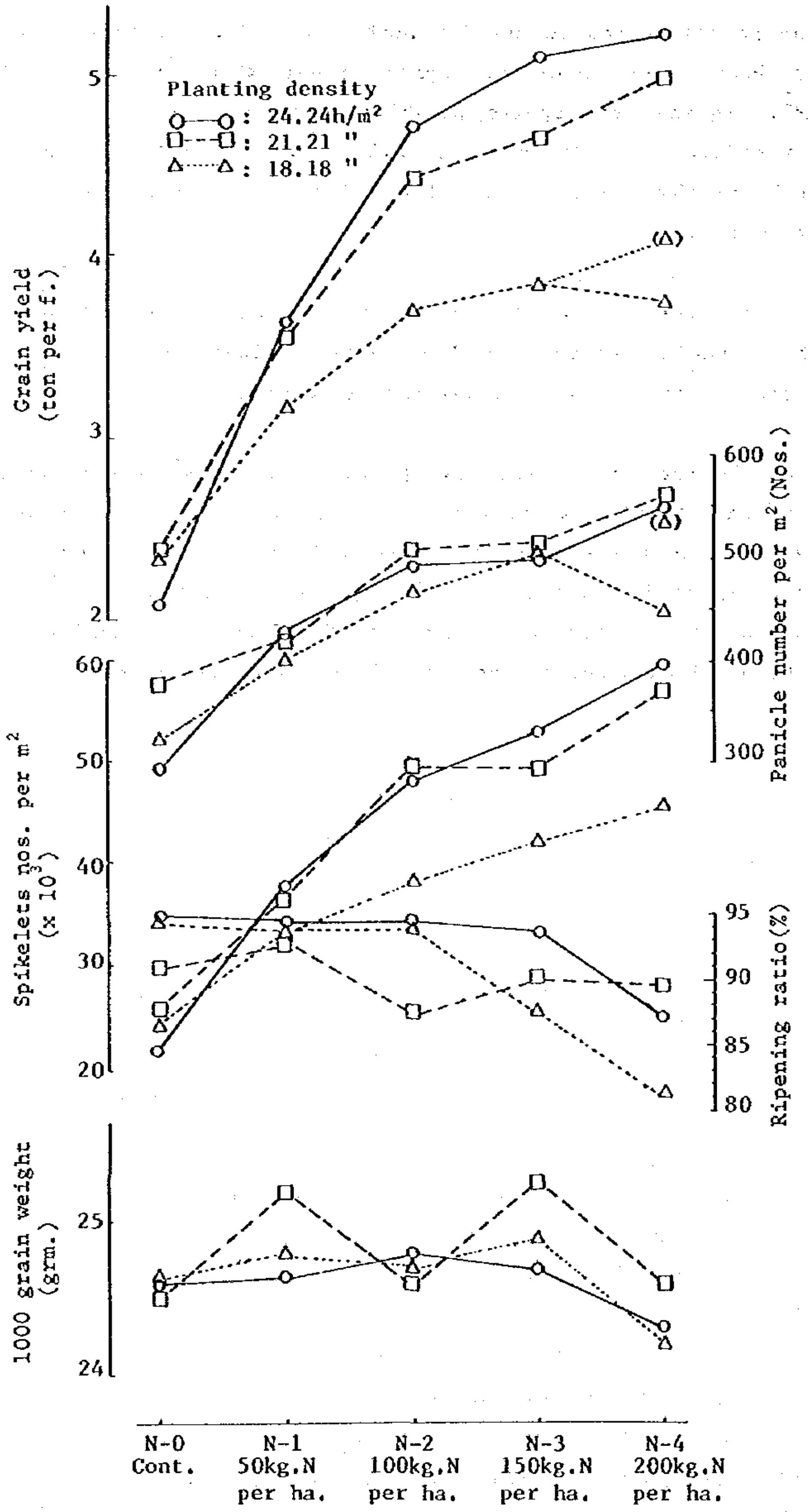


Fig. 20 Effects of Nitrogen Level and Planting Density on Yield and Yield Components

2.1.1. (5) Effective Methods of Fertilizer Application

According to the survey of fertilizer application practices currently used by the farmers, there appeared to be many defects related to the existing conventional methods utilized in applying it to the fields. These can be outlined as follows: (i) no set control exercised over quantities of nitrogenous fertilizer used' (ii) no split-application method followed: and (iii) the fertilizer used did not contain the three elements considered to be essential.

In order to obtain the maximum grain yield, fertilization must be considered as the most important factor of rice cultivation. This Chapter deals expressly with fertilization practices; nitrogen quantities; split-method application; and, the importance of the three elements used in the formula for fertilizer.

(a) Nitrogen quantity trial to the Main Field.

According to the survey it was revealed that applications of fertilizer given by the farmers to their fields were not standardized and ranged from under dosages to more than 60kg per feddan, with the most popular quantity being from 25 to 35kg. In connection with this, trials were conducted, using various amounts of nitrogen, to determine the optimum quantity which would be suitable for mechanical transplanting cultivation.

Different nitrogen levels were settled within a range starting at "0" (for control) and going up to 88kg. per feddan by element with P_2O_5 and K_2O applied in amounts of 25kg and 13kg per ha., respectively, excepting the control plot.

Split Application Method of Nitrogen

Basal	: 50% of total nitrogen quantity
1st Top Dressing	: 25% of total nitrogen quantity - at 7 to 10 days after transplanting
2nd Top Dressing	: Remaining 25% of nitrogen - at 7 to 10 days before the Panicle Initiation Stage for Nipponbare; and - at just before the Reduction Division Stage for Giza-172
Planting Density	: 30 cm x 15 cm (22.2 hill per M^2)
Number of Seedlings per hill	: 4 to 5 seedlings
Date of Seeding	: 1 May 1983
Date of Transplanting	: 2 June 1983
Variety	: Nipponbare and Giza-172

(kg/fa by element)

Plot	Nitrogen	P_2O_5	k_2O
T-0	0	0	0
T-1	13	25	13
T-2	25	25	13
T-3	38	25	13
T-4	50	25	13
T-5	63	25	13
T-6	76	25	13
T-7	88	25	13

Note: Nitrogen fertilizer used with Ammonium Sulfate for basal and area for top-dressing. P_2O_5 and k_2O used with Super Phosphate and Potassium Sulfate respectively.

According to the results, maximum yields at 63kg nitrogen level, were obtained for both Nipponbare and Giza-72. The latter variety obtained 5.0 tons per feddan in Plot T-5 and Nipponbare 5.03 tons. A decrease in yield was reflected in Plots T-6 and T-7 due to overgrowth and lodging caused by excessive nitrogen application.

The number of panicles per M^2 of the Nipponbare (which is a panicle number type) increased much more than the Giza-172 (a panicle weight type) when increased quantities of nitrogen were applied. The number of spikelets per panicle, another important component, showed the same transition in both varieties. In Plots T-6 and T-7 the ripening ratio of Nipponbare was not greatly reduced when compared with that of the Giza-172 type which showed a reduction. These plots were treated with fertilizer with nitrogen level of 15kg but overgrowth and high lodging occurred which brought down the ripening ratio. However, there was no large difference in the 1000 grain weight.

Thirty days after the Heading Stage, the lodging condition of the Nipponbare variety, under the different nitrogen levels, rapidly increased in the T-4 Plot (120 kg nitrogen) reaching 50% while 65% was recorded for Giza-172 at the 88 kg nitrogen per feddan level. Especially in Plots T-6 and T-7, for both varieties of rice used, there was observed many excrescences on the panicles.

Fig. 22 depicts the strong relationship existing between the grain yield and the number of spikelets per M^2 (commonly known as the ''Yield Capacity''). Amongst the contents comprising the yield capacity, such as the ripening ratio and 1000 grain weight, very little correlation was evident. However, a very high correlation was observed between the grain yield and the number of spikelets per $\underline{M}^2$ in the ratio of 0.949** for Giza-172 and 0.989** for Nipponbare, as shown in Fig. 19.

From the above results, the optimum nitrogen level would be from 50 to 55 kg per feddan and such levels are recommendable for both varieties.

(b) Different Split Application methods of Nitrogen Fertilizer and their Effect on Grain Yields.

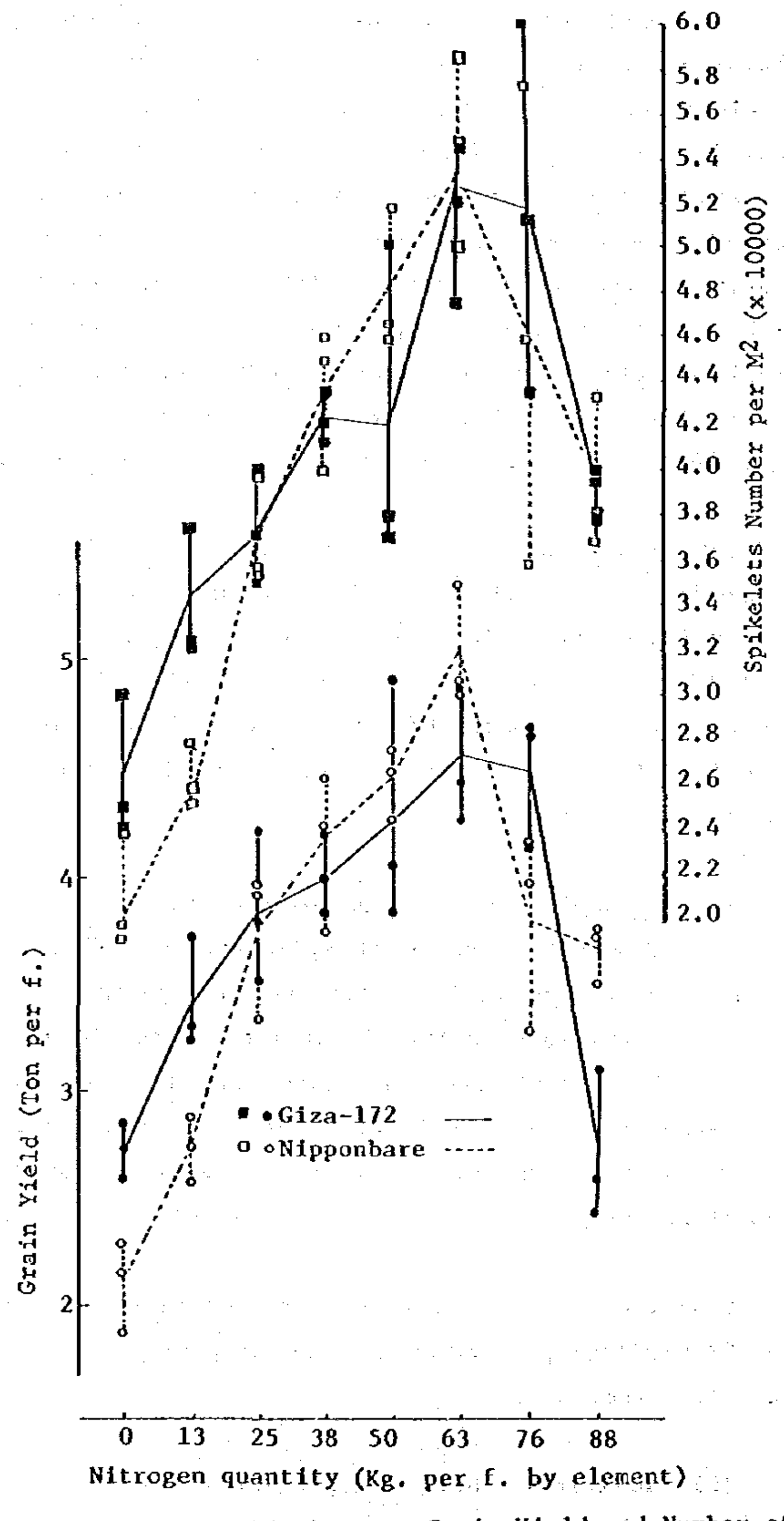


Fig. 22 Relationship between Grain Yield and Number of Spikelets per m^2 Using Different Quantities of Nitrogen (Giza-172/Nipponbare)

According to the survey of local cultivation methodology, it appears that most of the farmers never apply the basal fertilizer but they do apply nitrogen as top-dressing. The first top-dressing is applied around 20 to 30 days after transplanting and then a second one is added at around 50 to 60 days after transplanting. However, the second top-dressing is applied very irregularly and without any consideration of the growth stage of the rice plant. Consequently, over growth conditions can easily be observed in many farm fields during the latter half of the growth stage. This condition is known to induce lodging and the occurrence of blast disease. In cases of local hand transplanting, the seedling population per M^2 becomes 243 to 444 in number with the quantity of seedlings per hill ranging from 19 to 23 with hills where the planting density was 12.8 to 19.3 per M^2 at transplanting time. Under such abnormal conditions, the existing conventional methods of applying fertilizer only tend to encourage lodging and occurrence of diseases and insects.

