Discussion

Chairman : Reviewing the presented papers we have decided to discuss various subjects dividing into two major categories : The one is the problems related to varietal improvement, and the other is the problems related to fertilizer application and maintenance of soil fertility.

The problems related to varietal improvement are very important to make productivity of rice higher, especially with heavy application of fertilizers. Many academic as well as practical studies have been made in Japan and in Asia. And a sort of conclusion has, more or less, been reached through these studies regarding the ideal plant type for maximizing rice production. Moreover, good varieties for the tropics, like IR8, have been developed based on these studies.

To start the discussin, I would like to ask Dr. Murata to review his ideas of the ideal plant type.

Murata : I like to make a short comment on the subject of the ideal plant type. The varietal improvement so far as made is aiming at mainly increasing the responsiveness of rice plant to heavy fertilization and it seems that this aim has been realized through three measures : The first is making short stature varieties mainly in order to avoid lodging, The second is producing vigorous tillering varieties, aiming at increasing the "container capacity," that is, the container size for grain yield. In addition, it also aims at increasing the total leaf area as rapid as possible. The third is to make leaves erect in order to utilize the solar energy more efficiently.

By these three measures, a great achievement has been made, and as a result, superior varieties such as IR8 or IR5 in the Philippines, Houyoku and others in Japan have been developed. These are the main courses of development which have been followed in recent years. Now, I think, we must search for new directions for further increase in yield with more efficient use of fertilizer.

In connection with this, several points I want to emphasize here are : The first is related to the second measure mentioned above. Hitherto, an increase in the capacity of "yield-container" has been realized mainly by increasing the tiller number. But as you all know, a heavy nitrogen application, mutual shading becomes serious. This is, of course, unavoidable to some extent. And as Dr. Murayama says in his recent report and also Dr. Shiga has mentioned in the present paper, not the grain number itself but the grain number per unit leaf area should be increased. This is because, if only the absolute number of grains is increased by merely increasing tiller number, overgrowth of plants or excessive leaf area will be surely induced. To avoid detrimental effect of mutual shading, therefore, we must increase grain number per leaf area index. Actually, rice varieties in northern parts of Japan have larger grain number per leaf area index compared with those in southern parts of Japan as Dr. Shiga has introduced here. So, varietal improvement in this direction will be realized without much difficulty. And if this is realized, the manipulation of fertilizing practice may be made far easier than it is at present. At present a heavy application of fertilizer is quite necessary to obtain vigorous tillering. But in varieties with above-mentioned character, an overdose of nitrogen can be expelled so that we can avoid the detrimental effect of heavy mutual shading.

The second point I want to emphasize here is to increase the hull size. As Dr. Matsushima shows in his report, the hull size is a primary limiting factor for 1,000-grain weight, so this also must be increased by breeding in the future.

The third point is to increase the grain-straw ratio which has been discussed by Dr. Murayama and others. This is extremely important characteristics of rice varieties, although very little has been made clear concerning its physiological basis.

Concerning this point, I want to introduce a recent result which I have found in Dr. Osada's data in 1966. In those varieties differing in nitrogen response, two factors——the photosynthetic activity during the ripening period and the grain number per unit leaf area ——are very closely related to the grain-straw ratio. Therefore, by increasing the grain number per leaf area and at the same by keeping the photosynthetic activity at higher level during the ripening period, we can get a higher grain yield, with comparatively less straw weight.

The fourth point I want to stress here is related to the third measure I mentioned before. The essence of physiological basis for higher nitrogen response of rice variety can be expressed by the ratio between the capacity to synthesize carbohydrates and the ability to grow. That is, those varieties which show higher response to nitrogen possess a higher carbohydrate-synthesizing ability in comparison with their growth ability. and those varieties which show low response to nitrogen have a higher growth ability in comparison with their carbohydrate production. Thus, we can understand that the ratio of these two functions are quite important. One method to increase the ratio is, of course, to make varieties with higher photosynthetic activity. As for this point, rice varieties show considerable differences in their photosynthetic activity, ranging from some 46 to 60 mg CO_2 per cm^2 per hour, according to Dr. Yoshida's recent data. The highest value is even comparable to that of corn plant which is said to be one of the most efficient among many species. Therefore I think it is possible to breed out varieties with higher photosynthetic activity. But here, it must be remembered that the contribution of photosynthates to grain production differs with growth stages. It is the photosynthetic activity during the ripening period that is truly important and directly related to grain production. In contrast, photosynthetic activity at an earlier stage is less important. Moreover, those varieties which have higher photosynthetic activity at an earlier stage tend to grow too vigorously at first but growth declines in later stage. This is not desirable from the view-point of nitrogen response. Thus, the really important is to obtain such varieties as have higher photosynthetic activity at later growth stage, in other words, varieties which show little aging in their photosynthetic activity.

