# GENERAL DISCUSSION

**Chairman: Hesse, P.R.** (FAO): The general discussion will be divided into two main parts, as follows: first, there will be a summary of the country reports. Indeed, the most common problem soils identified by the various speakers were the acid sulfate soils. However, since these have been reviewed and discussed thoroughly already on several occasions, they will not be taken up this time. The same applies, to a lesser extent to the peat soils. Thereafter, two main topics will be discussed: 1) the question of acidity in relation to aluminum and phosphorus and 2) the selection of cropping patterns as a means of reclaiming the problem soils. Dr. K. Kyuma (Japan) and Dr. J.S. Kanwar (ICRISAT) will lead the discussion.

**Chairman: Kyuma, K.** (Japan): On the first day of the symposium, 8 papers were read concerning the soil constraints to agricultural production in each of the following countries: Brazil, China, India, Malaysia, the Philippines, Sri Lanka, Thailand and Japan.

As for the definition of problem soils, the general understanding of the term is that they are soils which set a restriction to agricultural production due to their chemical and/or physical characteristics.

The acid sulfate soils, peat soils, saline and sodic soils were listed among the problem soils in the reports from India, Malaysia, the Philippines and Thailand.

In Sri Lanka, peat soils in the wet zone and saline and sodic soils in the dry zone were counted among the problem soils.

Problems of acid sulfate soils are well known and the technology for their reclamation and improvement is available. However the problem remains because of the high investment required to implement the improvement measures. The most positive attitude for their reclamation and utilization consists of allowing pyrite-containing sediments to become completely oxidized by providing good drainage facilities. The resulting strong acids are then washed away with water or neutralized by lime. However irrigation and drainage facilities and application of large amounts of lime are costly. Partial oxidation by ridging or controlled drainage is less expensive. Also continuous submergence to keep the pyrite-containing sediments non oxidized may seem easy and practical. However, in a droughty year the soil surface may be exposed to the air and oxidized to develop strong acidity leading to complete crop failure. In addition to their strong acidity, aluminum toxicity, iron toxicity and phosphorus deficiency as well as sometimes salinity are the major problems in the management of acid sulfate soils.

Peat soils are extensively distributed in Indonesia, Malaysia and small areas can be found almost everywhere but these soils are also important in Sri Lanka and Vietnam. Peat soils occur in lowlands and under humid conditions. Reclamation for cropping rice, pineapple, oil palm, cassava and vegetables has been attempted. The major problems are land subsidence due to dehydration and oxidation as a result of drainage. Poor anchorage for crops, low mineral nutrient status (major and minor elements such as copper) are also observed. In the case of rice, sterility during the early years of peat reclamation has been recorded. As for soil dressing, it may be difficult for many countries to apply several hundred ton/ha of mineral soil as it is practiced on a large scale in Hokkaido. Studies are needed to determine whether deep ombrogenous peat could be reclaimed or conserved with fresh water swamp forests.

Saline and sodic soils could be utilized but their reclamation requires good quality water regardless of whether they occur in arid inlands or along the coast. To avoid secondary salinization those in the arid zone must be carefully managed. The key to reclamation lies in the use of gypsum, fertilizers (nitrogen, phosphorus, zinc), cropping systems including green manuring with legumes followed by rice (IR-8), wheat/Egyptian clover, etc. The land should be kept under crop cover most of the time to facilitate downward movement of salt and sodium/calcium exchange. Also deficiency in zinc is most pronounced in such soils.

Sandy texture soils are also problem soils in Brazil, Malaysia and Thailand. They include Regosols or Quartzipsamments in the coastal region, soils on old land surface such as those in

North East Thailand, and also groundwater Podzols with deep bleached $A_2$ horizon. Low inherent nutrient status, low nutrient and water-holding capacity and high erodibility are the major characteristics of these soils.

