RECENT ADVANCES IN THE SCIENCE OF SOIL AND MANURE IN JAPAN

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OVERSEAS TECHNICAL COOPERATION AGENCY

Foreword

This booklet is a compilation of extracts from the English translation of lectures given at the meeting for the commenmoration of the 40th anniversary of the Society of the Science of Soil and Manure, Japan.

Although seems to have been somewhat ameliorated in recent years, still world food situate the main task in agriculture is to realize the increase of food production.

The adoption of improved crop varieties is no doubt one of the most effective means for that purpose, and an appropriate application of fertilizers is an essential requisite for the extension of new varieties.

The lectures given here are rather of a retrospective nature, but I believe they contain many valuable suggestions and indications for the future progress of the study, and I hope this publication will contribute to the promotion of agricultural production and to the solution of food problem especially in the developing regions.

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I. 40 Years of Society of the Science of Soil and Manure, Japan

by Akio Fujiwara*

It became known recently that history of Japanese agriculture from the beginning is quite long. As long as agriculture was carried out on land, the knowledge of soil must have been indispensable to people of that time. Although it is commonly known that Yayoi culture was supported by rice growing, there is also a comment that an incipient agriculture existed in the late jomon culture in northern Kyushu. Furthermore, the fact that carbonized rice grain was found from the late Jomon culture ruins at Ukikumita of Karatsu-city proves that the history of paddy rice cultivation is quite old. We can agree with the theory that Jomon culture, which received this precise paddy growing technique, must have had an incipient agriculture to receive it easily. And who can say that there were no like situation too about the field crops, e.g. millet, sorghum, etc. or root vegetables like yam and taro?

Moreover in the Yayoi period, even as early as the 3rd to 4th century, it has been proven through relics that paddy rice had already spread as far as Aomori Prefecture. This is not a written history, and we only have earthenware with marks of rice grains carbonized rice, scenery of farms illustrated on the back of mirrors and copper bells and the ruins of paddy fields in Toro to prove that we had agriculture in those days.

Probably the knowledge on agriculture accumulated from those days relates to the article in the book "Hitachi Fudoki" on land reclamation by a god and to the articles about green manure and blood manure in "Harima Fudoki". After this we can see the gradual development of the soil and fertilizer side of Japanese agriculture techniques through the description of barnyard manure in the book 'Engi-shiki' and numerous records on agriculture starting from the Muromachi period. More recently in the Edo period advances in soil and fertilizer science can be seen through those books as 'Nogyo-Zensho' by Yasusada Miyazaki', 'Dosei-ben' and 'Baiyo Hiroku' by Shin-en Sato. But there was no form of primitive academy where agronomists, or people either connected with or interested in soil and fertilizer gathered and talked with each other. The medical study group gathered around Genpaku Sugita and collectors group of archeological materials with Sekitei Kiuchi as the central figure were rather genuine academic groups in those days. It is said that the earliest academy in the world are Academia dei Lincei (1603) and Royal Society (1662), but they started from a colleagues' gathering, and our Society of the Science of Fertilizer and Manure was, as we will see later, no exception. In the Meiji era western agronomy was introduced, and by Fesca, Kinch Kellner and others the door to soil and fertilizer science was opened. Important achievements in those days were published in various printed matters, for example in the Government official bulletion, etc., and contributed greatly to the modernization of our agriculture. About this time by Jikei Yokoi, a forerunner, the 'Dai Nihon Nokai (Agriculture Society of Greater Japan)' was formed in 1881 and the first Society's Report was published.

After that scientists gathered to form a society of agricultural science in 1887, and in the next year 1888 the Report of Society of Agricultural Science (latei renamed

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Agricultural Science Report) was published and this was the first appearance of a purely academic publication in the field of agronomy. This publication by printing many results of studies on soil and fertilizer, greatly helped the development in this field up to the Showa period. Until Showa period when each specific field began to be separated into their own societies and began to publish their own publications, this 'Report' played a very important role.

