(6) Fertilizers of magnesium ammonium phosphate origin

The accessory components of these fertilizers are just the same as those mentioned in the fertilizer of (1) group and about 10 percent of nitrogen exists in the form of $MgNH_4PO_4$. Hardness of granules is the highest among high analysis compound fertilizers.

Fertilizers of this group are suitable for all kinds of crops, especially vegetables that absorbs magnesium most.

Some of those most important high analysis compound fertilizers are occasionally applied with various additives or their nitrogen is converted into some other forms.

Most important among the additives, are agricultural chemicals such as herbicide and insecticide, nitrification inhibitors to prevent reaching of nitrogen, anti-caking agents mentioned above and micronutrients such as boron and manganese. As to the conversion of nitrogen, controlled release nitrogen, which usually replaces urea, is most important. Among controlled release nitrogen sources, IB (isobutylidene diurea) and GU (guanylurea) are used for paddy rice while ureaform and CDU (crotonylidene diurea) are used for upland crops.

Further improvement in these additives and nitrogen or other nutrients are in sight in the near future.

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Shortening the Breeding Cycle of Rice

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The establishment of a method for rapid turnover in the breeding cycle would effectively result not only in shortening the breeding period itself, but also in providing an opportunity for development of a fully artificially controlled procedure of crops breeding. The low temperature in the autumn and winter seasons makes it difficult in general in Japan to have two rice crops a year under natural conditions except in a relatively small area in southern Japan. Experimental studies on the procedures of short cuts in rice breeding were started in 1932 at Aichi Prefectural Agricultural Experiment Station in Japan[5]. During the early period of the study the shortening practices were limited only in F_1 or F_1 and F_2 generations. In recent years, however, the shortening cycles have been extended to F_4 or F_5 generation in rice breeding. It is since 1950 that the rapid turnover procedures have been widely used in a practical rice breeding program. In 1967, 54 highly promising lines of rice have been released at fifteen breeding stations in this country, among which 24 lines, i.e. 44% of the total, were the resultants from any type of shortening treatment in their breeding procedures. Almost all of the rice breeding stations in Japan have been using this short cut method.

Such an extensive use of the shortening procedure in practical breeding was initiated and stimulated by two factors:[3) 5)] The first is concerned with a rapid change of objectives in the breeding program.[5)] In recent years the agricultural situation has changed markedly during a short period, and so the breeding objectives have also been affected and diversified. One crop a year with the conventional breeding method could not meet the urgent needs.

The second is related to the development of the bulk method in autogamous plant in Japan. Since around 1950 this breeding method has been widely developed in practical use in rice, wheat, soybean and others.[1)] The bulk method has brought many benefits to breeders for increasing efficiency in their breeding works. However, it has some disadvantages, one of which is the fact that it needs a little longer period for breeding than the usual pedigree method. This weakness is overcome by means of a rapid turnover treatment of the breeding cycle. A closely spaced planting which is usually the case with the bulk method makes it possible to minimize the field area, and conveniently to use greenhouses and equipment for accelerating generation in breeding. Furthermore, it could be expected that there is a possibility for mass selection of certain characteristics, such as heading date, disease resistance, low temperature tolerance etc., during the period of shortened culture of breeding materials.

Types of methods for shortening the breeding cycle

The shortening method could be classified into three types:[3) 5)]

(1) The first method is characterized by its use of nursery boxes in a glass house during summer and in a green house during winter.[2) 3) 5)] Three or more generations a year could be advanced there. Plants are grown in nursery boxes under upland conditions without transplanting the seedlings. The seeding rate is kept at 200 to 1,600 per square meter, 1,100 seeds on the average, i.e. $3 \times 3\ cm^2$ per seed. Under such spacing conditions the number of grains per plant yielded at harvest could be expected to be 13~15 in summer and 5~6 in autumn. However, the F_1 generation should be grown at a lower seeding rate to obtain a sufficient amount of seeds for the F_2 generation. Heating in winter and photoperiodic treatment are both essential for this type of shortening procedure. It is required that the minimum temperature should be at least 21°C the year round and 23°~24°C in the particular growing stage during the period from primordial panicle to heading. The short-day treatment, 8 hours light a day, is also required to accelerate heading for 20 days after the fifth-leaf growing stage of rice plant. In some cases it is desirable and effective for rice plants to be subject to long-day treatment (all-night lighting) during the growth periods before the primordial stage and after heading.