The mechanical method, when compared with the local hand transplanting one, can be kept very uniform with ideal conditions being: 4 to 6 seedlings per hill; 18.5 to 25.6 hills per M^2; and a seedling population numbering from 74 to 153.6 per M^2.

From the above findings, the mechanical transplanting method can definitely increase the number of panicles. However, in the local hand transplanting method, it is difficult to do so because of the heavy competition in a hill and the fact that most of the panicles are from mother plants. A larger size panicle, or an increased number of panicles, are bred from newly-developed tillers from lower nodes rather than from the mother plant itself.

As so many different conditions exist between the mechanical and local hand transplanting, a modernized method of applying nitrogen fertilizer was required before the initial inauguration of mechanized transplanting could be undertaken.

Variety : Giza-172

Date of seeding : 20th April, 1983

Date of transplanting : 19th May, 1983

Total fertilizer doses : 42kg N, 25kg $P_2 O_5$ and 13kg K_2O per ha. by elements

[Treatment]

(kg/feddan by elements)

Plot No.	Basal	1st TD	2nd TD
T - 0	0	0	0
T - 1	100%	0	0
T - 2	50	25%	25%
T - 3	33	33	33
T - 4	0	50	50

Note: i) Split application method shown in percentage of total nitrogen quantity.

ii) Basal dose : Just before the first plowing

1st top-dressing : 7 to 10 days after transplanting

2nd top-dressing : Just before the Reduction Division Stage.

Note: Nitrogen fertilizer was used with ammonium sulphate for basal and with area for top-dressing.

The experiment was conducted following the above method, and the results are shown in Table 3 and Fig. 23.

According to the date obtained, the T-2 Plot, which was given the 50% basal split application formula of 25% at 7 to 10 days after transplanting, and 25% at just before the reduction division stage, produced the maximum grain yield of 9.84 tons per ha. (4.13 t/f).

The number of panicles per M^2 fell into transition of grain yield as shown in Fig. 22. However, the number of spikelets per panicle in Plot T-4 greatly increased as compared with Plots T-1 and T-3. The likely cause for this being degeneration of the spikelets caused by the effect of 50% nitrogen application administered just before the reduction division stage. No great differences in the other yield components, such as the ripening ratio, were observed form the various treatments applied.

The yield capacity (number of panicles per unit area and the number of spikelets per panicle) can be determined within the first half of the total growth period. This is a very important point at which time the grain yield can be increased, to accommodate mechanical transplanting methods in the Nile Delta.

Fig. 22 shows the correlation between yield and number of spikelets per M^2; number of spikelets and 1000 grain weight; and the number of spikelets and the ripening ratio. According to the results tabulated in this Figure, there is a strong correlation between the number of spikelets and the yield but none when compared with the other two factors. It was also proven from these trials that the capacity of the grain yield, which was determined during the first half of the rice growth period, had a strong influence on the final grain yield.

Table 3 Summary of Experiment Conducted on Different Nitrogen Fertilizer Split-Application Methods

Giza-172

Treatment	Grain yield ton/ha.		No of panicles/hill	No of panicles / m²	No of spikelets/panicle	No of spikelets / m² (x 10⁴)	Ripening ratio %	1000 grain weight gr.
T - 0	7.08	c	9.47	253	125.4	3.20	85.95	24.89
T - 1	7.91	b	14.62	384	86.6	3.30	95.56	25.40
T - 2	9.84	a	16.51	440	92.2	4.05	94.80	25.52
T - 3	8.82	ab	14.36	380	93.7	3.53	95.68	25.20
T - 4	8.39	b	12.07	337	117.4	3.89	89.89	25.03
X̄	8.41		13.41	358.8	103.1	3.59	92.38	25.21
c.v.(%)	8.50		11.67	11.86	11.69	11.01	3.05	1.92
Statistical significant	1 %		1 %	1 %	1 %	5 %	1 %	ns
LSD .05.	1.08		2.36	64.14	18.2	0.595	4.24	----

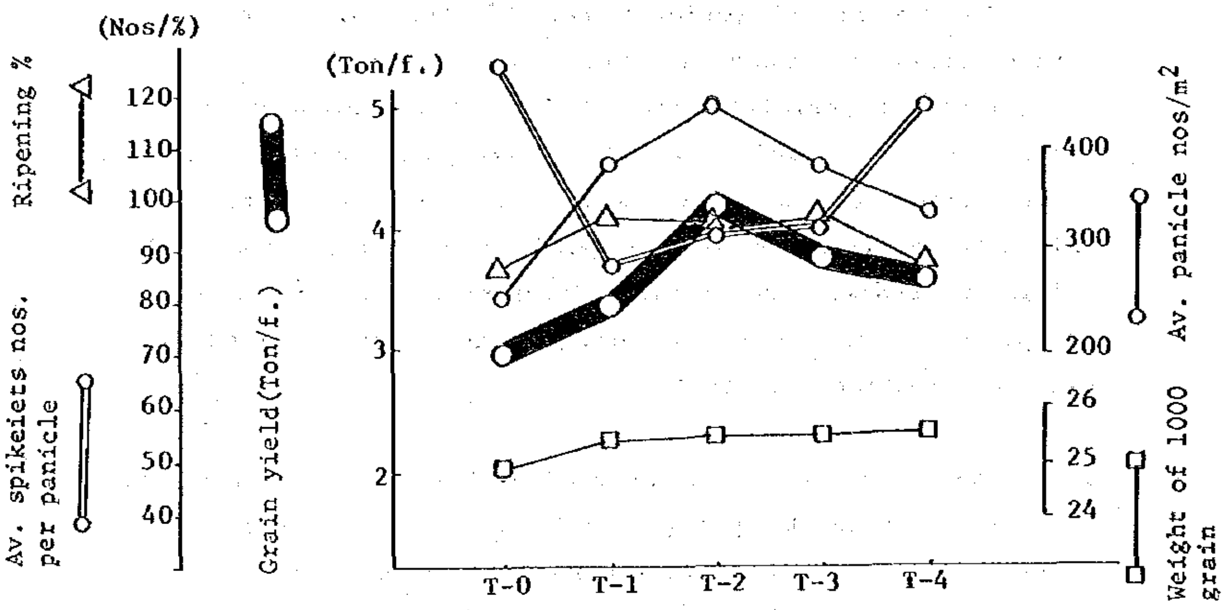


Fig. 23 Effects of Different methods of Fertilizer Applications on Yield and Yield Components (Variety: Giza-172)

(c) Experiment on the Use of Fertilizers using Three Elements

According to a survey conducted on farmers' fields, it was found that most farmers used only nitrogenous fertilizers, but very few used P_2O_5 and K_2O. For this reason, the Agronomy Division ran trials to determine the effectiveness of P_2O_5 and K_2O applications.

Generally, it was found that a balanced fertilizer was indispensable in obtaining maximum grain yields. However, many farmers are still conscious until now of the flooding of the Nile River and are inclined to adhere to the ancient methodology of fertilization for rice cultivation, passed on to them from generation to generation of farmers.

For the above reason, the Agronomy Division conducted the following trial:

[Method]

Variety	: Nipponbare
Date of seeding	: 20th April, 1983
Date of transplanting	: 19th May, 1983
Date of harvesting	: 10th September at Nipponbare and 5th Oct. at Giza-172

[Treatment]

(Kg per ha. by element)

Plot No.	N	P_2O_5	K_2O
T - 0	0	0	0
T - 1	34	0	0
T - 2	34	25	0
T - 3	34	25	13
T - 4	0	25	13
T - 5	0	0	13

Split-Application Method for applying Nitrogen:

(Kg per ha.)

Plot No.	Basal			1st TD	2nd TD
	N	P	K	(Nitrogen fertilizer only)	
T - 0	0	0	0	0	0
T - 1	17	0	0	8.5	8.5
T - 2	17	25	0	8.5	8.5
T - 3	17	25	13	8.5	8.5
T - 4	0	25	13	0	0

Note: Nitrogen used for basal with Ammonium Sulfate and Top Dressing by Urea; P_2O_5 used with Super Phosphate and K_2O with Potassium Sulfate.

1st Top-Dressing : 7 to 10 days after transplanting - for both varieties;

2nd Top-Dressing : 7 to 10 days before the Panicle Initiation Stage - for Nipponbare; and

7 to 10 days before Reduction Division Stage - for Giza-172.

According to the results obtained, the T-3 Plot, which was treated with a balanced fertilizer of ''N'', ''P'' and ''K'', produced maximum grain yields of 4.75 and 4.81 tons per ha. for Giza-172 and Nipponbare, respectively, as shown in Fig. 24 and Table 4.

Generally speaking, the phosphate application proved very essential for the production of nucleus acid, and cell multiplication, and in the production of tillers. When adequate phosphate applications were not administered or when there was a low availability, the leaves tended to become dark green and narrow. Also, tillering was appreciably reduced; the plant growth was arrested; and, the heading and ripening were delayed. It should be noted that it is also translocated from the plant to the grain in the formation of protein.

Hence it can be seen that it is essential for plants to be given a supply of phosphate initially by means of the basala dressing. The main advantage of phosphate is that it is not lost from the soil as is nitrogen, and, therefore, becomes available gradually to the plants as it is required.

On the other hand, potassium is required for the metabolism and for the activation of enzymes. It plays important roles in the cell division (i.e. in the growth and development) of the plant. When there is a deficiency of potassium, the root function is seriously affected and the plants become short in stature, weak, and lodge easily. The older leaves dry up quickly. A deficiency also indirectly increases the susceptibility to disease such as blast, leaf spot and leaf blight. In cases of acute shortage of potassium, the yield is reduced appreciably.

Signs of potassium deficiency are noticed in the leaves. They become dark green, narrow, and redish brown spots appears on the lamina. It is important to ensure the availability of potash during the active young panicle-formation stage. The balance between potassium and nitrogen should be brought about initially to ensure the optimum yield. As potassium is not lost in the soil like nitrogen, it is desirable to apply it as basal dressing.

Regarding the yield components, from the data obtained from Plot T-3, the number of panicles per M^2 clearly increased when the balanced fertilizer, rather than the other treatments, was applied. The other components, such as the ripening ratio and 1000 grain weight, also reflected increases when the balanced fertilizer was administered.

On the other hand, Fig. 23 shows the correlation between the number of spikelets and grain yield in this trial, and indicated a strong relation between them in both varieties of grain.

From the foregoing results, it can be concluded that a balanced fertilizer application is definitely required in this area.

2.1.1.(6) Rational Water Management

Water management is one of the very important techniques for encouraging the initial growth of rice plants. The important points of water management during the early growth period (which is from transplanting time to 45 days before the heading stage) can be pointed out as follows i.e. i) the reduction of pH and salinity injury, ii) the encouragement of rooting just after transplanting and iii) the avoidance of soil reduction during the tillering period.

(a) The reduction of high pH and salinity injury

A condition of high pH and high salinity prevents rooting and initial plant growth just after transplanting. To prevent this condition, the irrigation water should be drained out just after puddling. Putting flash water just before transplanting is very effective in encouraging rooting.

(b) Water Management during the rooting period

In general the duration from transplanting time to the maximum tillering period (the most active tillering period) is taken to be about 40 to 45 days and the duration of the effective tillering is around 30 to 35 days. It bears panicles, an effective tiller which are developed during this period. In the early stage after tillering, these developed tillers produce bigger panicles than those developed in the later tillering period. If the rooting period takes a longer time - caused by transplanting injury, high pH and salinity, shortage of water and very weak seedlings, the effective tiller period becomes shorter and the number of tillers which bear panicles will decrease as well as the number of spikelets per panicle will also decrease automatically.
It is not too much to say that the grain yield is swayed by 30 to 35 days of effective tillering period after transplanting in the Nile Delta region.

For the reason given above, a trial has been conducted on the effect of different irrigation management of tiller development and grain yield.

In this trial three different deviations of fields were set such as a normal field (± 0 cm), a 5 cm lower level field from the normal field surface (-5 cm) and a 5 cm higher level field from the normal (+5 cm) as shown in the figure below.

[Results]

The results of growth survey, grain yield and yield components are shown in Fig. 2, Fig. 3 and Table 1.

On the growth survey, -5 cm and +5 cm plots delayed the tiller development compared with the normal (± 0) plot which increased the number very smoothly.

On the normal elevation plot 17 panicles per hill were secured with very smooth rooting and outbreak of effective tillers taking place after the rooting stage under optimum irrigation water conditions.