Later in the field of soil and fertilizer science the 'Dojo Hiryo Shimpo (New Report on Soil and Manure)" was published. This was supported by Fusajiro Kobayashi, Kameichi Monta, etc., who gathered at Pottash Fertilizer Extension Assn. This magazine was printed in a rather large format for those days and was easy to read nad was enlightening. It must be stressed on the other hand that Chiyokichi Suzuki, after leaving the Agricultural Experiment Station of the Ministry of Agriculture and Commerce published according to his own editing style the "Hiryo Kenkyu Kai (Fertilizer Study)" in 1907, and mixing popular arricles and news on colleagues's activities, continued the publication until the end of World War II. In Japan, fish meal was considered the most important manure since the Tokugawa era. But as Japan increased influence in Manchuria through Sino-Japanese and Russo-Japanese Wars, soybean cakes began to take its place.

After around 1905, a large number of chemical factories especially of fertilizer factories were erected, but in 1907 with the outbreak of the world-wide economic panic our country's fertilizer industry centered around calcium superphosphate manufacturing was bit very strongly. It was also in this year that the Artificial Fertilizer Federation was established. Abroad, in Germany manufacturing of explosives and fertilizers through fixation of atmospheric nitrogen was tried. We could say this was the time of change inside and outside the country. All in all, the last part of Meiji era can be seen as the time when various potentiality was accumulated both internally and externaly. For instance, in the field of soil and fertilizer science, "Internationale Mitteilungeu" fur "Bodenkunde was published in 1911 in Berlin, and in 1916 "Soil Science" was published in the United States. Russian "Pochvovedenie" was published in 1899. Later still in 1922 Zeitschrift fur Pflanzenernahrun, "Dungung und Bodenkunde" was published in Germany. We can say last years of Meiji were the time when early modernization concerning soil and fertilizer was further urged both at home and abroad.

(1) Fertilizer Conference ("Hiryo Kondan-kai") Period (1912–1914)

As I have already said, the last part of Meiji can be regarded in many ways as the forerunning years of revolution in the field of soil science and fertilizer science. Feeling this move while abroad, Keijiro Aso, professor of Tokyo Imperial University College of Agriculture, came home in 1912, and together with Tsunejiro Imazeki, who was his senior and an engineer connected to the Agriculture and Commerce Ministry, Matsujiro Kamoshita, Teiichi Uchizawa, Wakito Yamashita, Gintaro Kaikubara and others, he founded the Fertilizer Conference.

The conference started officially in October, 1912 and was organized and operated by the technical experts of Tokyo Imperial University, College of Agriculture, agricultural colleges agricultural laboratories and fertilizer companies, and met once a month usually at Gakushi Kaikan (B.A. Hall) in Kanda talking about facts on soil and fertilizers and exchanging their knowledge. The character of this conference was not strictly academic, but it had the air of being a sort of a friendship meeting of the leading people of those days interested in various problems of soil and fertilizer. Around this time, Laue first started to use the X-ray analysis, this later proved very useful in analyzing the clay minerals. In 1912, when the Fertilizer Conference was formed, the price of rice rose exceedingly causing the import and sale of foreign rice and this situation of agricultural production and demand probably aided the establishment of Fertilizer Conference.

The very bad crop in Tohoku district in 1913 raised a cry for an increase in production. This too had an effect on forming the Conference. In the same year the "American Journal of Botany" was published in the U.S. We could also define this age as the eve of World War I when each country was strengthening its chemical industries backed by the development ain ammonia industries.

(2) The start of Society of the Science of Soil and Manure, Japan (1914–1927)