An example of this type is shown in Table 1. The system in the table has been actually used at Aichi Prefectural Agricultural Experiment Station.[4)] Two courses, I and II, run in parallel. The course I includes parental materials for crossing, F_1, F_2 and F_3 generations within seventeen months, while the course II includes F_1, F_2, F_3 and F_4 during the same period. It was proved that through these courses the breeding cycle could be completed within seven years, whereas it usually takes ten years or more under the ordinary pedigree method. Therefore, the breeding duration could be decreased by one third with the use of this type of generation acceleration method.

In usual cases the nursery boxes are filled with clayish or loamy soils. However, a sand culture method is also available, which is recognized to be convenient for management of rice plants and water. Several nursery boxes, each of which has small holes at the bottom, are kept in a shallow, wide vessels filled with nutrient solution.

(2) The second method is characterized by its use of nursery beds under natural climatic conditions.[3) 5)] Since air temperature can not be artificially regulated, the practical application of this type of shortening breeding cycle is limited to the area in the hot weather district. The shortening work of this type in Japan is assigned to two rice breeding stations located in the most southern area. The procedures for rapid turnover from F_2 to F_5 generations are carried on for two years, involving hybrid materials from the whole breeding stations throughout the country. Neither special facilities nor much labor is ordinarily needed for this type and so a larger amount of breeding materials could be involved in the breeding program, as compared with the first type mentioned have.

In case of need, short-day or long-day

Table 1. Shortening procedure of rice breeding cycle at Aichi Prefectural Agricultural Experiment Station, Japan. (Miyazaki et al. 1959)

Year	Period	Course I			Course II		
		Genaration	No. of plants/cross	Area needed	Generation	No. of plants/cross	Area needed
1st year	Spring cult. Mid. Jan.–Mid. May	Parents and crossing	15	1.7 m² /24 crosses	F_1	15	0.7 m² /5 crosses
	Summer cult. Late May–Late Aug.	F_1	15	6.9 m² /24 crosses	F_2	398	3.3 m² /5 crosses
	Autumn cult. Early Sept.–Mid. Dec.	F_2	390	13.8 m² /24 crosses	F_3	1,326	6.6 m² /4 crosses
2nd year	Spring cult.	F_3	1,326	13.2 m² /8 crosses	F_4	496	5.0 m² /3 crosses
	Summer cult.	F_4	5,000	800 m² /8 crosses	F_5	100 (lines)	300 m² /3 crosses

Total areas needed in each cultural season are 20.6 m² for spring, 10.2 m² for summer and 20.4 m² for autumn.

Table 2. Shortening method of rice breeding cycle at Hokkaido Prefectural Agricultural Experiment Station, Japan. (Chino, unpublished)

Year	Month	Generation	Locations used	Method for growing	
				Places	Notes
1st	May–Sept.	Par. and cross.	Hokkaido*	glass house	20–30°C
1st–2nd	Nov.–Mar.	F_1	〃	〃	
2nd	Apr.–July	F_2	Kagoshima*	nursery bed	Bulked populations, directly sowed with high seeding rate, covered with vinyl film in early spring. Mass-harvest.
〃	Aug.–Oct.	F_3	〃	〃	
2nd–3rd	Nov.–Mar.	F_4	Hokkaido	green house	20–30°C. Bulked pop., directly sowed with high seeding rate.
3rd	Apr.–July	F_5	Kagoshima	nursery bed	Same with F_2.
〃	Aug.–Oct.	F_6	〃	〃	Same with F_3, each panicle is harvested seperately.
4th	Apr.–Oct.	F_7	Hokkaido	field	Lines resulted from panicles in F_6. Selection.

* Latitude: Hokkaido-N 43°, Kagoshihma-N 31.5°.

treatment could be practiced. In order to protect the rice plants from low temperature injuries in the early stage of rice growth of the early-cultured rice, the nursery bed is readily covered with vinyl film. Around 10 square meters of the seed bed are provided per cross. Seeding rates are about 1,000 to 3,000 grains per square meter.

Some successful examples are presented in the tropical zone, which are characterized as the similar method for shortening with the second type stated here.