Compared to the normal elevation plot, the -5 cm plot obtained only 13.3 panicles per hill, due to the obstruction of tiller development under deep irrigation water conditions.

And in the +5 cm plot the rooting period was far more extended than in the other two plots and tiller development was also obstructed under the surface drainage conditions after transplanting. And finally, the size of the panicles was also very small with only 48.5 spikelets per panicle because of late tillering development. The reason for the very long rooting period and lower number of tillers in the +5 cm plot can be given as follows: i) rise in the percentage of salinity under the surface drainage conditions after transplanting; ii) with surface drainage very young small seedlings dry up.

There was also a big difference in the final grain yield with 3.63 tons per ha. in the normal elevation plot (± 0) against 2.66 and 1.64 tons per ha. in the -5 cm. and +5cm plots respectively. And the yield components also come down in the +5 cm plot.

According to this trial, irrigation water management in the mechanized transplanting method will require that the irrigation water must be kept a little deep to help smooth rooting and then the smooth tiller development after transplanting.

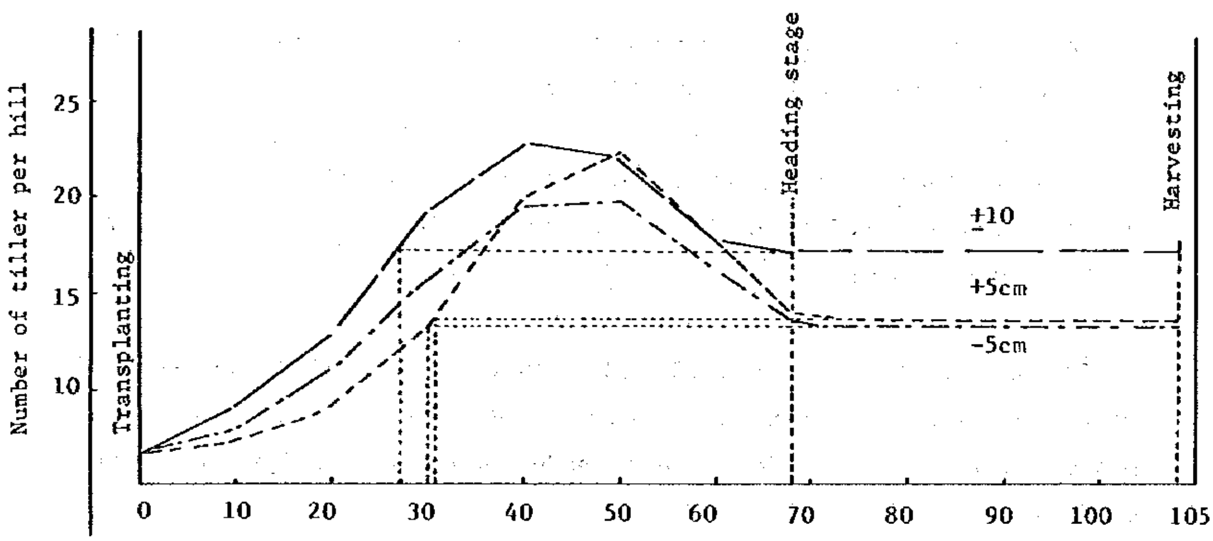


Fig. 25 Tiller increasing and decreasing curve in different elevated Plots

Fig. 25 Tiller increasing and decreasing curve in different elevated Plots

(c) Water management during tillering period after rooting

As mentioned above, soil reduction occurs under the high temperatures and after certain field conditions in Nile Delta soil. Especially, reduction of soil occurs very easily in very poor field drainage (percolation). It requires the intermittent irrigation method with shallow water after the rooting period is over as shown in the Figure. If the irrigation water is kept deep continuously, it not only causes reduction of soil but also delays tiller development.

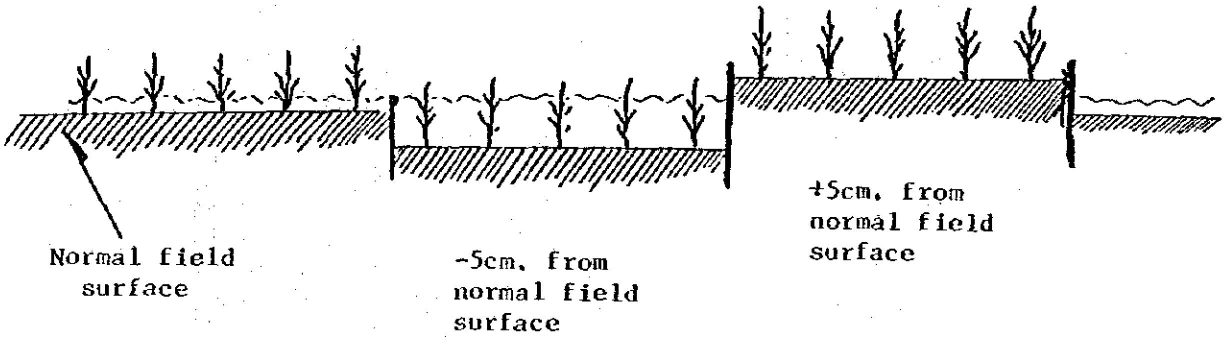


Fig. 26 Setting method for different field elevations

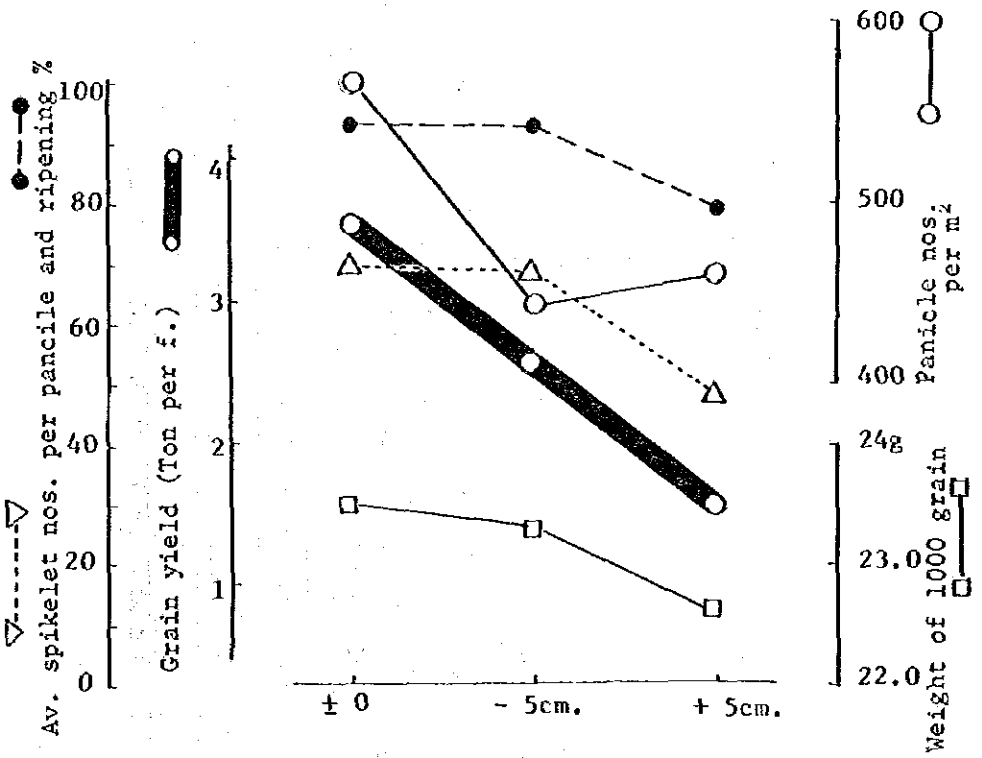


Fig. 27 Effects of Different Elevations on Yield and Yield Components

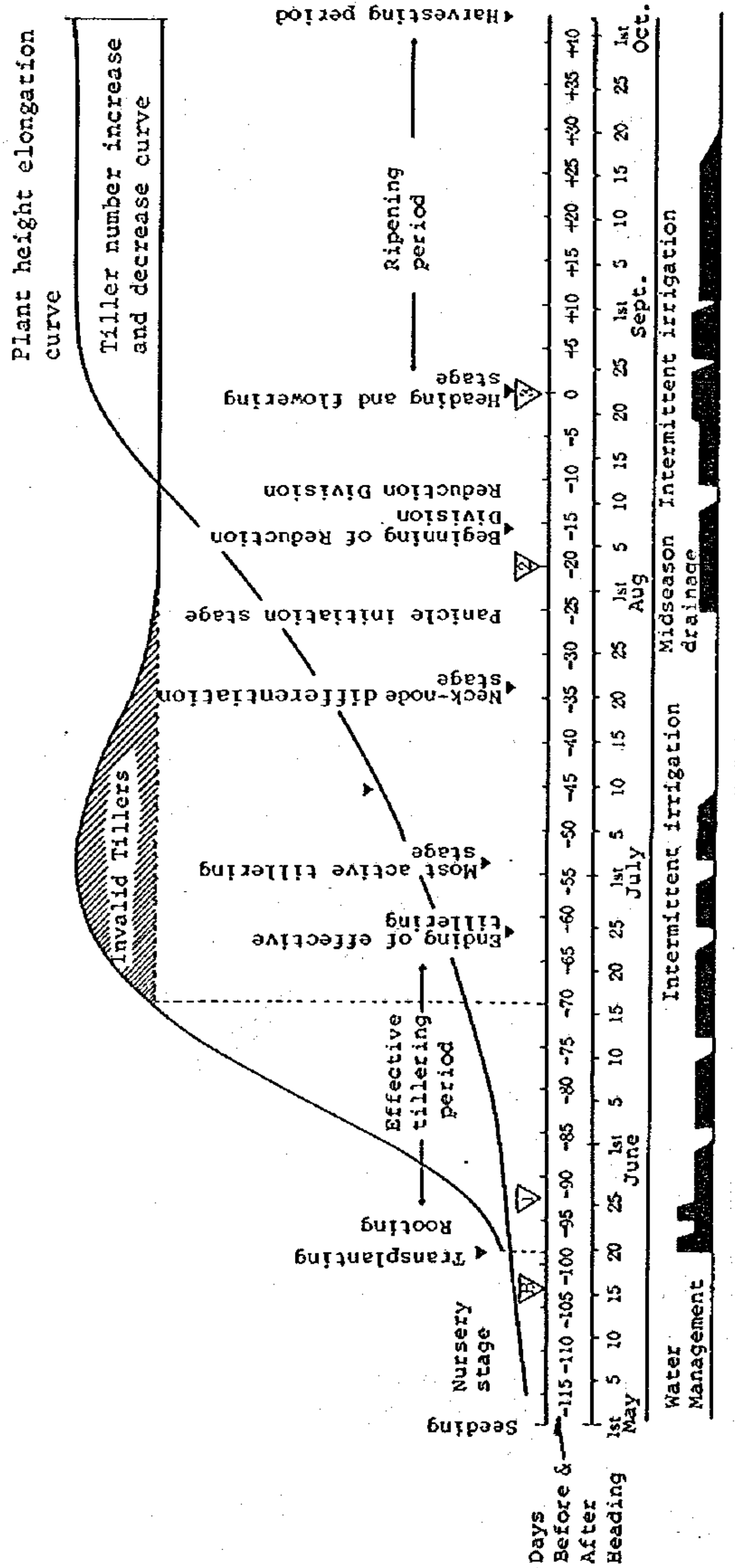


Fig. 28 Life History of Rice Plant and Water Management Method

To repeat what has been said about irrigation management in the initial stage, the irrigation water must be drained out after puddling and fresh water supplied just before transplanting to reduce the pH and salinity injury. Enough irrigation water must be kept after transplanting during the rooting stage and after the rooting stage intermittent irrigation is required to encourage the tiller development.

2.1.1.(7) Effective weed control technique

(a) Kinds of paddy field weeds

The weeds injurious to paddy plants are the following:

(1) Enchinochloa crus-galli*
(2) Enchinochloa colonum*
(3) Cyperus difformis**
(4) Eclipta alba
(5) Ammania spp
(6) Cyperus rotundus**
(7) Cynodon dactylon*
(8) Panicum repens*
(9) Paspalum paspaloides*
(10) Dinebra refroflexa*
(11) Scirpus praelongatus**

Note: *Gramineous weed **Cyperaceae

The weeds from (6) Cyperus rotundus to (10) Dinebra refroflexa are recognized to include up-land weeds but these weeds are observed as paddy field weeds in this region under the alternation of land usage between dry and flooded conditions. Among all these weeds Echinochloa crus-galli and Cyperus rotundus are recognized as the most dominant weeds and the most injurious to the paddy plant.