Now the fifth point is to maintain the total leaf area as large as possible, during the latter half of ripening period. The last two points can be realized by obtaining a healthy root system as Dr. Ota has shown in this symposium. Root activity has quite a close correlation with photosynthetic activity and also with maintaining the total leaf area at the later growth stage. A healthy root system will be realized through two processes : one through absorption of nutrients and the other through RNA synthesis which is coupled with protein synthesis. If more knowledge is accumulated in this field in the future, it will surely be a great help for breeding work.

Chairman : Thank you Dr. Murata for your comments. Many of you may have something to say based on your own observations in relation to this subject.

De Datta : Is it possible to develop a variety which has a longer duration after flowering under the climatic condition of the tropics, in order to utilize photosynthate effectively for grain production. Is it possible to select a variety which has longer ripening duration beyond 30 days ?

Murata : I think it is possible. If we can develop a variety which has a longer duration of ripening period, more photosynthetic activity may be expected. This will contribute to raising a higher yield, but this can be realized only under the following conditions : In ordinary varieties, the so-called "accepting abillty," i. e., the ability of grain to collect material or the translocation ability of pathway leading to grains, becomes aged toward the end of ripening period. Therefore, extension of ripening period must be accompanied with that of longevity for the accepting ability of grains or translocation ability of conducting

tissue. On this point, Dr. Nakayama has made some interesting experiments and in the future this point will be made clear and utilized for breeding.

Tsunoda : From the point of plant breeding, it is rather easy to select a variety with so-called large container or sink, but I think it is rather difficult to make a variety with longer duration after heading. From the point of plant breeding, we have to emphasize that we should select a variety with a longer duration after heading with every effort. If such a variety can be bred out it is rather easy, in my opinion, to select a variety with a large number of grains, that is, with a large container. In this case, however, we have to remind that a dwarf gene, which is often used to make plant short, must not be used too widely. The expression of such dwarf gene should be restricted to the stem length, not reducing the size or the number of grains. This is most important. If we can find such a proper gene, we can easily get an ideal plant with short statures and at the same time with a larger container.

Shafi : I would like to know how the increasing of the duration from flowering to maturity is going to effect the yield. What yield component will be increased so that there will be more yield, if this period is increased. ?

Tsunoda : We can find out examples in the history of rice breeding in Japan. The recent varieties generally have longer duration after heading. One of the examples is Fujisaka 5, which is 5 days longer compared with old varieties. However I cannot say anything about the yield components. Sorry.

Shimazaki : We observe sometimes in the field high yield potential varieties or pedigrees with rather droopy leaves. So I suppose that there are some characters to produce high yield, for instance, the ablity of translocation of carbohydrates from the leaf to the panicle which was mentioned by Dr. Murata. Iwould like to know what character is more important than photosynthetic ability.

Chairman : If I understand correctly what Dr. Shimazaki said, his point is that the improvement of the plant type was definitely one of the breakthrough in maximizing rice production. However, by his observation there are varieties which do not have erect leaf, but produce a good yield. Is there anyone who can give some solution to this paradox? As Dr. Murata mentioned, Dr. Yoshida has some evidences to say that varietal difference in the photosynthetic rate per unit leaf area is one of the important characters on which we should put more emphasis in future. I wonder if Dr. Yoshida can give information so far you have obtained?