(3) The third method is a combined procedure of the two types described above.[5] The actual processes for shortening are shown in Table 2. This is the type which has been actually used for practical breeding in Hokkaido Prefectural Agricultural Experiment Station during this decade.

Some problems involved in the methods

The standard types of the method for rapid turnover of breeding cycle have already been established. However, it should be noticed that each of the procedures has some problems to be improved.[5] Some of them have been solved to some extent but others have not.

(1) The duration of the interval from harvesting to seeding is generally very short. Therefore, poor and non-uniform germination of the seeds is occasionally caused by their dormancy or immatuarity immediately after harvest. It may be said that such troubles in germination and seedling growth might give a bias in the genetic constitution of the hybrids in later generations. As regards seed dormancy, the desiccation treatment under high temperature is recognized to be effective to eliminate its dormancy; i.e. 10-day desiccation treatment under 40°~43°C, 3 to 5-day treatment of the sealed seeds under 45°~50°C or 5-day disposal of the non-sealed seeds under 50°~55°C. However little is known about the effectiveness of these treatments for seeds of rice varieties which show a high degree of dormancy.

(2) Poor germination and inferior seedling growth are also caused by unfavorable environmental conditions during the seeding period. The environmental conditions should be improved so as not to give a genetic bias in the hybrid population with the exception that the selection in the early growing stage is in the breeder's interest.

(3) It is one of the great concerns for rice breeders to know whether there exists any particular genetic shift in hybrid populations due to natural selection during the period of shortening under natural environmental conditions. Several experimental data have been presented on this matter. Some of them showed differences of genetic variation on agronomic characteristics between the two kinds of populations resulting from shortening and non-shortening of breeding cycle, while others showed no significant differences between them. No general conclusion has yet been obtained. However, it may safely be said that the genetic shift, if it might actually exist, could be decreased to a considerably low extent through the careful management of experimental plots and the appropriate practices of harvesting of breeding materials.

(4) Since shortening procedure requires some special facilities, especially in the case of the methods of type I and III, hydrids to be accelerated should be appropriately selected. It is essential for shortening practices to be accompanied with the studies on the testing method of parental ability and hybrid ability in breeding.[3) 5)]

(5) Population size in each of accelerated generations is also a great concern to rice breeders.[1) 2) 5)]

(6) A method for shortening the later generations of breeding cycle should be devised to increase its efficiency.

The prospects for the future

It is quite sure that shortening the breeding cycle can favorably meet the urgent necessity in agricultural situations and also in breeding objectives. This is so true in rice breeding. The rapid turnover technique could generally be used to make up the weak point of bulk breeding method, or to fix and propagate any highly promising lines as fast as possible for their prompt use.[1) 2) 3) 5)] The methods of progressive improvement by T.P. Palmer (1953) and cumulative selection by T.R. Richmond (1949) could be effectively carried out by means of the shortening techniques of the breeding cycle.[5)]

However, the utility of the technique ought not to be confined to "acceleration" only. Development of an artificially controlled environmental condition would make it possible for breeders to distinguish precisely the minute differences of lines on various sorts of agronomic quantitative characters and to select superior lines accordingly. Some of the specific environments might reveal characteristics of breeding materials which might have been concealed under an ordinary environmental condition. It would be expected that a fully artificially controlled procedure of crop breeding could be developed in the future. Further innovation of the method of rapid turnover might lead breeders to establish "crop breeding without field."[5)]

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Fungicides for Rice Blast Disease

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Fungicides for Rice Blast Disease

Rice is the principal axis of agriculture in Japan. The greatest precautions have been taken for controlling pests of rice plants. Rice blast disease caused by *Piricuraria* oryzae is the most noxious of all rice-damages, including damages by diseases, insects, typhoon, drought, cold-weather etc. It is said that the damage by rice blast is about one third of all damages to rice plants. Since organo mercuric compounds were induced as a seed treatment for preventing rice blast in 1915, and especially since they were applied to rice plants in fields for controlling this fungi in 1955, rice blast has been controlled mostly by organo mercuric compounds, and it is well known that this practice be contributed greatly to increased production of rice.

In recent years, however, the residual toxicity of organo mercuric compounds to human or animals have come to be a serious problem. The reason for fear of mercuric poisoning was shown by "Minamata Disease" in Kumamoto Prefecture and a disease on the Agano River in Niigata Prefecture. How-