Vertisols are problem soils in India, Sri Lanka and Thailand. Owing to their physical properties associated with high content in montmorillonite they are difficult to manage. Also water management problems stem from their shrinkage and swelling properties. Poor consistency when dry and wet is a major problem for the farmers. Low soil fertility (phosphorus, nitrogen and zinc) characterizes those in the semi-arid tropics. Due to their high water retention capacity and self-mulching nature, if cultivated at the right time with proper fertilization and management, they can produce 2 crops/year even without irrigation. Broad bed, furrow system of tillage and dry sowing concept developed by ICRISAT for the management of these soils enable to increase productivity under rainfed conditions in the semi-arid tropics.

Andosols are regarded as problem soils in Japan due to their strong acidity and high phosphorus sorption capacity which reduce fertility. Low bulk density is a cause of susceptibility to wind erosion. Their structure and water retention characteristics are good because of their high organic matter content. In the tropics Andosols are not necessarily problem soils although they share the same characteristics with regard to fertility with those in Japan. In the tropics they cover highland areas where high income cash crops are cultivated, such as vegetables and temperate fruit trees. Favorable physical properties are counted as an advantage in such a use of Andosols.

The largest group of problem soils in each country of the tropics are the red and yellow colored soils with low activity clays. They are represented by the Oxisols, Ultisols, Alfisols and dystrophic Inceptisols and Entisols. They are the products of long-term weathering and/or pedogenesis in the humid tropical environment. Their inherent fertility, nutrient-holding capacity and base status are low. They are acid with high aluminum toxicity.

Due to their high content in hydrated oxides of iron and aluminum, phosphate sorption capacity is high. These soils have acute mineral stress and acidity. As for their physical properties, they differ among each other.

1) The Oxisols have a fine texture of the surface soil and are well aggregated. Therefore, their infiltration rate is high and their erodibility is low. However, their moisture retention capacity is similar to that of the sandy soils and not favorable for crop growth.

2) Alfisols and Ultisols have a lighter texture of the surface soil and a clayey subsoil. The surface soil is easily dispersible and tends to form a crust. These characteristics along with the presence of a compact clayey subsoil inhibit ready infiltration, resulting in runoff and erodibility. Poor tilth of the surface soil is also a problem for the farmers. Land treatment of the Alfisols to reduce erosion and increase moisture retention requires attention.

**Chairman: Kanwar, J.S.** (ICRISAT): I shall only add a few points to the excellent summary of the country reports presented by Dr. Kyuma.

I would like to draw your attention to a similar symposium held at IRRI on "Constraints to Production". These problems have been summed up and highlighted quite remarkably. However, they require a follow-up.

Regarding the Vertisols, I would like to inform you that a special symposium on these soils is being organized under the auspices of the Indian Soil Science Society during the XIIth International Congress on Soil Science which will be held in New Delhi in February 1982. Various aspects relating to basic and applied research on these soils will be taken up.

Also recently a symposium on the so-called "Black Soils" (Vertisols) which are characterized by heavy clay was held in Australia. As you may know, there are about 257 million ha of such soils in the world, mainly in Australia, India and Sudan. Small areas also cover Tanzania, Thailand and Nigeria. These Vertisols can be highly productive when adequately managed due to their high water retention capacity and 2 crops/year can be produced under rainfed conditions.

As for the Alfisols, runoff water in excess could be harvested, stored and recycled, thereby contributing to the productivity of the system.

The sandy soils belong to all the groups listed above, in particular the Alfisols and millions of hectares are covered by these soils which produce very important crops such as groundnut and millet in various parts of the world. Moisture retention which is a problem for fertility should be studied in more detail.

Lastly, although in the past research efforts have been made to develop a technology for irrigated farming, presently research on rainfed farming should be emphasized so as to optimize the productivity of soils under such system.

**Chairman: Hesse, P.R.** (FAO): The discussion on the summary of the country reports is now open.

**Benckiser, G.** (IRRI): As we explained it in our presentation, iron toxic soils are highly weathered soils which are also often deficient in phosphorus, potassium as well as magnesium and calcium and it appears that iron toxicity of the plant results from multiple stress. Therefore it would be preferable not to classify these soils in a separate group but to include them within the group of phosphorus deficient soils.

**Goswami, N.N.** (India): It has been well recognized in the symposium that phosphorus is a key factor in crop production in most of the problem soils.