Yoshida : Sorry, I would like to reserve my comemnt on this subject. I just like to ask Dr. Murata. You mentioned the importance of how to increase the grain number per unit LAI, and Dr. Tsunoda mentioned it is rather easy to select varieties with increased number of grains. I wonder which is true, that is, the total photosynthetic activity of the rice population determines grain number or some other gene is controlling this character.

Murata : There are several workers making researches on this subject, that is, "sink" size and its relation to photosynthetic activity. But as far as I know, the problem has not yet come to a conclusion. In my opinion, it is not so simple as to be governed by a single gene, but may be governed by complicated characteristics. And this is a problem just resembling the relation of growth capability to protein synthesis. As Dr. Tanaka has said, the growth activity is governed by a gene, but the protein synthesis does not seem to be directly governed by a gene. Concerning the photosynthetic activity, I thik the latter case will be correct. Thus, in order to make a variety of high photosynthetic activity, more study is needed.

Chee : Certainly I think from what I know from Dr. Yoshida, in one of his papers presented at IRRI, he states IR8 plant type has almost reached the perfect stage. So we presume

that all these LAI and K, and SLA (specific leaf area) almost reached the maximum development. And he suggested that perhaps breeders should look into other direction. Now surely my feeling is that all they have to do is harvesting the solar energy by cutting down the inefficiency of, shall we say, mutual shading, and so on. But one other point I think we missed is, beside increasing the duration after heading stage, we should also increase the efficiency of the photosynthesis. My feeling is that little has been examined, say, for instance, a plant which has the same duration period, the same LAI, K and SLA, I think, there could possibly be difference under the same measurement inefficiency of solar energy utilization. I think this is important especially after we have reached a perfect plant type.

Chairman : I believe what Mr. Chee said is correct. We should look into these problems more closely in future. However, what we can say at this moment is that by improving the plant type, so far, a big jump of potential rice production has been accomplished.

At this stage, I would like to discuss another subject. Rice is harvested for consumption, not only quantity but also quality is important. May I ask Mr. Shafi to make some comments on merit and demerit of *Basmati* and IR 8 in West Pakistan. ?

Shafi : In West Pakistan, we'll like to have *Basmati* rather than any other variety. Because, one thing is that *Basmati* has aroma. And the other is that the grain guality ; when cooked, it is very tender and very easy to swallow and eat. Then it has quite a taste. Some of the people who have tasted *Basmati* for the first time would like to have that. For example, there were some Japanese farmers in West Pakistan about ten years ago, in the first month they liked to eat japonica rice rather than *Basmati.* But I gave them some *Basmati* to eat, after one month they did not like japonica rice but the *Basmati* rice. That is I developed their taste and they like it better. IR 8 is a very high-yielding variety that has given the highest yield in West Pakistan. But it has not been liked by our people and they are now switching over to some other varieties, for example, we have after one year of introduction to another variety IR 6 which has given as high a yield as IR 8, but the quality is better and grain is finer than IR 8.

Chairman : Anyone who wish to make some remarks in relation to this subject? May we hear something from the delegate from Thailand?

Chalermkiat : For quality, according to my opinion, in Thailand, people like good cooking quality. Especially we export rice, and if possible, I'd like to have suggestion from many experts here how we get the variety that has a good cooking quality and good milling quality. I'd like to get some suggestion from Dr. De Datta and Dr. Tanaka.

Tanaka : Anyway, a good quality and a large quantity do not necessarily come together. My feeling is that after everybody in the country is well-fed, the problem of quality will come into the picture. Since we have a good future in producing more rice, quality will become a serious problem in the near future.

Chairman : During the past 3 days session, the problems related to organic substances have been discussed several times. I'd like to invite you to discuss this subject. To start with, if Dr. Kawaguchi has something to say with this subject, we would be glad to hear.

Kawaguchi : For discussing this problem in detail, another symposium will be needed. So here, I would like to say only on two points. One is, on the very high yielding rice soil in Murrumbidgee irrigation area in New South Wales, Australia on which Mr. Langfield mentioned yesterday. Recently I had an opportunity to visit there and make some studies on paddy soils there. The organic matter content of these soils is not too low, but not too high in spite of continuous pasture cultivation for five to six years. They are between one to two percent as organic carbon content. This value is less than the average value of Japanese paddy soils, even excluding peaty, strongly gleyed and humic volcanic

ash soils which are all rich in organic matter.