After two years of the establishment of Fertilizer Conference where volunteers of the soil and fertilizer field talked, plans of reorganizing it into Society of the Science of Soil and Manure began to be completed. On the 3rd of October, 1914, at its 14th Conference at Kanda B.A. Hall, the official motion of changing the Conference to the Society of the Soil and Manure was adopted, and thus the Society started. As a rule, it was to meet on the first Friday every two months. Although the name was changed into new one there was not much difference in the management of the Soil and Fertilizer Society. At the 3rd meeting in February 1915, the chairman, until this time not set, was appointed. Matsujiro Kamoshita was elected as the first chairman. The Soil and Manure Science Society held extraordinary meetings other than the regular ones. A meeting held in January 1916 at the dining hall of the Tokyo Central Station, with Yoshinao Kozai, the Director of Agricultural Experiment Station, Director of Agriculture Bureau of the Ministry of Agriculture and Commerce, and, Hitoshi Doke, as guest speakers. This meeting was a very successful one with 86 people attending, among them were Umetaro Suzuki, Keijiro Aso Manure Science Society Gintaro Daikubara, Bun-ichiro Mitsunari, Fusajiro Kobayashi, Chutaro Yonemaru, Unokichi Yamagata and Toyotaro Seki. But this society also bore a character of a group of likely minded colleagues most members living in Tokyo district, succeeding the colour of its predecessor, Fertilizer Conference.

In those days, soil science in Japan was full of energy so that the term "Daikubara Acidity" which showed the successful achievement of the study on acid soil, Dr. Daikubara presiding as the leader, was employed world-wide.

Economic activities were on upward trend and food production increase was urgent problem facing the coming World War I. The Ministry of Agriculture and Commerce promulgated in 1916 Rice, Barley and Wheat Variety Improvement Promotion Regulation to stimulate production of food grains and secure the nation's food supply.

From 1916, Tsunejiro Imazeki, Keijiro Aso, Gintaro Daikubar, Chutaro Yonemaru Bun-ichiro Mitsunari, Iomaro Nanba, Michi Imai, Ichiro Kawasaki succeeded each other every year as the chairman of the Soil and Manure Science Society.

In 1925 when Dr. Aoi became chairman, talks about publishing a bulletin came up. Meanwhile, food problem had become the subject pressing agricultural policy, and in 1918 the Ministry of Agriculture and Commerce established a Temporary Foreign Rice Control Division to cope with the increase in the import of rice from abroad.

In 1922 a sharp decline in rice price occurred, and in the next year the Central Bank for Industrial Cooperatives Act was promulgated.

In 1921 the "Fertilization Standard Research", which bore a revolutionary meaning in Japanese soil research history, started. This research was based on a edaphological viewpoint with the three-element test as a nucleus. And this was much different from the soil classification system based on geological series or mother materials, introduced in early Meiji years by Fesca and others.

Hadding (in 1923) and Rinne (in 1929) experimented X-ray analysis of clay around this time. From the study on plant nutrition the three following microelements were put down as necessary elements: manganese by McHargue (in 1926), boron by Warington (in 1923) and zinc by Sommer and Lipman (in 1926).

It is a well known fact that copper and molibdenum joined later in the group of necessary elements. The ecology and physiology of soil microorganisms especially of the nodule bacteria posessing nitrogen fixing capacity, were given attention. "Plant Physiology", a book that later bore a heavy importance in the studies of crop nutrition, was published in the United States in 1925. With World I in the middle, this period was the time of active movements. We could say this was the time when rice prices jumped up and down and when new study methods were introduced in the field of agricultural science throughout the world.

(3) Period of large sixe ("Kiku" format) vertical column Journal (1927–1933)

In 1926 the "Journal of Agricultural Chemistry" was published under the leadership of Umetaro Suzuki by researchers of agricultural chemistry who until this time as the members of Japan Society of Agricultural Science had been publishing their numerous achievements in "Society of Agricultural Science Report". This made a very strong impression on the Society of the Science of Soil and Manure. Until that time Toyotaro Seki and Keijiro Aso, who were leaders of a committee in the Society of Agronomy, helped the establishment of the soil naming system. This system has been maintained until today and is called the "Society of Agricultural Science System". Although they might not have been satisfied with the fact that the name was not "Soil and Manure Science Society System", the noted ASK selective analysis apparatus was manufactured on the basis of this system.