I would like to suggest that methods of determination of phosphorus fixation (or adsorption) capacity be compared and a standardized method be recommended, in particular when it comes to the application of fertilizers. In India, we determine the phosphorus fixation capacity based on the Waugh and Fitts method (USA) which we find most suitable.

**Chairman: Hesse, P.R.** (FAO): We will now proceed to the discussion of some technical problems highlighted in the symposium.

We will first consider some aspects relating to soil acidity with particular reference to aluminum toxicity and fixation of phosphorus.

Dr. Tanaka will lead the discussion.

**Chairman: Tanaka, A** (Japan): Phosphorus deficient soils especially those with low pH are widely distributed in the humid tropics. Proper management requires the determination of how much lime and phosphorus should be applied. From the standpoint of plant nutrition, it is important to determine the optimum pH for various crops along with the optimum concentration of phosphorus in soil solution to increase yields. Water culture experiments could possibly enable to determine which pH is optimum for a certain crop but there are differences between the results obtained in water and soil culture, which could be attributed to the interaction between pH and aluminum. At low pH, aluminum dissolves and comes into the soil solution, whereas under water culture conditions, there is no aluminum in the solution at low pH. The problem is how to estimate the level of aluminum which is toxic to the plant in soil. Would the determination of exchangeable aluminum or of aluminum saturation degree or of pH be useful for such purpose? The problem is to develop a method whereby it would be possible to adjust the pH at the level which would induce aluminum to become toxic to the plant. Various standard methods used in different countries for the determination of phosphorus absorption should be compared.

**Goswami, N.N.** (India): I would like to mention that crops differ in their tolerance to aluminum saturation. Information on the degree of tolerance of crops to aluminum saturation should be compiled. Once this information is obtained, the pH could be adjusted to different levels based on the requirements of the specific crops.

**Li, C.K.** (China): I believe that the method for the determination of phosphorus absorption which is used in Japan (soil/solution ratio 1/2) is a good method but it may be too tedious. Also some of the data available consist of the determination of phosphorus absorption in an equilibrium state whereas others do not. I would also like to know more about the significance of iron toxicity. Is it observed in upland soils only or also in paddy or lowland soils?

**Imai, H.** (Japan): Since phosphorus adsorption is affected by equilibrium pH as well as equilibrium phosphorus concentration, phosphorus adsorption of different soils should be compared under the same equilibrium pH and phosphorus concentration. In this regard, much wider soil/solution ratio should be adopted in order to avoid too large a modification in pH and phosphorus concentration before and after phosphorus adsorption.

**Watanabe, I.** (IRRI): The participation of breeders in the discussions on how to solve problem soils would be very important. Although the necessity of breeding varieties resistant to toxicity is understandable, the breeding of varieties tolerant to deficiencies or adaptable to deficient conditions is confusing. The breeding of such varieties could enable to reduce the use of the amount of soil amendments but not to exclude any effort toward soil amelioration.

**Hew, C.K.** (Malaysia): I noticed that the symposium dealt very little with the relationship between the limiting conditions of problem soils and the cultivation of perennial crops such as rubber, oil palm, coconut and other plantation or horticultural crops. Could research efforts be promoted in this direction?

**Chairman: Hesse, P.R.** (FAO): The problem of solubility products is also important. It is well known that if phosphorus is added to soil, it is preferentially taken up by free aluminum. If the soil is kept wet for a certain period of time, the phosphate leaves the aluminum and goes on to the iron. Aluminum phosphate changes into iron phosphate because of the solubility product concept. Has anyone found any evidence of renewed aluminum toxicity, in other words, could aluminum toxicity be induced or re-introduced by the conversion of aluminum phosphate to iron phosphate?

**von Uexkull, H.R.** (Singapore): Evidence of renewed aluminum toxicity is unlikely because the quantity of phosphorus applied would be too small. Such conversion could take place only under reduced soil conditions when the pH is rather high. However, heavy application of KCl on soils high in exchangeable aluminum could induce aluminum toxicity as in the case of oil palm plantations.