The liberation of ammonium nitrogen of the Murrumbidgee soils is rather slow, but increases steadily after submergence. The total amount of ammonium nitrogen produced under the condition employed is from 8 to 15 mg N per 100 g of soil for the most of the soils examined. This value seems to be quite adequate. Any drawback in chemical, mineralogical and physical properties of the soils was detected from neither field nor laboratory studies. The soil in the Murrumbidgee area is probably one of the best soils for rice cultivation.

Now I will proceed to the second point. Two kinds of patterns of ammonium nitrogen production under the submerged condition were identified for the soils in Southern Asia. One is for the soils under Savanna climate, which are dominant in the most parts of Continental Asia, northern part of Ceylon and in some parts of the Philippines and Indonesia. In these soils the liberation of ammonium nitrogen is slow and steadily increases after submergence just as in Australian soils. The total amount of nitrogen produced, however, is considerably smaller than that from Australian soils. The other is for the soils under tropical rain forest climate. The liberation of ammonium nitrogen is undesirably rapid after submergence in the soils of this kind. The evaluation of organic manure should be discussed from the different angles for these different areas.

Chairman : Through my experiences, there are two extremes in handling the straw in the tropical Asian countries. One extreme is the incorporation of all straw into the soil, such as practised in some part of Indonesia. The other extreme is the burning of all straw on the soil, such as practised in some part of the Philippines. Does anyone of you have a theoretical background for these peculiar customs?

Soebijanto : In Indonesia, actually, I mention there are two limiting factors on using the straw material to be incorporated into the soil. As I explained, as long as the green matter or organic matter is available, it's all right. But it's not efficient. You have to have your labor to throw all your straw and then to incorporate it into the soil. As long as the two factors, the organic matter and labor are available, that's all right. They are going to incorporate with. But, if one of the two factors is lacking, then they are inclining to just burn it. This is the condition in Indonesia.

Reyes : I think the main problem or the main reason why our straw is being burned in the Philippines is because in certain areas where double cropping is practised, the problem would be in the preparation of the land. And especially if the straw material is rather mature, it would take quite some time for these to be decomposed and so that the farmers take it upon themselves to burn it in order to get rid of the difficulty decomposable material. However, in case of, for instance, the rain-fed areas where rice is grown, farmers sometimes just let this loosen, because there is a time lag before next planting and there should be a sufficient time for the materials to be decomposed. And if especially we find the one rather tender, there is no material that would be hard to be decomposed while waiting for the next planting.

Chee : I think in most of the Southeast Asian countries you find that there is quite a variation of practices depending from locality to locality. And I think there is no real one reason or the other that are practicing. And I think the other reason that should be added to it is, in the absence of insecticides in the old days, this business of cleaning up of the land, by burning up all the straw is also of a good disinfection value in so far as particularly stem borers are concerned. In many of the good areas like the major double cropping areas in Malaysia, straw are all completely burned and, you find that the stem borer infestation is far much lower.

Chairman : Dr. Ishizawa, could you make some comment from the standpoint of micro-

biology ?

Ishizawa : This problem is very difficult for detailed discussion, as Dr. Kawaguchi said. I cannot say my opinion in detail in a few minutes. But, concerning the effect of organic matter, the most important thing is the condition under which organic matter is decomposed, and the composition of organic matter, especially C : N ratio may be added. On this point it must not be neglected that the effect of organic matter poor in nitrogen such as straw is fairly large on nitrogen fixers, i. e. on autotrophic such as photosynthetic bacteria as well as heterotrophic organisms especially under water-logged condition. In addition, the effect of carbon dioxide produced during organic matter decomposition on the crop will be considered.

Chairman : Two big scientists mentioned that this subject is too big to discuss within a few minutes. I will close the discussoin on this subject with the hope that the Ministry of Agriculture and Forestry of Japan or some other institutions will organize a separate symposium on this subject in the near future.