All these moves, both internal and exteranl, towards the publication of their own bulletin led to the official adoption of a motion during the time when Dr. Aoi was chairman of the Society and in December 1926, with Toyotaro Seki as the chairman for the second time, the bulletin was published, and this is a great step toward modernization of the Society of Soil and Manure Science, Japan. Around this time the Pan Pacific Scientific Congress was held in Japan and the status of the members were sometimes decided by whether they has their own bulletin or not. A number of agricultural academies became independent from the Society of Agricultural Science and published their own bulletins. We could say that this helped promote the trend toward the publication of the Soil and Manure Science Society's own Journal.

In May 1927, all members of the executive committee with Chairman Seki as the leader, voted in facor of publishing a bulletin, and at the second council held on the 17th of June rules for the publication of a bulletin were enacted. We deem this date as the day of establishment of our Society. In July invitation to the membership of the new born "Society of the Science of Soil and Manure, Japan" was sent nationwide, and by September 1400 members subscribed.

At this point the Soil and Manure Science Society evelved out of the character of Tokyo centered conference and became closer to true national society.

The "Journal of the Science of Soil and Manure" published at this time was printed vertically in "Kiku" size, and was published 4 times annually. The contents were editorial, excerpts, miscellaneous articles, questions and answers, articles on meetings, etc. and was practical as well as theoretical. We can see this by the fact that it is written in the article of the General Rules, "This society aims at the study of soil and manure and its popularization". The member fee were 2 Yen per year. The editiorial policy was very aggressive. There were many enlightening articles, and they tried through questions and answers to meet the demand of the engineers of the agricultural associations who made up a majority of the 1400 members throughout the country.

Fertilizer market price table and records of patents were contained too, and in a word had the characteristic of a general magazine, such as the "Agricultural Techniques" and "Agriculture and Horticulture" we have today. Looking at the first and second number of volume one, we are rather astonished at the coincidence that most of the initiatives of important fields of study in later years can all be found there.

In the field of pedology we see "The distribution and origin of the Kanto Loam" by Tetsugoro Wakimizu, "The characteristics and origin of the so called mineral acid soil in Hokkaido" by Koji Miyake and Ishio Tamachi, in the field of clay and minerals, "On the structure, nature and function of major soil colloids" by Toyotaro Seki, concerning fertilizer and fertilization, "The rational method in substituting ammonium sulphate for soy bean cakes" by Keijiro Aso, "Results of experiments on fertilizing effect of phosphatic fertilizers" by Shin-ichiro Kasugai, "The effects of habitual use of fertilizers heavily inclined in inorganic substances" by Maki Takasaki, in crop physiology, "The effect of silicic acid on rice blast" by Rokuro Kawashima, in fertilizer industry, "Synthetic Ammonium Industry" by Matsuo Tokuoka and in the field of agricultural policy, Ichiro Kawasaki's "The fertilizer policy in our country".

One of the activities our Society participated in was the first Discussion Meeting of the Japan Society of Agricultural Science held in Kyoto in March 1927, at which Ichiro Kawasaki, Yotaro Mori, Keiichiro Tazaki, Michi Imai, Rokuro Kawashima, Shin-ichiro Kasugai and Konita Yokota of our academy took part in the discussion under the title of "The effects of fertilization of phosphoric acid on paddy".

In April 1928 a joint meeting of societies related to agricultural sciences was organized in Tokyo. The Soil and Fertilizer Science Society participated in Group Three and had a successful meeting with 19 lectures and over 100 people taking part. At the second Discussion of the Society of Agricultural Science held at this big meeting our members Toshio Araki, Yotaro Mori, Jiro Kimura, Genzo Ikari, Masumi Kanai, Riichi Fukami, Maki Takasaki, Isenosuke Onodera and Kametaro Konishi joined in the debate of "Comparison of fertilizing effects of nitrogenous fertilizers on paddy".

The fact that the problems of phosphates has priority over that of nitrogen shows the characteristics of our country's Agricultural Science, which had grown up on the volcanic ash soil of Konosu and Nishigahara Experiment Stations in Kanto District of Japan.

In 1929, the Ministry of Agriculture and Forestry began Designated Local Experiments which death with the characteristic problems of each region's soil and fertilization scientifically. It was done in prefectural experiment stations under complete financial aid from the Ministry of Agriculture Forestry. This aided greatly in the development of soil and fertilizer science.