(b) The damage caused by strongly injurious weeds

In the mechanized rice transplanting areas being developed by Kafr El-Sheikh governorate, there were some cases which a high yield could not be expected due to the occurrence of a high density of Echinochloa crus-gali, Cyperus rotundus and Cyperaceae weeds such as Cyperus difformis and Scirpus praelongatus under the less irrigated water in the paddy fields and the very high amount of solar radiation in the Nile Delta. Therefore investigations were made regarding the damage by strongly injurious weeds to paddy plant growth, yield and the development of the numbers of Cyperacae weeds.

The damage to plant growth and yield were clearly recognized as being caused by injurious weeds. The vegetative period of the paddy plants and the numbers of tillers were severely decreased, influenced by both Echinochloa crus-gali and Cyperus rotundus from 30 days after transplanting. The damage caused by Echinochloa crus-gali especially indicated a rather high decreasing ratio in one treatment plot compared to the Cyperus rotundus plot. Echinochloa crus-gali and Cyperus rotundus were planted with paddy seedlings on the hills where they caused far more damage than when both weeds were planted between the rows. The damage caused by Cyperus rotundus tends to increase in ratio to the increasing numbers of Cyperus rotundus. As far as yield components are concerned their decrease was severely influenced by Echinochloa crus-gali whereas the numbers of panicles were decreased by Cyperus rotundus. It is obvious that the damage to paddy fields by both Echinochloa crus-gali and Cyperus rotundus of C^4 plants is very large under the high amount of solar radiation conditions in the Nile Delta. The damage to paddy rice caused by both varieties of weeds has a tendency to occur severely in fields where mechanized rice transplanting is employed due to the small young seedlings being in shallow irrigation water conditions. Therefore countermeasures should be taken by using herbicides just after the puddling period.

In lowland rice nurseries, weed control by herbicides should be done to prevent mixed transplanting with weeds. Echinochloa crus-gali developed in some places in the paddy fields even after the application of herbicides. This weed should be pulled out before the heading period of the paddy plants to prevent its seeds spreading as well as preventing its affect on the yield components.

(c) Field husbandrytic weed control for the most injurious weeds

The relationship between the depth of irrigation water in the paddy fields to the development of the numbers of Cyperaceae weeds and the height of its plants.

Studies were made on the effect of planting depth and water depth on the germination of Cyperus rotundus. A natural growth of Cyperus rotundus, (small seedlings under 2cm, large seedlings over 10cm, 10 seedlings of each), was transplanted in the 1/2000 a. Wagnel plot, with the planting depth and water depth as shown in Table 5, on August 5th. The numbers of its germination were investigated 15 days after transplanting.

No germination was observed for the small seedlings planted at depth of 5, 10cm. Only one germination was observed of the large seedlings. When planted on the ground most of them survived even under water depth conditions of 5, 10 cm.

As a result, it became clear that burying the tubers of the plants in soil is effective for controlling Cyperus rotundus.

Studies were made on the effect of the irrigation water depth in the paddy fields on the development of Cyperaceae weeds.
Actual puddling was done and the plots were divided into 6 as shown in Fig. 28. Investigation was done 20 days after puddling.

No development of Cyperaceae weeds (Cyperus difformis and Scirpus praelongatus) was noticed in irrigation water of 12 cm in depth in the paddy fields. From a depth of 7 cm, cases of Cyperaceae weeds developed and plant height was rapidly increased in accordance with the decrease in the depth of irrigation water in the paddy field. As a result of these trials it became clear that deep irrigation water, around 10 cm in the paddy fields, is effective for weed control such as cyperaceae, Cyperus difformis, and Scirpus praelongatus.

		Number of Germination	
Planting Depth	Water Depth	Small Seedling (below 2cm)	Large Seedling (above 10cm)
10 cm	5 cm	0	1
5 cm	5 cm	0	1
0 cm	5 cm	8	9
0 cm	10 cm	6	9
0 cm	0 cm	8	8

Table 5 Relation of Germination of Cyperus rotundus with Planting and Water Depths

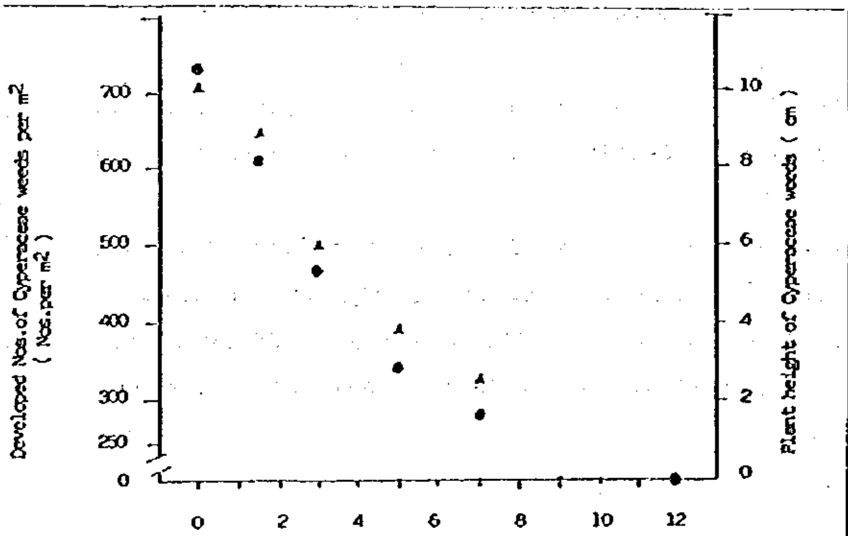


Fig. 29 Irrigation water depth in paddy field (cm)

Figure 29 shows the relationships between the depth of irrigation water in the paddy fields to the development of Cyperaceae weed numbers and plant height.

Note : Cyperaceae weeds = Cyperus difformis and Scirpus praelongatus.

= Nos. of developed Cyperaceae weeds per M^2,

$Y = - 59.24 x + 688.87$

$R = - 0.990^{**}$

= Plant height (cm) of Cyperaceae weeds,

$Y = - .873 x + 9.431$

$R = - 0.966^{**}$

(d) Experiments on weed control using herbicides.

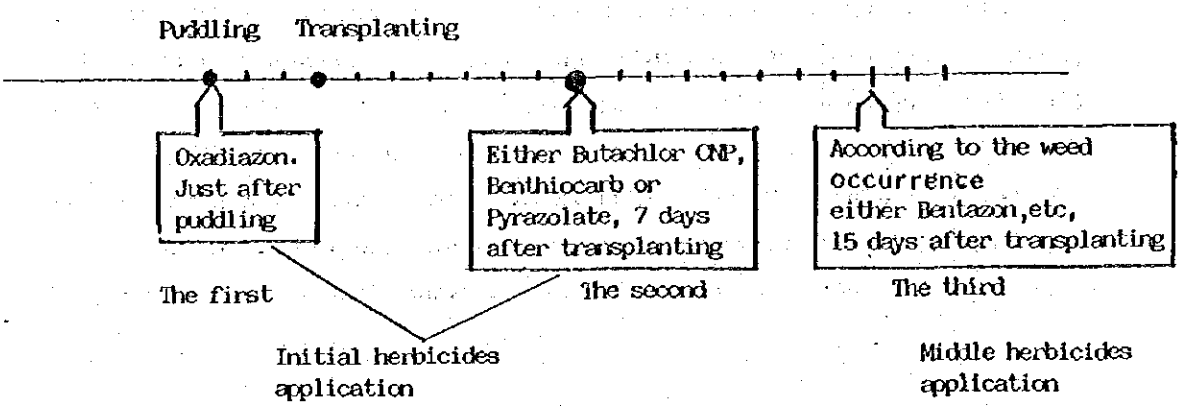
In the mechanized area being developed by Kafr El-Sheikh governorate, there were some cases where high yield could not be expected due to the obstruction of the occurrence of high density weeds. Therefore investigations were made regarding weed control using herbicides in order to determine a system for weed control.

The weeding effect by herbicides are shown in Figs. 30.31 and 32. The remarkable weeding effect of initial herbicide application on paddy plant growth and yield was clearly recognized and the character of each herbicide was also established. Pyrazolate, Butachlor, Benthiocarb and Oxadiazon were extremely effective against Echinochloa crus-gali, Ammonia sp and Cyperus difformis at 0 to 7 days after the duration of transplanting. And propanil was especially effective against Echinochloa crus-gali. In the cases of Cyperus difformis and Ammania sp, however, Propanil had a less effective weeding effect compared to the other remaining herbicides. Bentazon also demonstrated on excellent weeding effect, especially against Cyperus difformis, which is recognized as the most highly developed and the most strongly injurious weed in this region. But it was for less effective against Echinochloa crus-gali.

The application time of middle and late herbicides containing Simetryne also demonstrated remarkable weeding qualities at 15 days after transplanting without injuring the paddy plants. The development of weeds in the paddy fields has shown many differences depending on the soil and the regional groups in the Nile Delta. Generally it can stated that the development of Cyperus difformis, Echinochloa crus-gali. Ammania SP and the other Cyperaceae weeds has been accelerated after irrigation. The growth of Cyperus difformis especially will be accelerated in shallow irrigation depths with strong solar radiation on the paddy field levels.

Larger numbers of Cyperus difformis tend to occur in mechanized transplanting fields, due to the ideal conditions for the development of this weed, than in the traditional paddy fields.

The number of tillers of the paddy plants were clearly reduced by the presence of weeds from 30 days after transplanting. In other words, weed damage will have taken place before the 30 days. The damage caused by weeds was in direct ratio to the rapidity of their growth. Application of herbicides in the initial stage therefore, is most important in order to obtain high yields. Judging from the above, herbicide application in the initial stage affects not only Echinochloa crus-gali but also Cyperus difformis. The first consideration is that herbicides which have a wide weed control spectrum are suitable for initial applications in this region, namely. Pyrazolate, Butachlor CNP, Oxadiazon and Benthiocarb. The control system of weeds by herbicides can be taken as follows :



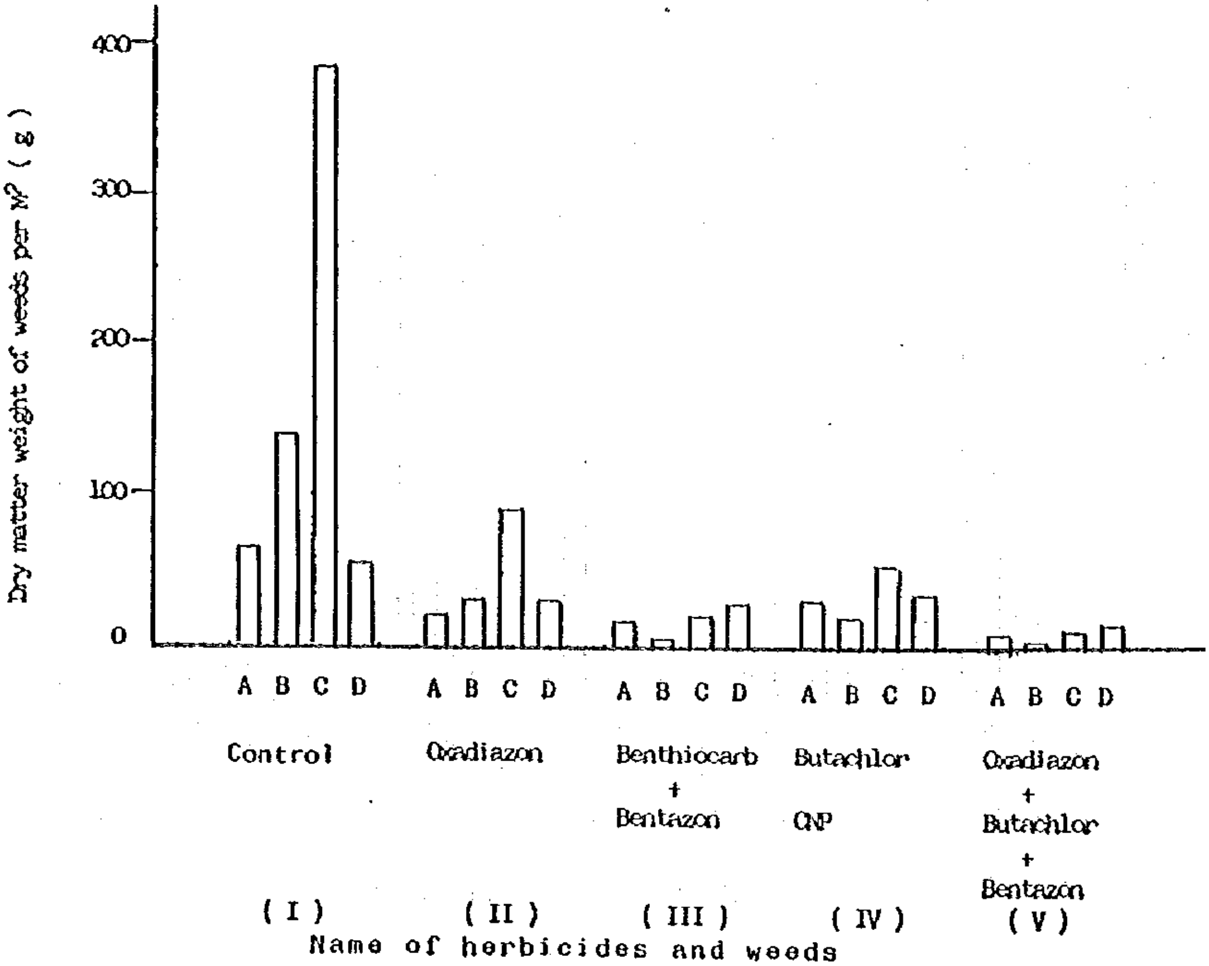


Fig. 30 The effect of Herbicides on different kinds of Weeds
(90 days after transplanting, dry matter weight (g) per M^2)