Then, the next subject will be the method of fertilizer application. The optimum method of fertilizer application depends upon the nature of varieties being used and the environmental condition under which rice is grown. Due to this reason the optimum method is very complicated. I hope Dr. Murayama can tell us his experiences with the complicated nature of fertilizer application.

Murayama : There is a trend in Japan to give more importance to the top-dressing than basal application. The physiological basis of this method of application has been already discussed in this symposium. The method of fertilizer application, however, should be varied depending upon the various conditions. The above-mentioned trend in Japan is based on the characters of varieties, kind of fertilizers, properties of soil, etc.

As reported by Mr. Langfield of Australia, a high yield of 10 t/ha can be obtained by a rather small amount of single application at sowing, if the soil is fertile. There are alike examples also in high-yielding contest of Japan. The field of IRRI may be also very high in fertility, I think.

An advantage of the top-dressing practice is to prevent luxuriant growth in the earlier stages that might be caused by a large dosage of basal application. If a short-statured' erect-leaved variety that shows no luxuriant growth is used, a single dose of basal application might be adequate for a cartain high yield. IR8 seems to be one of these varieties.

Another advantage of top-dressing is to keep the plant in a healthy nutritional status in the later stages of the growth. However, for the variety of short duration, the basal application will be enough for the maintenance of nutritional status until its later stages especially in fertile field. This would be one of the reasons of low response to the top-dressing of short duration varieties.

The effect of fertilizers tends to last longer when applied deeply into the soil. If slowly acting fertilizers are used, this tendency will become more pronounced. A simple dose of application before the transplanting might be sufficient to sustain the plant under proper combination of the kind and the placement of fertilizers There are some examples of the experiment of this kind in Japan. Needless to say, the meteorological condition influences the yield of rice. In the tropics, dry and wet seasons make difference in the optimum dosage of fertilizers, while in Japan there are different methods of application between cool northern area and warm southern regions as mentioned by Dr. Shiga. The effect of top-dressing at heading stage as presented by Dr. Matsushima would be influenced also by the meteorological condition during the ripening stage.

The fertilizing practice that gives importance on the split application is concerned with the problem of soil conditions and water management. The elaborate techniques of top-

dressing in Japan will display its effect more efficiently under proper water management.

Considering these examples, I would say that the method of fertilzation is not unconditionally immutable, but variable depending upon the condition. It seems to be most important for researchers to pursue the way for increasing the efficiency of fertilization under various conditions.

Chairman : Dr. Matsushima, I'm sure you have something to say in relation to top-dressing.

Matsushima : From the point of view of yield-determining process, I emphasize there are 3-4 times for top-dressing, the first is just before the most active tillering stage. It is to increase the number of tillers. The second time is just neck-node initiation stage. This top-dressing is to increase the number of spikelets per panicle. The third one is just before reduction division stage. It is to decrease the number of degenerated spikelets per panicle. And the fourth time is at full heading stage, which is to increase the percentage of ripened grains as well as the weight of 1,000 grains. But I emphasize that most important time for top-dressing varies with the condition.

Under the condition where the percentage of ripened grains is quite high, we need not top-dress to increase the percentage of ripened grains. Under this condition we should make effort to increase the number of spikelets per unit area. So, we have to top-dress at the most active tillering stage or the neck-node initiation stage to increase the number of spikelets per unit area. Under the condition where the percentage of ripened grain is quite low, we have to make effort to increase the percentage of ripened grains. For that purpose, we had better, in many cases, top-dress at full heading stage, and it is quite effective.

Chairman : No one argues that the optimum method of fertilizer application depends upon conditions, such as the varietal character, the climatic condition, the kind of fertilizers and the economic status of farmers. Taking all these condition into mind, farmers will get the maximum benefit out of fertilizer application.

I would like to ask Dr. De Datta to make some comments. And if you like, you can start to talk about slow releasing fertilizer.

De Datta : I am not contesting that slow release fertilizer has no advantage. But the data available at least in tropical Asia so far, have not convinced us there is a distinct advantage. I must say that our experience at IRRI has been limited in this field, we have tried out a sort of slow and control release materials, but we did not find there was any advantage in grain yield. In case of most farmers in Asian countries, if the advantage is the same they would prefer the cheaper. Slow release fertilizer usually costs more than the conventional one. But in cases if any experimental data suggest that there is an advantage for slow release material, I don't see why they should not use it.