Prior to this time at Tokyo Imperial University Faculty of Agriculture, a Free Nitrogen Utilization Laboratory was opened. The laboratory laid emphasis on the study of azotobacter, etc., and contributed greatly to the development of our country's soil microorganism study.

Great achievements were made around this time internationally by Ross, Kerr (1927), Hendricks, Fry (1928), Kelley (1928) and others through X-ray analysis of clay and minerals. Attention was also given to the field of study concerning the effects of base substitute on plant growth, studied by Gedroiz (1930) and others.

In 1930, the former joint meeting of the societies of the various fields of agriculture and forestry sciences was reorganized, and the first Convention of Agricultural Sciences was held. The Soil and Manure Science Society participated in the Group No. 10, giving 24 lectures. The content of the lectures were published in the second issue of the Journal published that year.

Also in the same year, the second International Soil Science Council was held in Moskow and Keijiro Aso, Masataka Omasa and a few more members participated.

In Discussion Meeting of 1931, held by the Society of Agricultural Science, a very interesting theme of "Method of reducing the production cost of agricultural products (including fishery, forestry, livestock and sericulture products) as seen from the technical side" was taken up. Our member Toshio Araki took part in it.

From the 6th volume in 1932 pages of the Journals were numbered all through the year and quotation became much easier. This was the time when Soil and Manure Science Society, publishing bulletins showed very vigorous external activities. We could say the energy accumulated during the past period began to blossom.

Keijiro Aso was elected chairman and Matsusaburo Shioiri, expert of the Ministry's Agricultural Experiment Station, was elected vice-chairman in December, 1928. In those days, general conference of the Society was held in December and the administration for the next two years were decided there. The fiscal year was from January 1st to December 31st. It was later changed to begin on the 1st of April.

(4) The period of laterally columned 3 x 3 size Journal (1933 – 1939).

In 1933, when Keijiro Aso was chairman and Arao Itano of Ohara Agricultural Institute vice-chairman, a brand new policy was adopted concerning the publication of the Journal. Printing office was moved, in order to reduce the cost, to Kurashiki-city in Okayama Prefecture, home of the vice-chairman.

Furthermore, concerning the publication, various proposals were made. These were (1) to attach English titles and excerpts to the articles, (2) to print laterally, (3) to issue Journals six times annually instead of four, (4) to divide the publication into A and B, designating A for academic study thesis and B for practical reports and publish them alternately each month, (5) to publish the list of members' names and addresses, (6) to promote contributions of reports, etc. Not all the proposals were immediately adopted, but they marked the evolution of the Journal out of the character of general magazine to that of the more academic magazine. It was an important period.

Among items above mentioned, (1) was put into practice from the seventh volume. Moreover, the name, volume and number were printed on the back of the Journal. This reformation was attained from 1934, when Yokendo Printing Co. took charge and printed it in a laterally printed 3 x 3 format.

It should be mentioned here that "Japan" was added to the title of Soil and Manure Science Society and the name was read "Society of the Science of Soil and Manure, Japan." This too shows the enthusiasm for a larger scaled society.

From the 8th volume in 1934 the excerpts of lectures were published as an appendix. Accordingly, with the four quarterly publications, actually five issues were published annually.

In 1935 Keijiro Aso was elected chairman, Yoshizo Hayashi, engineer of the Agricultural Experimental Station of the Ministry of Agriculture and Forestry, as vice-chairman, and in the next year of 1937, Keijiro Aso was elected again as chairman and Jiro Kimura, engineer of the Agricultural Experimental Station, as vice-chairman.

In 1935 the 3rd International Soil Science Council was held in England, and Matsusaburo Shioiri and a few others participated. I might also add that in the Society of Agricultural Science Discussion Meeting in April 1932 Ichiro Kawasaki participated under the theme "The management system to make our country's agriculture remunerable" and also in the next year's Meeting in April, Hirokichi Suzuki participated. This time the theme "Measures to overcome the depression of our country's sericulture" was taken up.