Note ; Effective ratio of herbicides, (Weed weight of each treatment / weeed weight of control)

	A	%	B	%	C	%	D	%
Control	66.7	100	142.3	100	386.8	100	57.6	100
Oxadiazon	19.0	28	29.5	21	91.8	24	29.9	52
Benthiocarb + Bentazon	17.6	26	6.1	4	21.6	6	28.7	50
Butachlor + CNP	31.2	47	19.3	14	53.4	14	35.4	61
Oxadiazon + Butachlor + Bentazon	8.6	13	3.0	2	11.0	3	25.4	44

A.B.C.D. = Dry matter weight of weeds per M^2 (g)

Names of Weeds

A = Echinochloa spp

B = Amania sp & Echlipta sp (Broad leaves weeds)

C = Cyperus difformis and Scilpus sp

D = Cynodon dactylon, Panicum Repers and Cyperus rotundus

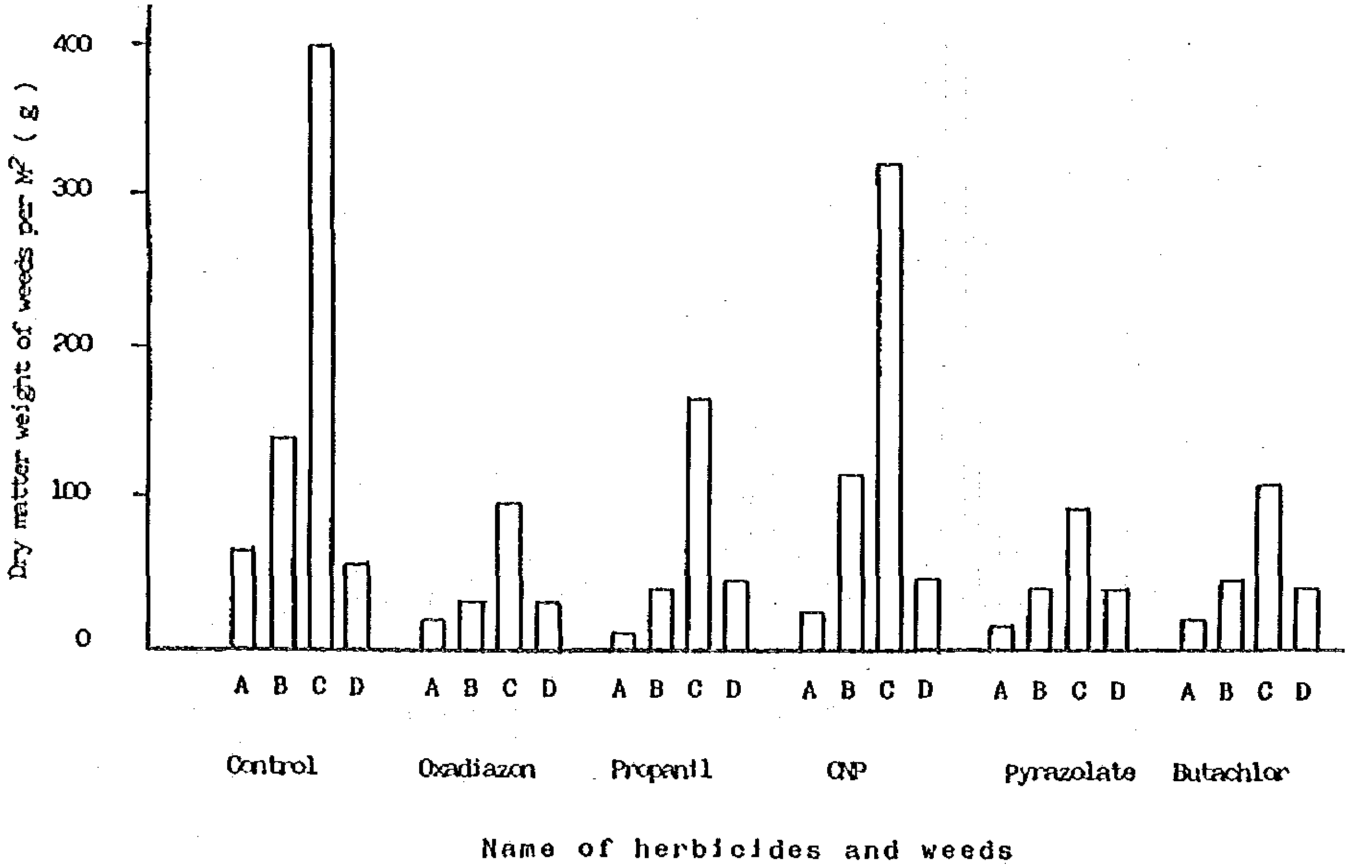


Fig. 31 The Effect of Herbicides on Different Kinds of Weeds
(90 days after transplanting, dry matter weight (g) per M^2)

Note: Effective ratio of herbicides
(Weed weight of each treatment / weed weight of control)

	A	%	B	%	C	%	D	%
Control	65.0	100	141.7	100	389.9	100	56.6	100
Oxadiazon	20.3	31	33.2	23	98.3	25	33.3	59
Propanil	11.03	17	38.4	27	166.8	43	45.0	80
CNP	24.97	38	111.6	79	320.0	82	47.9	85
Pyrazolate	15.1	23	41.7	29	93.6	24	39.9	70
Butachlor	19.1	29	46.7	33	108.5	28	40.0	71

A.B.C.D. = Dry matter weight of weeds per M^2

Names of Weeds

A = Echinochloa spp

B = Amania sp & Echlipta sp (Broad leaves weeds)

C = Cyperus difformis and Scilpus sp

D = Cynodon dactylon, Panicum Repers and Cyperus rotundus

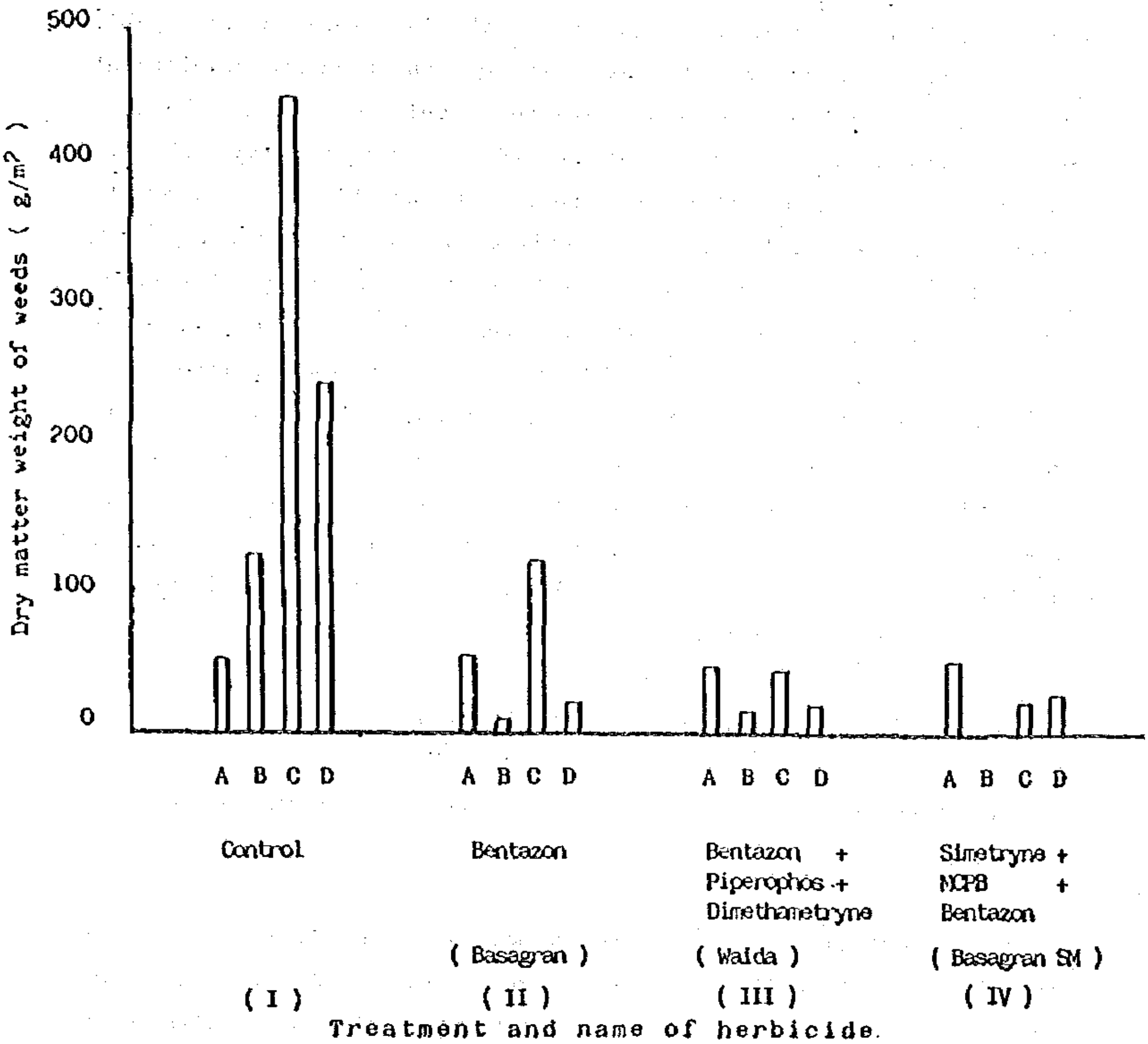


Fig. 32 The effect of Herbicides on Dry Matter Weight of Weeds (90 days after transplanting, dry weight matter (g) per M^2)

Note: Effective ratio of Herbicides (Weed Weight of each Treatment/Weed Weight of Control)

	A	%	B	%	C	%	D	%
I	51.9	100	125.0	100	450.0	100	24.6	100
II	55.0	106	10.0	8	120.1	27	20.0	81
III	44.9	87	14.8	12	40.0	9	21.6	88
IV	52.3	101	0	0	23.1	5	26.6	108

A = Echinochloa sp
B = Amania baccifera
C = Cyperus difformis; Cyperus rotundus
D = Cynodon dactylon; Panicum repers

Variety: Giza-172
Transplanting date : 17 June 1985
Application date : 3 July (16 days after transplanting)

Actually, a one time application of a herbicide seems to be capable of controlling weeds but, in cases of continuous heavy development of weeds, a second and third application should be given; The type of herbicide will be selected in accordance with the type of weed present. Two applications of Bentiocarb should be avoided to prevent dmarfing which has been confirmed by studies in Japan. To obtain the maximum efficiency of the herbicides, correct water depth and good field levels should be controlled. When spreading herbicides, certain factors should be taken into consideration such as studies of its toxic nature to men, fish, animals and up-land crops, such as cotton, vegetables, etc.. These should be considered to avoid pollution and other problems arising from their use. In order to develop these studies, the prior settlement of problems peculiar to Egypt is essential and mixed herbicides which have a wider spectrum are required.

2.1.1.(8) Trace Element Fertilizer Application Technique.

(a) The effect of Zinc application on seedling growth and initial stage growth.

It was confirmed that Nile Delta Soil contains lower amounts of Zinc, high alkali soil and minor elements such as Zn, Mg, Cu, etc. are also generally changed to non-available elements under high alkali soil conditions. These micro-elements are used as a nucleus in the formation of chlorophyu. A deficiency of these micro-elements can after be detected by etiolation and poor plant growth. In view of these circumstances, trials for the effect of Zinc application on seedling growth and initial stage growth were conducted.