**Li, C.K.** (China): In our laboratory we regard iron phosphate as fixed phosphate in the upland soils of the red earth region of China. It is not available under dry soil conditions and hot climate. However, we consider the phosphorus of aluminum phosphate as available phosphorus. The reaction is reversible and $PO_4^{=}$ ion is liberated in the soil solution.

**Chairman: Kanwar, J.S.** (ICRISAT): With regard to the methods for the determination of available phosphate, exchange of information would be very important, particularly for the soil scientists dealing with highly acid soils so as to standardize the techniques for a given crop.

There are two approaches to alleviating the situation created by problem soils: 1) that of the soil scientist who uses inputs for reclaiming the soils, 2) the other is that of the biologist, which is becoming more important. Indeed, in the case of marginal soils, the inputs are often not available as some of the soils cover areas with difficult access. The approach should be pragmatic and the economic aspect of reclamation should not be under-estimated.

**Chairman: Tanaka, A** (Japan): It appears to me that the way of characterizing the soils on which studies are carried out is not very well defined.

**Watanabe, I.** (IRRI): I agree with Dr. Tanaka that very often there is an inadequate description of the conditions under which the experiments and tests are conducted. For example, in the case of tolerance to acidity, the mechanisms underlying tolerance are very complex. Presently salinity appears to be a condition which can be defined most accurately from the chemical standpoint and the tolerance to this condition can be related to a single factor. Therefore, at IRRI efforts are focused on the development of rice varieties tolerant of salinity as the results can be easily followed in the laboratory.

**Benckiser, G.** (IRRI): In breeding varieties for tolerance to a specific condition, dynamic aspects related to plant-soil relationships during crop growth should be considered. For example, pH and Eh are not static parameters but are the reflection of biological activities of the plant (roots) and the soil micro-organisms combined with physico-chemical properties of the soil system which change continuously during the growth cycle.

**McIntosh, J.L.** (IRRI): As a scientist I believe that it is important to develop methods for the determination of available phosphorus or aluminum toxicity in soil as well as of other factors which control plant growth. However as a scientist working in the developing countries where scientific manpower and funds are limited, I believe that it is equally important to develop methods which can be used so that comparison of results could be made within and among countries.

Also, as a scientist working with cropping systems in the developing countries, management techniques should be considered. On the Red Yellow Podzolic soils it is advisable to apply 1,200 to 2,000 kg/ha of phosphorus which is unpractical. How can we maximize the application of 40 kg of $P_2O_5$/ha? Can it be done by adapting and selecting patterns that would fit those conditions? Can we develop management techniques such as returning crop residues or applying organic matter? Such measures could be useful in newly cleared land where the pH is low (4.6). Indeed, the application of 40 kg phosphorus per hectare and small amounts of lime could result in yield increases. Thereafter, as the farmers become more economically strong, they could apply more of these materials and nutrients so as to build up a more stable and productive system.

**Chairman: Hesse, P.R.** (FAO): We should now move on to the second topic of the discussion, namely cropping patterns to optimize the use of these problem soils. This topic will be divided into two main parts, one dealing with nutrient supply by recycling and the other with water management.

With regard to the first part, if we review what has been presented during the symposium, we may recall that Dr. Miyake in his paper recommended the use of mineral soil to improve peat soils but he also recorded the use of farmyard manure and compost to increase rice yields, in spite of the high amounts of organic matter in these soils.

Dr. McIntosh emphasized the importance of recycling crop residues to maintain soil organic matter and to provide buffering and exchange capacity to these soils (Red Yellow Podzolic soils in Indonesia), in addition to improving their physical structure. With such management, 5 harvests/year were made possible. Also he pointed out that it was important to return the crop residues to the soil each time after harvest.

Dr. Li clearly demonstrated the detrimental effect of cultivation and deforestation on the organic matter content of Red soils in tropical China. He also showed how the regular incorporation of crop residues can be used to restore organic matter in these soils. He then mentioned that compost was being used with advantage in paddy soils, along with *Azolla* for rice fertilization. It also appears that *Azolla* can be utilized for upland crops as well. In China, I saw a compost consisting of rice straw mixed with silt used to fertilize *Azolla* which in turn was used to fertilize other crops.