Although the name was changed to Society of the Science of Soil and Manure, Japan and nation-wide academic activities were looked for, actual results were not completely satisfying, and a move towards the establishment of local branches began.

In 1936 a change in rules allowed establishment of branches, and in 1937 with the members of the old Special Lecture Meeting as nucleus, Kanto Branch was founded. After this Kansai Branch, West Japan Branch, Formosan Branch and Manchurian Branch were established one after another, and energetically promoted branch activities till the end of World War II. Of these, Kanto Branch inherited the character of the Fertilizer Conference and Special Lecture Meeting, and on an independent finance from the main office of the Society promoted its own friendship activities, too.

Furthermore, the 1st issue of the 10th volume published in 1936, was named the 10th anniversary commemorative edition and the 4th issue had as the supplement a member list and a complete index from volume 1 through 10. This was quite significant as the sum total of the 10 years. It is worthwhile noting that from the 8th volume a supplementary issue containing extracts of lectures began to be published and the actual number published per annum became 5. Later, from the 10th volume publication became bi-monthly and from the 13th volume, published in 1939, the Journal became monthly. Thus the magazine literally became a first class academic bulletin.

(5) Period of expansion over wide area (1939 – 1944)

Although our Society had been renamed Society of the Science of Soil and Manure, Japan and established its branches all over Japan and abroad trying to extend its activities, its penetration into provincial areas were not perfect, for all of the chairmen had been living in Tokyo district.

We see a great significance therefore, in the fact that Shigeru Osugi of the Kyoto Imperial University was elected in 1939 to the chairmanship, which from 1914 had been held by people in Tokyo district. The vice-chairman was Shin-ichiro Kasugai of the Tokyo Imperial University.

This does, in a sense, show that the activities of the Society had penetrated to local districts, but on the other hand it was backed by the general mobilization campaign to raise agricultural production and to secure food, fostered in the coming of the Second

World War.

Following Dr. Shigeru Osugi, professor Koji Miyake of Hokkaido Imperial University became chairman in 1941 with Matsusaburo Shioiri as vice-chairman. In 1943, professor Kazumi Kawamura of Kyushu Imperial University and Yoshizo Hayashi became chairman and vice-chairman respectively.

With Japan plunging into war, the researches and studies of soil and fertilizer in Asian Continent and in Southeast Asia became active during the period, and some of them were published in the Journal. And with Matsusaburo Shioiri as a leading figure, the study on paddy soil was promoted too. A publication of this period that helped the activities of soil and fertilizer scientists indirectly, was the "Glossary of references for the promotion of fertilization improvement" published by "Dai Nihon Nokai (Agriculture Society of Greater Japan)".

This Glossary was published with the financial aid of the Agriculture Bureau of the Ministry of Agriculture and Forestry. The Society published many printed matters written by specialists in the field of Soil and Fertilizer Science such as "The basis of fertilization method" and "Chemistry of paddy soil" by Matsusaburo Shioiri, engineer of the Agricultural Experiment Station of the Ministry of Agriculture and Forestry, and at the same time Dai Nihon Nokai held study meetings called "Local study meeting on technical problems concerning fertilizers" in various parts of Japan inviting soil and fertilizer engineers of the district with professors of the Imperial Universities in the district presiding.

At these meetings Koji Miyake, Shin-ichiro Kasugai, Shigeru Osugi, Kazumi Kawamura and other leaders of our Society presided. The Universities became closely connected with the local agricultural engineers in the district and the research on development of unused domestic fertilizer sources and reexamination of customary agricultural techniques became the main theme for the academic circle. As the war became serious, our Society's activities dwindled because of lack of goods and travelling difficulties in Tokyo and elsewhere. In 1942, the "Food Control Act." and in 1943 "Agricultural Organizations Act" were passed.

(6) Dormant Period (1944 – 1948)

As the situation of the war became worse for Japan, the activities of our Society were restricted from every direction and activities came to an almost complete halt. Most of the printing press in Tokyo were burnt out with the bombardment becoming more fierce. The Divisions of Agricultural Chemistry and Soil Survey of the Agriculture Ministry's Agricultural Experiment Station had to be moved to the countryside. The members of our society too became scattered, and further activity of the society was impossible.