The remarkable effect recognized in Zinc treatment compared with non-treatment is clearly shown in Fig.32. Namely, as against the checked items of non-treatment, plant height 1.28 times; leaf age 1.24 times; chlorophyll index 1.41 times; were each increased by Zinc treatment.

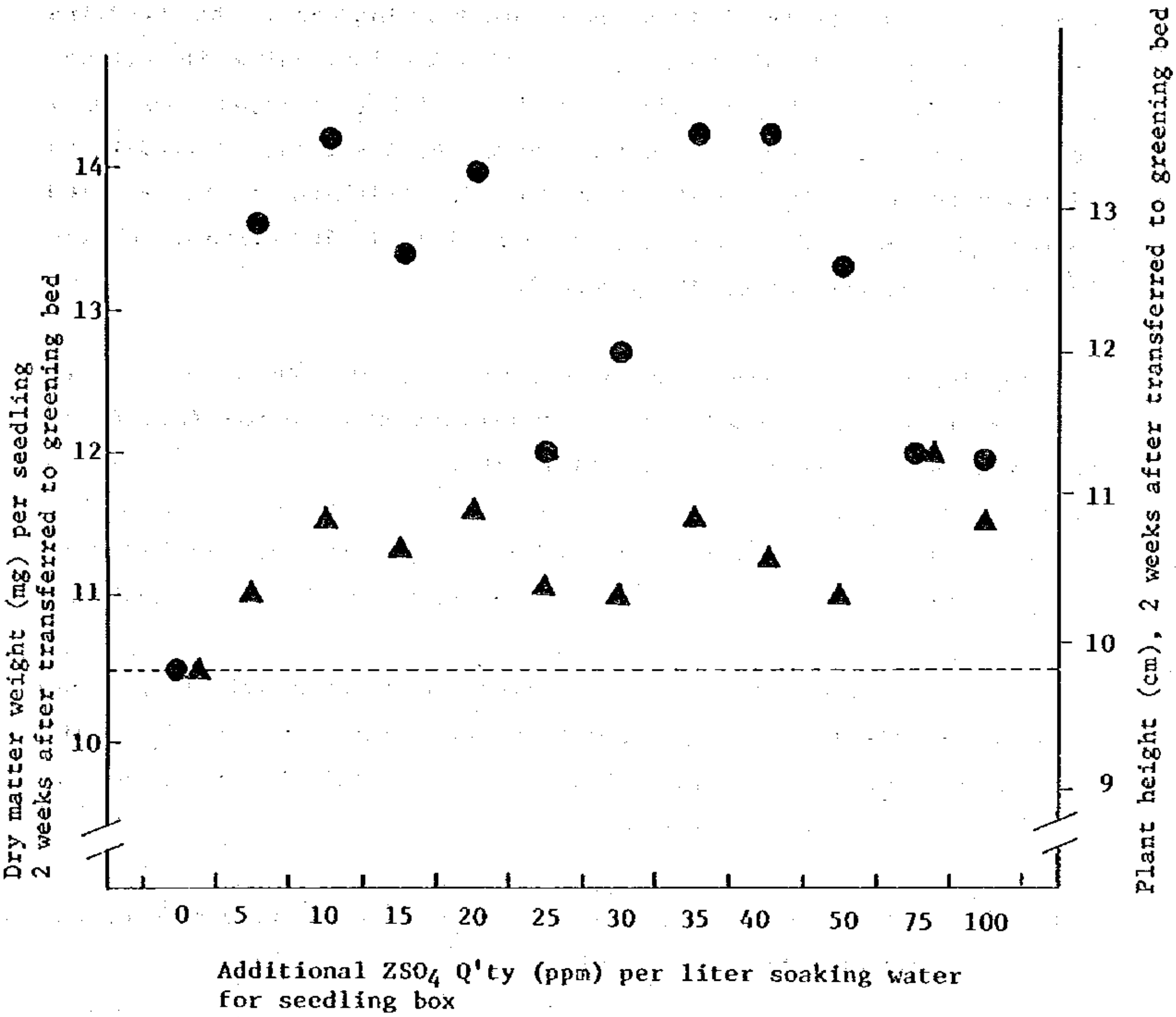


Fig. 33 The effect of ZSO_4 for the plant height and dry matter weight of seedling (2 weeks after transferred to greening bed)

Note: ● Plant Height
▲ Dry matter weight per seedling

The leaf colour after Zinc treatment was much darker compared to non-Zinc treatment and the chlorophyll index also indicated this clearly. The application of Zinc greatly increased the seedling character and initial stage growth thereby increasing the yield. Soluble Zinc such as Zinc Sulphate (ZSO_4) adapts to easy application with remarkable effect under the dry soil bed conditions in this region. The results show that Zinc Sulphate can be applied around 10 ppm (19. Zinc Sulphate mixed with 100 liters of the soaking water for the seedling boxes).

Applications of Zinc and adjustments to the PH value can be characterized as adequate steps to prevent obstruction factors in the raising of seedlings in the Nile Delta.

Other trials were also conducted on the effect of Zinc Sulphate on initial growth and grain yield as mentioned in chapter 2.1.1.(2).

According to the results, an application of Zinc Sulphate, about 5g. per seedling box 7 days before transplanting, shows good results in the encouragement of initial growth and especially in increasing tiller numbers and grain yield.

(b) Effects of Zinc Sulphate Application to seedling tray on growth after transplanting and yield.

The soil of the Nile Delta is very low in sometimes hampered after transplanting.

To counteract this problem a Zinc application trial was conducted to the seedling trays during the nursing period.

The method of treatment was as follows. 2.5g., 5g. and a control plot was set per tray with Zinc Sulphate applied to the seedling trays 5 days before transplanting. The Giza-173 variety was used for this trial and fertilization of the main field of 42 kg. P_2O_5, of 25 kg of K_2O and 12 kg were applied.

According to the results, the maximum yield was obtained with 5g. Zinc Sulphate applied for 2.43 ton per feddan, and 2.5g. Zinc plot followed with 2.25 ton. per feddan. In the yield components the effect of the Zinc application appeared on the number of panicles per per square meter and this number increased even more by increasing the quantity of Zinc Sulphate these results show that increase in yield can clearly be observed by applying Zinc Sulphate to the seedling trays. Another very important point to observe is that application to the seedling trays calls for less manpower than application to an entire main field.

In the Nile Delta, Zinc absorption by the rice plants is checked owing to the soil conditional of high PH and the initial growth is also checked for the same reason. To meet this problem the Zinc is applied to the seedling trays before transplanting which encourages their growth after the transplanting and clearly increases the grain yield.

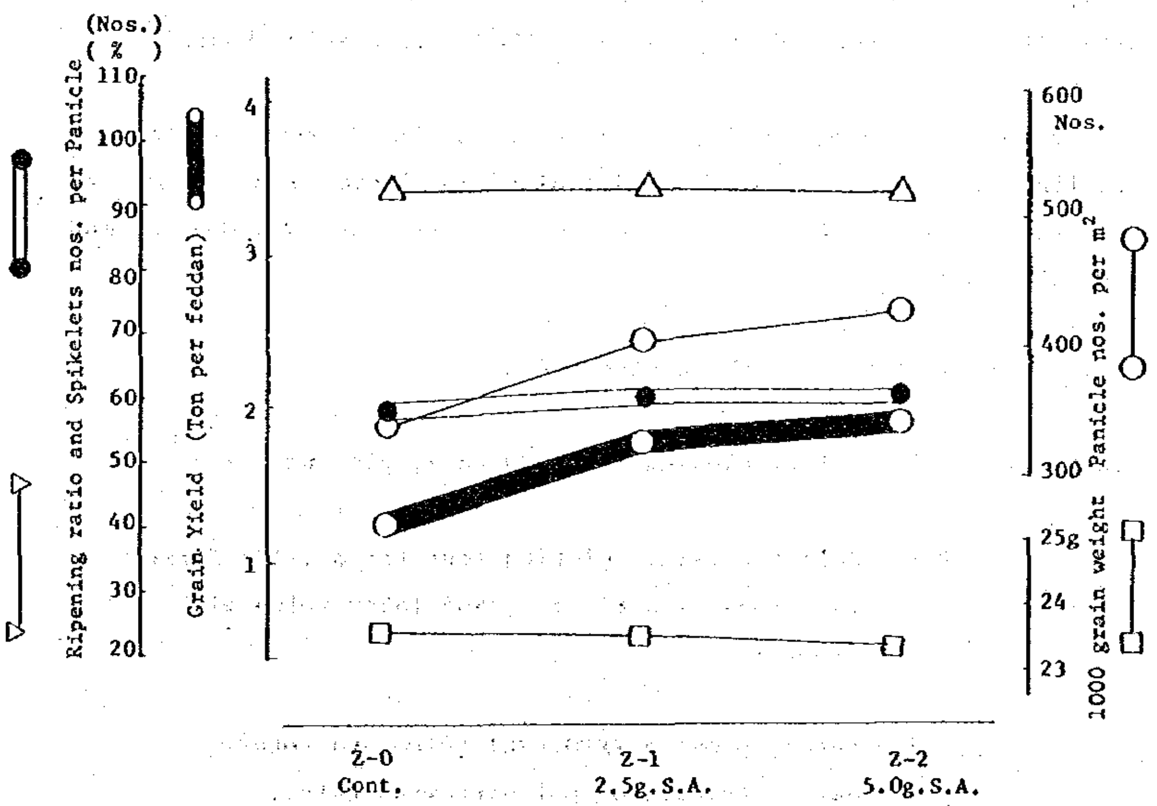


Fig. 34 Effect of Zinc Application to Seedling Tray (Variety : Giz-173)

2.1.1.(9) Possibility of Mechanized Direct Seeding Cultivation.

Rice cultivation techniques in the Nile Delta have changed from the commonly used transitional direct seeding method to the transplanting method which has recently become popular.

Land utilization in this area is according to a specific plan of rotation system and is composed of regional complexes of 50 to 100 feedans.

Therefore small farmers are used to the rental system of farm machines through the Agricultural Cooperative Association which implements cooperative work with each farmer.

Under these circumstances of big scale farming, direct seeding will be considered a necessity in the future.

The possibility of mechanized direct seeding on dry and flooded paddy fields was therefore studied. The establishment of seedlings with different main land preparation methods was mainly studied.

For this purpose, studies were made on the method to improve seedling establishment in the cultivation of direct seeding in dry conditions to reduce the expense of raising seedlings and transplanting them.

The following trial methods were taken:

Treatment : T-1 = Rotary plowing (PTO:620 rpm), plowing twice.

T-2 = Rotary plowing, plowing four times (PTO: first two times with 620 rpm, and later twice with 810 rpm).

T-3 = Rotary plowing (PTO:620) twice and rotary harrow (PTO:1400 rpm) harrowing twice.

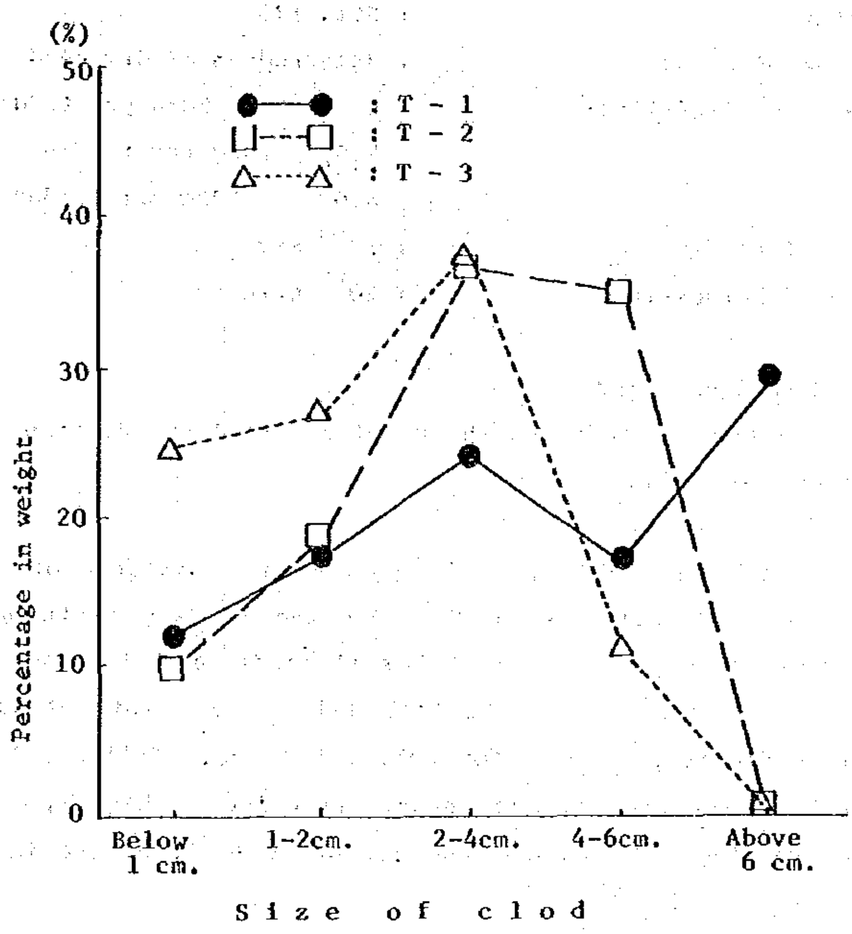


Fig. 35 Distribution of different size of clod under different plowing conditions

Variety	: Giza-173
Amount of seeds	: 34kg/feddan of dry seeds
Amount of fertilizer	: N 50kg per feddan
	P_2O_5 25kg per feddan
	K_2O 13kg per feddan
Date of seeding	: 19th May
Date of harvesting	: 20th October

(a) Plowing Method and clod

Table 6 and Fig. 35 indicate the plowing method and distribution of clod respectively.