Dr. Samrit described how important it is to maintain organic matter in the Thailand upland soils which are characterized by a low base status, low water-holding capacity and low nutrient retention capacity. He also showed that the effect of mineral fertilizer was enhanced when manure was applied as well. However, he indicated the disadvantage of recycling crop wastes because of the bulk and transport difficulties, which made this practice unprofitable. He also pointed out that mulching was a good practice.

Dr. Kubota showed that the use of crop residues as mulch improved the water regime of upland soils of Thailand and enhanced their fertility.

Dr. Tokudome found that the addition of organic materials promoted the development of water stable aggregates in soil and that fresh green manure was superior to compost.

It thus appears that most participants pointed out the advisability of recycling crop wastes.

The discussion is now open.

**Somasiri S.** (Sri Lanka): I quite agree with the need for using crop residues on soil. However, the methods of incorporation of the crop residues which would be the most suitable require further research. When these are used as a mulch, seeding within the mulch becomes a problem. I believe that a better definition of the use of crop residues would be useful.

**Li C.K.** (China): As far as China is concerned, the problems of restoring soil organic matter and providing organic manure largely depend on the supply of power and energy sources to the farmers.

**Chairman: Kanwar, J.S.** (ICRISAT): The concept of recycling organic matter or organic residues is very sound but there are some practical problems. Presently in northern India, where the "Green Revolution" is going on and rice/wheat rotation is being actively promoted, in the irrigated areas, the problem is how to incorporate this material into the soil, let it decompose so as to be able to sow the next crop on time. As a result, the farmers have no time to incorporate this material and they simply burn it. Yields of paddy amount to 6 ton/ha. After burning rice and wheat stalks, the farmers sow a legume crop and come back to paddy.

I wonder if any research is being done on the turnover of this material.

**von Uexkull, H.R.** (Singapore): I believe that if the farmers are obtaining such high yields (10 ton/year, of which 6 ton of rice and 4 ton of wheat), there will be a large amount of organic matter in the roots which will remain in the soil. With such yields, the farmers can afford to buy fertilizers which will further increase the amount of organic matter and improve the soil.

**Chairman: Kanwar, J.S.** (ICRISAT): I agree with you that yields are high. However this type of technology is based on the use of a considerable amount of fertilizers which are becoming very expensive, in particular nitrogen fertilizers. The farmers will be faced with the following problems: Should they burn crop residues and add fertilizers or should they develop cropping systems whereby legumes are introduced to supply nitrogen to the cereal crops in the rotation? It seems that the use of legumes will assume a growing importance.

**McIntosh, J.L.** (IRRI): I believe that more research should be carried out with regard to the effect of management of organic residues and materials on soil over a long period of time.

For instance there are conditions under which returning crop residues to the field may decrease, have no effect or increase the productivity of the next crop.

We should determine the soil and environmental conditions which cause these different results. We could perhaps suggest on the occasion of this meeting that long-term experiments which are better defined and characterized be carried out so as to study the effect of residues management on soil fertility and crop production.

**Chairman: Hesse, P.R.** (FAO): I agree with you and I also believe that the problem of organic recycling should be approached in a more scientific way.

**Watanabe, I.** (IRRI): The importance of organic matter as fertilizers, soil amendments and mulching material to upland soils was pointed out in many reports. In paddy soils, the management of straw is drawing the attention of many scientists and farmers as the development of multiple cropping requires appropriate management of straw and the shortage of fertilizers stimulates the use of straw as a source of nitrogen fixation.

At IRRI, we plan to hold a workshop on the use and role of organic matter in rice production in September 1982.

I would also like to add that as a part of the International Network of Soil Fertility and Fertilizer Evaluation for Rice (INSFFER) activities, we have organized collaborative trials to study the decomposition of organic matter using the same material, i.e. rice straw, in a wide range of environments from the temperate to the tropical areas. We would like to analyse the effect of temperature and other soil conditions on the decomposition rate of straw in paddy soils. We do hope that cooperative research will be set up with other institutions interested in this problem so as to compare the role, decomposition rate and effect of organic matter in a wide range of environments.