Chairman : The next subject will be problems related with elements other than nitrogen. Rice is most intensively cultivated in alluvial areas with plenty of precipitation. However, by the pressure of population, rice fields are expanding to elevated high lands where we are going to meet with various soil problems, and also to the areas with less precipitation where we often have soils with high pH. Today we had several papers related to physiological diseases or nutritional disorder. As Dr. Yoshida has been making quite an extensive survey on this subject, the audience will be happy if Dr. Yoshida can make a brief report of his survey.

Yoshida : A survey on nutritional disorders of rice in Asian countries was initiated by Dr. Tanaka about seven years ago, and since 1966 I have been helping him in his investigation. However, he is now chairman, so I'd better mention something about what we have found so far.

In Southeast Asian countries, phosphorus deficiency is most widely spread in lateritic soils, black cotton or regur soils, red or chalka soils, Ando soils, and some acid soils. Occurrence of potassium deficiency is rather limited at present. However, in the near future when farmers start using more nitrogenous fertilizers, we can expect more incidence of potassium deficiency. Zinc deficiency often limits nitrogen response in calcareous soils as explained by Mr. Shafi. If rice cultivation is extended to arid zone where soils are generally calcareous or sodic, we can expect that zinc deficiency becomes more important problem.

Iron deficiency in high pH soils occurs under upland conditions but seldom occurs in submerged soils.

In general, it is relatively easy to correct these deficiencies from technical point of view. Just apply the nutrient concerned. It is a socio-economic problem, and, also a matter of willingness of farmers to improve their crops.

Salinity is a problem not only in arid zone areas but in coastal areas. The best way to correct salinity is to leach salts away from the soil. Therefore, basically, it is a problem for engineers and it requires a lot of investment. Breeding salt resistant varieties my not be too fruitful.

Acid sulfate soils are widely spread in such countries as Vietnam, Thailand, Malaysia, India, Indonesia and West Africa. We now know much about the chemistry of acid sulfate soils but we know very little about how to improve these soils economically. This is one of the most important problems for soil scientists.

Bronzing occurs in acid sandy soils and peaty or boggy soils in Ceylon. This is, most probably, caused by iron toxicity. The iron toxicity symptoms are frequently observed in acid sulfate soils.

Recent investigations appear to indicate that some physiological diseases such as Penyakit Merah in Malaysia, Mentek in Indonesia, and suffocation disease in Taiwan are virus diseases.

Chairman : Dr. Yoshida mentioned about acid sulphate soils. The potential acreage for rice cultivation on acid sulphate soils in the world is enormous. Some works have been done on this subject in West Africa and in Thailand or Vietnam.

In these few days, several reports discussed merit and demerit of various fertilizers. For example, the comparison between urea and ammonium sulphate, etc. was discussed. Information on this subject in Japan is available. However, unfortunately these usefull pieces of information are based on the experiments conducted on soils with low pH, at least lower than 7. Mr. Thenabadu mentioned this morning about the inferior nature of urea on high pH soils. Would you mind elaborating this subject a little bit more?

Tenabadu : This type of soil is limited to few areas in rice grown area in Ceylon where pH is generally high, I would say about 8. And in these area we find that ammonium sulphate is better than urea as far as these are concerned. My view was that may be due to ammonium toxicity. But I haven't the experience of Dr. De Datta who said it may not be ammonium toxicity, but just an effect of some other ammonium lost on these paddy soils. And of course the extent of such soil is very small, and right now we are not concentraing much effort on this soil.

Shafi : In some areas of West Pakistan pH is above 8, but we did not find any difference between urea and ammonium sulphate.

Reyes : You mention, Mr Shafi, that urea and ammonium sulphate did not cause any difference. Is it not possible that if you apply ammonium sulphate to alkaline soils, ammonium also volatilizes. In other words, both forms of nitrogen would be equalliy lost on alkaline soils.

Shafi : There may be similar loss in both cases. But you find increasing yield. If you get same increase in yield of the two on the equal nitrogen bases, I don't think there is any difference.