According to these tables, soil clods with a diameter of more than 6cm account for 30% in T-1 and the seeding depth by a seeder would be very deep. In T-2 soil clods of 2-4 cm and 4-6 cm account for over 70% . In both T-1 and T-2 soil clods of under 1 cm diameter account for only 10% or so. Unlike T-1 and T-2, both rotary plowing and rotary harrowing at high rpm were used in treating T-3 so more than 80% of soil clods were in the range of 2-4 cm diameter.

(b) The establishment of seedling under different soil clods and plowing conditions using a direct seeder.

Table 7(1) shows the number of seedlings established by plowing treatment.

According to this table T-1 is 22.6% and T-2 is 23.9% showing little difference. But in T-3 the establishment ratio is 29.9% thereby showing a little improvement. Though there was a considerable difference in the size of the clods between treatments, the difference in seedling establishment was small. This indicates that Nile Delta soil collapses in a short time by containing water regardless of the size of the clod. Table 7(2) shows the results of the investigation into the depth of established seedling in each division. According to this table, T-1 has an average depth of 3.05 cm and T-3, 2.4 cm, the latter being a little less deep.

(Agronomy Division, RMP, 1984)

Size of soil clod (in diameter)		T - 1			T - 2			T - 3		
Treatment		Number of clod	Weight of clod	Ratio in weight	Number of clod	Weight of clod	Ratio in weight	Number of clod	Weight of clod	Ratio in weight
		Nos.	gr.	%	Nos.	gr.	%	Nos.	gr.	%
Below 1cm.	1	-	0.300	9.74	-	0.190	6.05	-	0.610	25.50
	2	-	0.410	14.34	-	0.340	16.59	-	0.590	27.76
	3	-	0.535	14.72	-	0.195	7.93	-	0.630	24.66
	4	-	0.330	8.96	-	0.235	8.12	-	0.815	21.50
	Av.	-	-	11.94	-	-	9.67	-	-	24.61
1cm.--2cm.	1	156	0.460	14.94	114	0.450	14.33	224	0.715	28.71
	2	255	0.820	28.67	163	0.560	27.32	213	0.665	31.29
	3	177	0.515	14.17	127	0.430	17.48	156	0.560	21.92
	4	144	0.425	11.53	126	0.450	15.54	280	1.025	27.04
	Av.	-	-	17.33	-	-	18.67	-	-	27.24
2cm.--4cm.	1	39	0.780	25.32	48	1.060	33.76	47	0.940	37.75
	2	50	1.030	36.01	49	0.920	44.88	44	0.770	36.24
	3	24	0.465	12.79	33	0.625	25.41	48	1.000	39.14
	4	33	0.825	22.39	61	1.230	42.49	58	1.350	35.62
	Av.	-	-	24.13	-	-	36.64	-	-	37.19
4cm.--6cm.	1	6	0.430	13.96	16	1.440	45.86	3	0.225	9.04
	2	4	0.335	11.71	3	0.230	11.21	2	0.100	4.71
	3	10	0.955	26.27	3	1.210	49.10	4	0.365	14.28
	4	5	0.615	16.69	8	0.980	33.85	5	0.600	15.84
	Av.	-	-	17.16	-	-	35.03	-	-	10.97
Above 6cm.	1	6	1.110	36.04	-	-	0	-	-	0
	2	1	0.265	9.27	-	-	0	-	-	0
	3	3	1.165	32.05	-	-	0	-	-	0
	4	5	1.490	40.43	-	-	0	-	-	0
	Av.	-	-	29.45	-	-	0	-	-	0

Fig Table 6 Size of Soil Clod under Different Plowing Conditions

Note: T-1 - (Two times plowing by rotary plow with 620 RPM of PTO)
T-2 - (Four times plowing by rotary plow, and two times 620 RPM and two times 810 RPM of PTO)
T-3 - (Two times by rotary plow with 620 RPM of PTO and two times by harrow with 1400 RPM of PTO)

TABLE 7

(1) ESTABLISHMENT OF SEEDLINGS UNDER DIFFERENT PLOWING CONDITIONS

Variety: Giza-173

Treatment	Number of established seedlings					Percentage of establishment
	1	2	3	4	Av.	
	nos.	nos.	nos.	nos.	nos.	%
T - 1	27	26	38	29	30.00	22.6
T - 2	29	23	34	41	31.75	23.9
T - 3	37	34	39	49	39.75	29.9

Note: Seeding Quantity = 133 seeds per meter

(2) THE ESTABLISHED SEEDLING DEPTH FOR DIFFERENT METHODS

Treatment	Depth of established seedlings				Average
	1	2	3	4	
T - 1	3.5 cm.	2.7 cm.	2.9 cm.	3.1 cm.	3.05 cm.
T - 2	3.6	3.1	2.9	2.6	3.05
T - 3	2.4	2.3	2.1	2.8	2.40

(3) DISTRIBUTION OF THE ESTABLISHED SEEDLING DEPTH UNDER THE PLOWING METHOD

Treatment	Depth (cm.)					
	Below 1cm.	1cm.-2cm.	2cm.-3cm.	3cm.-4cm.	4cm.-5cm.	5cm.-6cm.
	%	%	%	%	%	%
T - 1	0	19.44	29.16	25.00	15.28	11.11
T - 2	0	17.65	23.53	35.29	20.59	2.94
T - 3	1.64	34.43	49.18	13.11	1.64	0

(4) IRRIGATION METHOD FOR DIRECT SEEDING FIELD AND ITS ESTABLISHMENT OF SEEDLING

Treatment	Number of established seedlings					Percentage of establishment
	1	2	3	4	Av.	
	nos./m	nos./m	nos./m	nos./m	nos./m	%
Flooding method	11	21	18	28	19.50	14.66
Absorption method	74	69	71	69	70.75	53.20

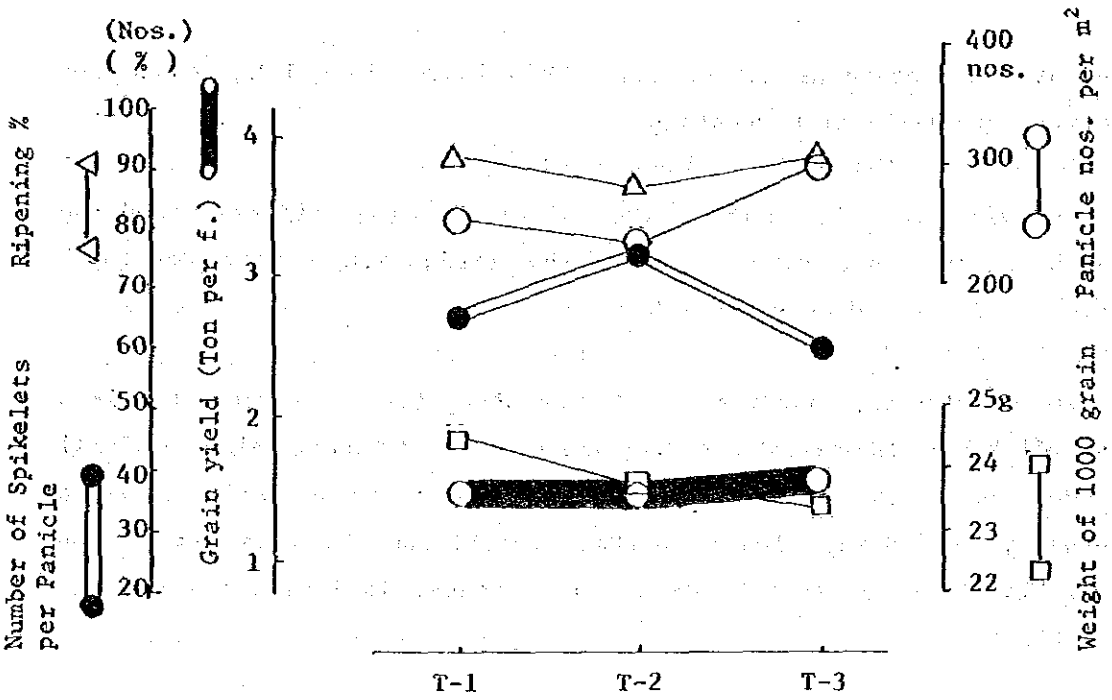


Fig. 36 Direct seeding trial with dry conditions
(Variety : Giza-173)

Distribution of established seedlings'depth is indicated in Table 7(2) and 7(3). In T-1, more than 50% of seedlings are distributed in the depth of 2-4 cm, but in T-3, most of them are distributed in the depth of 1-3 cm due to the smaller clods, reflecting the size of clods. In T-1, 11% of seedlings are distributed in the depth of 5-6 cm, but no such distribution is noticed in T-3.

c) Irrigation method after direct seeding on dry field and establishment of seedling

Table 7(4) shows the irrigation method after seeding and seedling establishment ratio.

According to the table, seedling establishment by the flooding method was 14.66%, but in the case of digging small irrigation channels with a ditching machine in the field so that water gradually permeates into the soil, seedling establishment rose to 53.2%. In the case of the flooding method, breaking of soil rapidly develops simultaneously with water filling and seeds are put in a non oxygen condition. The absorption method delays soil collapse and avoids a state of non oxygen. This is considered the cause for better establishment percentage.

In view of the above, the size of clod affects seedling establishment more or less, but the irrigation method exerts a stronger influence on establishment.

In conclusion, studies on the method for improving seedling establishment in direct seeding in dry conditions using a drill seeder have made it clear that the higher crush ratio shows a tendency to bring about better establishment, and that the irrigation method after seeding has a greater influence on seedling establishment.

Namely, flooding just after seeding remarkably lowered, the seedling establishment percentage, but the highest percentage was obtained through gradual permeation of water in the soil, making irrigation channels in the field.

2.1.2. Establishment of a technique for controlling plant growth in the Middle Growth period (43 to 20 days before heading).

Traditional rice cultivation in the Nile Delta shows a remarkable over growth of inter-node and leaf blade in the middle growth period of rice plants. Furthermore the crude and rough techniques of the method of applying fertilizers and water management cause the lodging, promotion and deterioration in light receiving efficiency. Moreover the traditional fertilization system is liable to bring about the occurrence of blast disease because dense fogs frequently occur at this period in the early morning which enhance the high humidity.

Therefore the following three points are the targets in the middle growth period with the restriction of nitrogen : i) improvement of light receiving efficiency, ii) lodging prevention and iii) improvement of physical condition to prevent blast disease.

(1) Nitrogen absorption restriction method

Rice cultivation has been done in accordance with the preceeding clause of (2) to (8) for promoting techniques in the early growth period. It has clearly shown that by decreasing the nitrogen concentration in the body of the rice plant, which absorbs the nitrogen in the early growth period, the targets can be attained resulting in whole, healthy plants, shortening inter-node and leaf blade and preventing leaf colour fade.

Accordingly, it is necessary to consider preventing (making) leaf colour fade in the middle growth period without applying a nitrogen top-dressing except where there is an extreme nitrogen deficiency.

(2) Mid-Summer Drainage Technique

The traditional rice cultivation practised by ordinary farmers uses successive irrigation from after transplanting to 20 days before harvesting. This is a cause of promoting lodging as well as the frequent occurrence of damage through root rot under high temperature conditions in the middle growth period.

Giza-172 variety is a long culm panicle weight type which is cultivated in most of the Nile Delta Area. In 1982 Giza-173 (Reiho) was introduced by the MOA as a new variety for mechanized rice cultivation. Unfortunately this variety was affected by blast disease in 1984's cultivation in the KFS area and was therefore prohibited for cultivation in that area.