**Goswami, N.N.** (India): The use of organic residues in soil conservation is important. However the management of organic residues in the field should be so organized as to meet specific objectives, whether it is intended to 1) serve as a mulch, 2) increase the amount of organic matter or 3) supply nutrients.

The effect of the incorporation to soil of organic residues on the dynamics of soil systems with regard to the physical, chemical and biological properties should also be studied.

**Inoue, T.** (Japan): We know that organic residues are very important for the conservation of the chemical and physical properties of soil. However, in the semi-arid areas or under upland conditions plant residues are not available at the beginning of the rainy season as crops are not being cultivated during the dry season. Since the farmers usually apply plant residues after harvest, the decomposition pattern of organic materials during the dry season requires more research.

**Li, C.K.** (China): Although the recycling of soil organic matter can be studied in field plots over a long period of time, it might be preferable to carry out research in larger areas under more complex topography and environmental conditions. This problem should be better approached from the angle of ecology or environmental science.

**Ismunadji, M.** (Indonesia): I would like to make a few comments: 1) In some parts of Indonesia it is a common practice for the farmers to incorporate rice straw directly after rice is harvested in areas where the water supply is adequate. It seems that as far as water is available, direct incorporation of rice straw is not harmful to lowland rice. 2) In the tropics, organic matter content of soils is very low and it seems that the decomposition rate of organic matter is extremely rapid due to the hot and humid climate. 3) Recently, we have conducted experiments on lowland rice by applying increasing rates of rice straw (0, 10, 20 and 40 ton of straw/ha) on a Latosol in Bogor. The results indicated that plots with the highest level of application had the highest yield. However, it has also been shown that a high amount of straw application in heavy Grumusols decreased yields. It is therefore necessary to conduct experiments on straw incorporation in relation to the soil texture.

**Zahari, A.B.** (Malaysia): We have observed the occurrence of $H_2S$ toxicity after the application of rice straw in acid sulfate soils. It appears that this residue promotes the establishment of an extremely reduced condition whereby $SO_4^{2-}$ is transformed into $H_2S$ and although excessive amounts of ferrous ions occur in the system, up to 10% of the sulfate-S is released as $H_2S$.

**Chairman: Kanwar, J.S.** (ICRISAT): I believe that problems pertaining to the recycling of organic matter require a precise definition of the soils and environments. What is applicable to the humid tropics is not necessarily suitable for the semi-arid tropics. In the humid tropics, for example, where there is a good production of organic matter rapidly decomposed, recycling of organic matter is practicable unlike in the semi-arid tropics where the amount of organic matter available is very limited. Also, there is often a discrepancy between field and laboratory results.

**Chairman: Hesse, P.R.** (FAO): We are now going to proceed to the discussion of the part 2 of the second topic, namely water management. Dr. Kyuma will lead the discussion.

**Chairman: Kyuma, K.** (Japan): There were a few papers on the moisture regime of upland soils. Cropping systems designed with a view of preserving moisture regime in soil and conserving soil were presented. I would like to ask Dr. Kubota whose work aimed at the first objective to indicate what his initial purpose was and how he designed the cropping systems he described.

**Kubota, T.** (Japan): It appears to me that the problem of the preservation of the moisture regime in soil varies with the countries.

For example, in Indonesia, where the precipitation averages 100 mm/month multiple cropping is possible.

In contrast, in Thailand which has a distinct dry season soil conservation is more difficult and cropping patterns are limited. If legumes are cultivated as a first crop, the effect on the second crop is not always beneficial as the first crop may have depleted the water resources in soil.

The situation of Malaysia where the monthly precipitation is about 60 mm seems to be intermediate between that of the two former countries and soil erosion is likely to be less severe so long as grasslands are maintained.

In areas where forests are being cleared to make room for the cultivation of agricultural crops, water management is most important for preventing soil deterioration. As for the management, the first stage after clearance is crucial and minimum tillage should be promoted in order to preserve the thick horizon of soil, particularly in hilly areas so as to avoid irreversible soil damage.