Chee : Mr. Chairman, I would like to add a little bit about this urea utilization in Ceylon. Mr. Thenabadu is referring to the dry zone. Apparently the area he described is dry and sandy. I think the question of using ammonium sulphate being superior to urea, does not rule out the question of the element of sulphur being required. Particularly in sandy soil, the question of sulphur as the deficient element, should also be considered. In most pasture country, we find that sulphur as one of the yield component, I mean, nutriment requirement is very serious.

Chairman ; Time is running out. After the improvement of varieties, the amount of fertilizer usage in the tropical Asia rice growing countries will definitely increase. Under such conditions, the kind of fertilizers will become more important problems. In relation to this, with his long experience we'll be happy if Dr. Fujiwara can give us some suggestions.

Fujiwara : The most suitable fertilizer for South-Eastern Asia must be considered from both agricultural and industrial stand points.

As to the nitrogenous fertilizer, ammonia-nitrogen or urea-nitrogen seems to be fit for paddy field. Nitrate-nitrogen would be used for the top-dressing in some special cases.

The phosphate, sulfophosphate, sulfate of ammonia and urea are all good for rice plant and in addition to these, ammonium chloride showed remarkable effect in India and Japan. The nitrification inhibitor would be applied in some cases to prevent the loss of the nitrogen through the rapid nitrification and denitrification in the tropical climate.

From the industrial stand point. both ammonia and urea are least expensive to set up the plants.

In the tropical climate, the prevention of the hygroscopisity of the fertilizer is most important. The next comes the problem of slow-working nitrogen and the substantial slow-working fertilizer other than the coating method should be developed in the near future.

The content of phosphorus in the soil of Continental Southeast Asia is generally very low, so that the phosphatic fertilizer is indispensable for the rice plant, and the form of the phosphate is not always necessary to be water soluble, but the insoluble or scarcely soluble from must be studied if its price is cheap.

Any way, N-P concentrated compound fertilizer is recommendable because of the saving inland freight.

Also as the shortage of the trace elements in the continent is often observed, the addition of the trace elements to compound fertilizer is advisable.

The establishment of the fertilizer-control-law would be important in the near future in the South-Eastern Asian countries.

Chairman : Before closing, I'd like to add one more point. Yesterday, Mr. Shinozaki explained his experiments in which the fractional factorial design was used. This design may be very handy for field works in various countries. If Mr. Shinozaki wouldn't mind, will you please explain a little bit more about this?

Shinozaki : The fractional factorial design has been originally developed by statisticians in England. It is rather difficult for the experimenters to select a fraction of the possible factorial combinations. The simplified procedure devised by Dr. T.Okuno using the Tables of Orthogonal Arrays has been widely introduced in agricultural experiments in Japan. We take an example of 32 experimental plots as in this experiment. We can conduct the experiment with one replication of 2^5, 1/2 fraction of 2^6 or 1/4 fraction of 2^7 factorials. Of course, in the application of this kind of designs, careful considerations should be given

to the selection of factors and of the number of levels as well as to the determination of levels themselves.

In the analyses of the experiments it is indispensable to use an electronic computer. A general computer programme is now available. It can handle experiments with any number of factors each at two levels as well as at three levels. So, researchers including the participants in the Symposium will be advised to send the request with their data for processing on this computer at the expense of the Japanese Government.

Chairman : I understand that Mr. Shinozaki's group is very eager to give services at a very low charge. So, those who are interested in this subject may approach to the group.

This is the end of the discussion. I'm very sorry I couldn't do a good job, because of my incapability. However, owing to your cooperations, somehow we could spend time with useful discussions. Thank you very much.

Dr. Hsu presented the following request on behalf of the participants from abroad.

REQUEST

Taking advantage of this opportunity when we gained fruitful experience at this Symposium, I wish to express our gratitude to the Government of Japan and further make a request for the following of Japanese Government.

1. Such symposium as this should be held at regular intervals, at least every few years.
2. Considering the importance of Fractional Factorial Design as an effective means of research, it is our sincere wish that Japanese Government would furnish the researchers in other Asian countries with necessary programming and computation service to enable them apply this very useful method.