For this reason, only Giza-172 is cultivated in the KFS area, even for mechanized cultivation. The Giza-172 has very low lodging resistance in the case of long culm panicle weight type and the harvesting by self threshing type combines is extremely difficult. Moreover harvesting losses are very high under the lodging conditions.

It is therefore very important to control the plant height with mid-summer drainage during the middle growth stage of rice plants in mechanized rice cultivation.

The methods used in the trial of mid-summer drainage were as follows:

	With top-dressing*				Without top-dressing*			
Plot No.	I-1	I-2	I-3	I-4	I-1	I-2	I-3	I-4
Mid-summer drainage (Days centering Neck-Node Differentiation Stage)	Cont**	10 days	14 days	20 days	Cont**	10 days	14 days	20 days

Note: * = With top-dressing: 2nd top-dressing applied at Panicle Initiation Stage
Without top-dressing: 2nd top-dressing NOT applied
** = No mid-summer drainage

Total fertilizer doses: With top-dressing N = 42kg per feddan
P = 25kg per feddan
K = 13kg per feddan
Without top-dressing
N = 32kg per feddan
P = 25kg per feddan
K = 13 kg per feddan

Split application method:

(kg per feddan)

	Basal doses			1st TD*	2nd TD**
	N	P	K	N	N
With top-dressing	21	25	13	11	10
Without top dressing	21	25	13	11	0

Note : * 1st top-dressing = at 7 days after transplanting
** 2nd top-dressing = at around Panicle Initiation Stage.

(a) Inter-node elongation.

The results in Fig. 37 show that in the group of no top-dressing, the plants in control plot (I-1) reached a height of 111.5 cm up to the neck-node compared to 102.2 cm in I-2, 98.8 cm in I-3 and 84.9 cm in I-4. From the neck-node to the 1st node is the 1st inter-node, from the 1st node to the 2nd node is the 2nd inter-node, etc. Mid-summer drainage exposed the 4th and 5th inter-nodes considerably in the no top-dressing group.

In the group of top-dressing applied plots, the plants in control plot I-1 reached a height of 110.6 cm up to the neck-node as against 105.1 cm in I-2, 102.6 cm in I-3 and 91.9 cm in I-4. The 4th and 5th inter-nodes were less elongated than those in the no-top-dressing group.

Generally speaking lodging is very strongly effected by the length of the 4th and 5th inter-nodes. When comparing the 4th and 5th inter-node lengths in I-1 and I-4 of the no top-dressing plots, the 4th in I-1 were shorter by 47.7% and the 5th was 61.2% against the control plot. On the other hand the 4th and 5th inter-nodes in the top-dressing applied plot were shorter by 32.8% in the 4th and by 28.7% in the 5th inter-nodes respectively. The suitable height for the rice plant when using a self threshing type combine is 95 cm.

So I-4 in the top-dressing applied plot satisfies this requirement. In addition, lodging was not observed in either I-3 or I-4 plots where top-dressing was applied and not applied.

(b) Paddy yield.

The paddy yield of the top-dressing applied was 4.0 ton per feddan against 3.6 ton per feddan in the no top-dressing plots with a difference of 0.4 ton per feddan and a 9.3% yield decrease.

Yield differences were bigger in the top dressing group. In I-4 and I-1 in the top-dressing applied plots the yield. Difference was 0.39 ton per feddan and in the no top-dressing plot it was 0.19 ton per feddan.

The mechanized division reported, however, that harvesting lost due to the lodged condition reached more than ten percent.

Efforts should be made to reduce the percentage of loss caused by lodging in order to attain an increase in the working efficiency of the combine.

From the above results, the following conclusions can be drawn:

(i) The paddy yield decrease by mid-summer drainage was minor and negligible;

(ii) Although inter-node elongation was observed by the application of top-dressing, it was very small; and

(iii) It can be recommended that mid-summer drainage is very effective in the prevention of lodging, centering on the 14 to 20-day period during the panicle initiation stage.

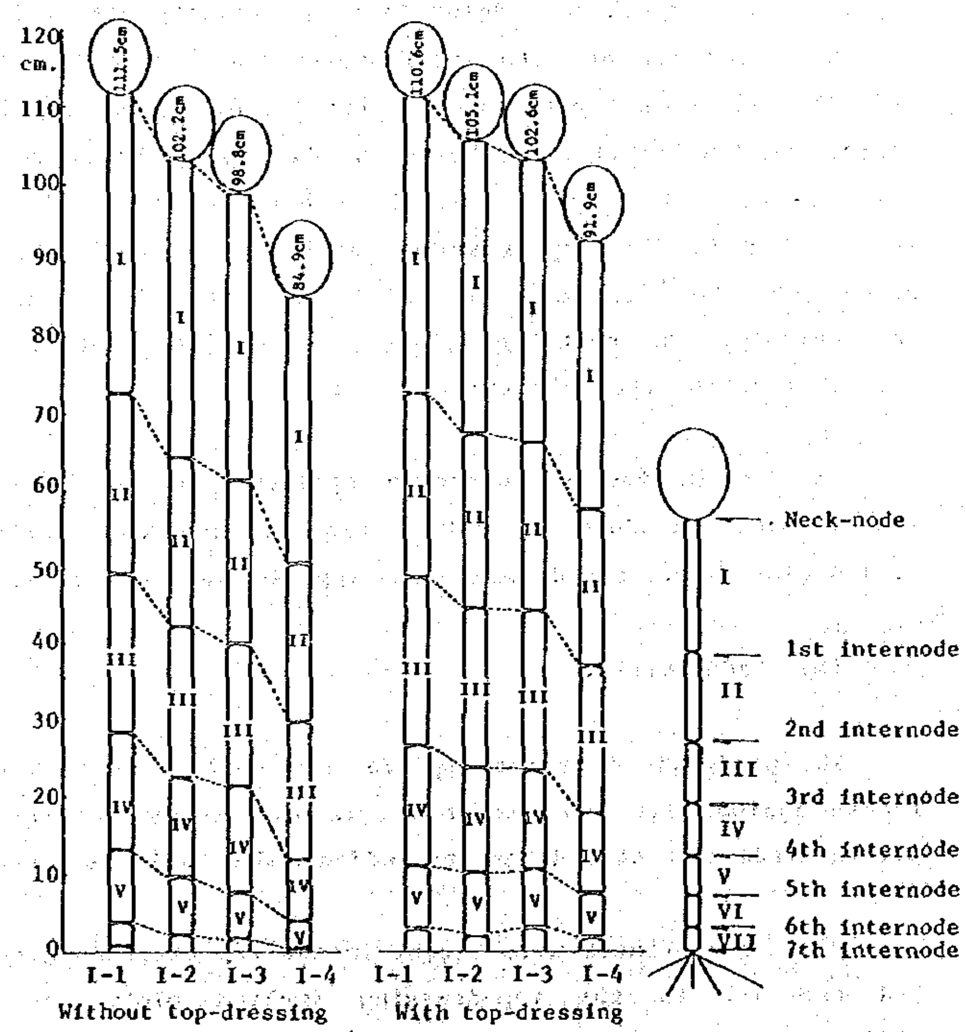


Fig. 37 Inter-node Elongation with Different Irrigation Conditions and Top-Dressing

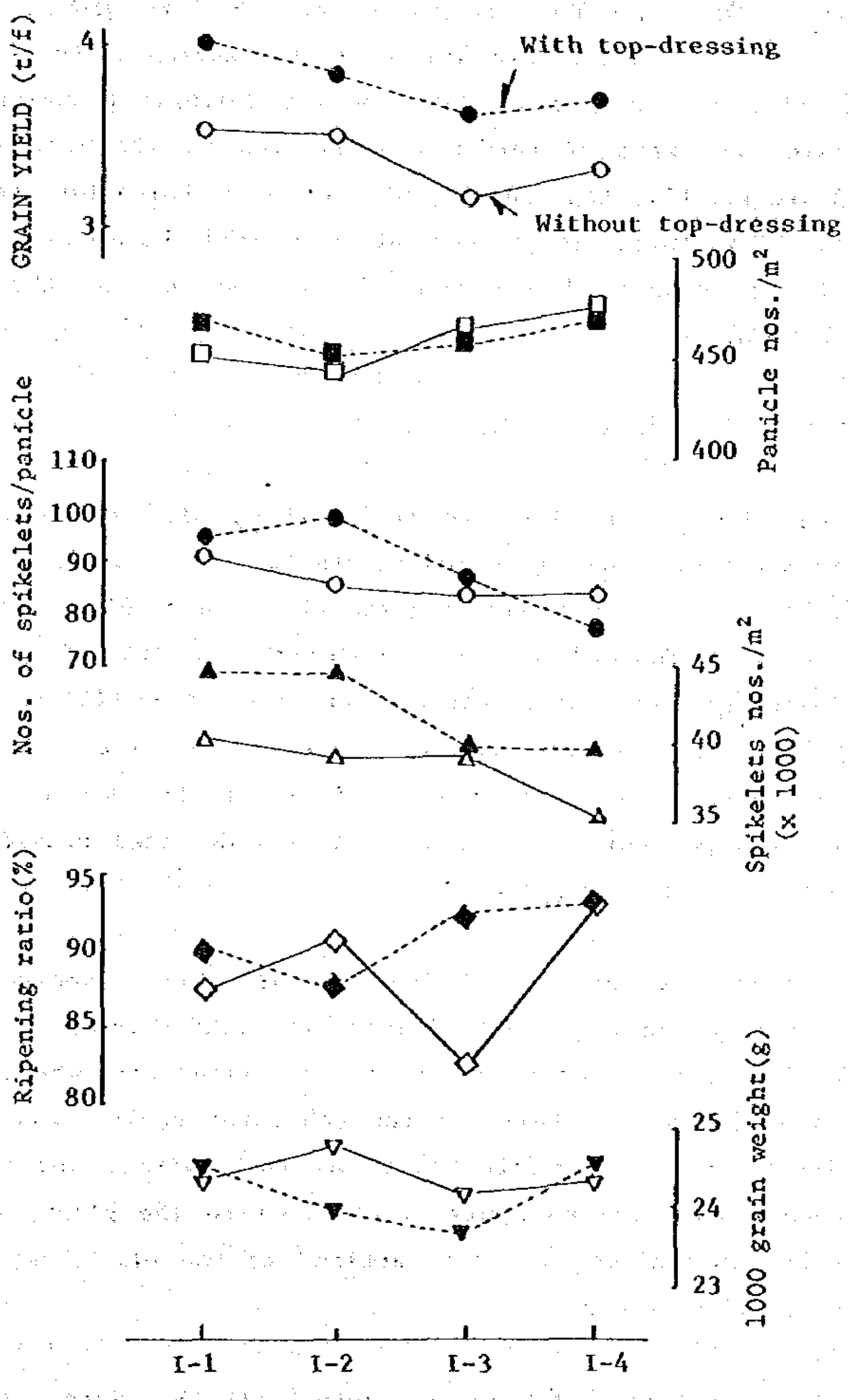


Fig. 38: Effect of Mid-season drainage and Nitrogen Application on Inter-Node Elongation

2.1.3. Establishment of Technique for the Enhancement of Photosynthesis in the Late Growth Period

The main target for cultivation in the late growth period which is from 20 days before heading to harvesting is to increase in the rate of carbon assimilation. The cultural practices for increasing the rate of carbon assimilation in the late growth period are firstly, top-dressing with nitrogen twice (at the late spikelet initiation stage and at the full heading stage), secondly, to conduct intermittent irrigation to make the plant roots healthy.

(1) Nitrogen Top-dressing Method.

The first requisition is top-dressing with nitrogen. As soon as the middle growth period terminates, the "top-dressing at the spikelet initiation stage" should be applied. The time of-dressing corresponds to the 20th to the 18th day before heading and to 1 to 2 cm in panicle length in large tillers.
The purpose of the top-dressing is to recover the faded leaf color as soon as possible so as to increase the rate of carbon assimilation per unit leaf area which has declined considerably during the middle growth period.

The amount of nitrogen for the top-dressing is generally 10 to 15Kg per feddan at least, otherwise the leaf color will not be recovered. If the leaf color is not recovered, nitrogen must be applied again on the 7th day after the first application. When the rice plant attains this stage, no carbohydrate decrease in the plant occurs due to applying nitrogen to the plant, and no matter how much nitrogen may be applied to the plant, no damage will occur in most cases.

After applying the "top-dressing at the late spikelet initiation stage", again "top-dressing at the full heading stage" must be applied, because, after heading, nitrogen in leaves is translocated into panicles, and consequently the nitrogen