**Chairman: Kyuma, K.** (Japan): The discussion is now open.

**Resende, M.** (Brazil): In the cerrado region of Brazil, water, crop and soil management is extremely important for rainfed agriculture during the dry spells in particular. Emphasis is placed on increasing the root depth (25 cm) as the water table is very low and high evapo-transpiration rate is usually recorded (5 mm/day). The practice of minimum or no-tillage requires chemical control which is expensive and not practical over large areas. Therefore, crop and soil management appears to be more realistic and leaching with gypsum or deep application of lime could be practiced. Also lime and phosphorus can be placed behind the mouldboard of the machine used for plowing the soil.

**Ohno, Y.** (Japan): In the subtropical zone of Brazil, minimum tillage is being practiced for the cultivation of wheat after harvesting soybeans or other summer crops. This method enables to preserve soil moisture and stabilizes the cultivation of wheat at the early stage of growth, compared with conventional techniques, particularly when precipitation is low. Yields of wheat average 2 ton/ha with little fluctuation. Although minimum tillage is being adopted for summer crops such as soybean and others, weed control may be one of the constraints for other crops.

**Chairman: Kanwar, J.S.** (ICRISAT): The experience of minimum tillage in the humid tropics has been well documented at IITA in Nigeria.

In the semi-arid tropics efforts are made to minimize soil disturbance. The watershed concept is being practiced on a 0.4 to 0.6% slope. Once beds 1.5 m broad are made, harrowing is carried out. This type of deep land treatment on Vertisols enables to minimize the use of energy for cultivation, to increase the infiltration of water in the soil, to facilitate surface drainage, resulting in the production of 2 crop/year, as moisture is readily available to the plants.

On the basis of meteorological forecasts, one week prior to the monsoon season starts, dry sowing of maize and sorghum should be done with a legume as intercrop. Maize and sorghum are harvested first after the rainy season is over and the legume is maintained. Tillage is not practiced and little harrowing is needed after both crops are harvested.

This system has been evaluated for many years and found to be very effective. A yield of 4 ton of crop/ha can be achieved regardless of the presence of drought.

As for the Alfisols, the same system can be applied but land treatment is more difficult due to runoff of water which should be collected and recycled for irrigation.

**Somasiri, S.** (Sri Lanka): Land treatment for soil and water conservation is chiefly a problem of soil conservation. In Alfisols, the water-holding capacity is far less than the seasonal rainfall. The most critical problem is the safe disposal of excess rainfall. In this regard, it is important to carry out research in the individual environment rather than apply information from other countries directly. A critical evaluation of the physical environment (climate, land characteristics, etc.) would be the starting point for such investigations.

**Chairman: Hesse, P.R.** (FAO): As we are coming to the end of the session, you may remember that on the first day of the symposium Dr. Kanwar asked the following question: "What about second generation problems"? These could perhaps be discussed now.

**Chairman: Tanaka, A.** (Japan): I would like to suggest that Dr. Kanwar comment on this question.

**Chairman: Kanwar, J.S.** (ICRISAT): In the case of the developing countries, the major problem to consider is the soil fertility problem, in addition to the physical and chemical properties of problem soils. Productivity can be increased by the judicious use of fertilizers along with the selection of the best adapted cropping pattern. Although good results have undoubtedly been obtained, the environment still requires improvement so as to increase the efficiency of fertilizer application. The problem to tackle is how to improve the efficiency of these nutrients to further increase productivity. Also it would be important to improve the environment. In particular, when shifting from one crop to another to achieve higher cropping intensity, the environment changes with regard to the availability of nutrients or fertilizer efficiency.

To sum up, the second generation problems are the improvement of the efficiency of the inputs and of the environment for crop production.

In the case of the developed countries, the problems consist of coping with the consequences of the application of high technology, such as leaching loss of fertilizers and pollution of the environment. These problems are also facing the developing countries. For example, in the irrigated areas, the disposal of organic residues must be tackled actively, while, on the other hand, phosphate, zinc and nitrogen deficiency is being increasingly recorded. Thus, these countries will have to cope with the decline in soil fertility as a consequence of intensive cropping.