On the 11th of December 1944, the last pre-war General Conference was held in Otemachi Hall, and Kazumi Kawamura, the chairman at the time, made an ammouncement of all activities being stopped temporarily. Though Shin-ichiro Kasugai and Hiroshi

Kamoshita, Agricultural Experimental Station engineers were elected chairman and vice-chairman respectively, the desolation after the war did not permit for a while the restoration of the Society's activities.

(7) Reconstruction Period (1948–1955)

Under chairman Kasugai, secretary Teruo Nakamura worked hard to restore the Society. The income from membership fees of the Society had stopped completely but there still remained a small amount of fund and contributions from the Japan Fertilizer Company, a national policy company, were added as funds for activities. The amount of available funds left in the Society fluctuated with the frequent freezing and de-freezing of the new Yen currency. But by efforts of the executive staff printing paper was allocated periodically from Japan Publication Council (Nippon Shuppan Kai) and was stored by the Society, which proved to be very useful later when publication was commenced.

By the middle of 1947, opportunity for the revival of the Society's activity began to ripen. The secretariat first sought out the old membership cards and sent a restoration notice and gained a membership of about 500.

In 1948 the manuscripts damaged by war at the printing presses were put into order and published as the 1st issue of the 19th volume of "Journal of the Society of the Science of Soil and Manure, Japan", the 1st revival issue. This was printed in B5 size, and 1000 copies were printed. The same year including excerpts of lectures, issues 1, 2, 3, 4 and combined 5 and 6 were published and activities again became animated. A new roster of members was attached to the 4th issue.

In the same year North Japan Branch, Kanto Branch, Kansai Branch and West Japan Branch were re-established, and in 1949, Tohoku Branch was added making the total of 5 branches.

A complete revision of the rules for the new age was attempted by chairman M. Shioiri and vice-chairman S. Mitsui, then assistant professor of Tokyo University. New provisions such as concerning the election system of the chairman were adopted.

It is also noteworthy that in 1951 General Conference was held outside Tokyo district at Shiga Agricultural Junior College where chairman Shioiri was president.

Professor Azuma Okuda of Kyoto University, after being elected to the chairmanship in 1952, promoted the modernization of the Society initiated by the former executive staff.

To establish the financial basis for the Society first, he started the system of supporting member besides the regular members. He asked for the understanding and support of organizations and companies for the advancement of the soil and fertilizer science. This greatly helped the development of the Society.

At the same time, to keep contact with and receive advice from the industry, the chairman could at his own discretion, choose ten trustees other than the thirty trustees elected. Also the chairman oculd commission a vice-chairman form industrial connections. It is quite natural that the mangement of the Society became flexible.

At that time under chairman Okuda the lected vice-chairman was professor Kenzo Kobo of Tokyo University and the commissioned vice-chairman was Eiji Kamatani, managing director of Fused Phosphate Fertilizer Association.

In August 1953, an extra meeting was held in Hokkaido and observation trips were made besides the research reports and speical speeches with substantial content, and all members wree given opportunity to understand Hokkaido's agriculture. This was a very successful meeting. With this precedent, it became customary to hold an extra autumnal meeting every two years, at the second year of the chairman's term. Since then extra meetings have been held in Shizuoka, Okayama, Kagoshima, Miyagi, Aichi, Hokkaido and Ehime Prefectures.

Countries abroad too were recovering from the wounds of World War II in this period, and new research activities were started resulting in new knowledge on the formation of soil, achievements through new research methods for clay minerals and humus, and new knowledge on nutrient absorption and photosynthesis in the field of crop nutrition. In 1949, "Plant and Soil" was published in the Netherlands and "Journal of Soil Science" in the United Kingdom. Thus the major countries of the wourld came to have a technical publication of their own in the field of soil and fertilizer science.

As a basis for the recovery in agriculture after the war various soil research projects were started in our country. For instance in 1947 the low yield area research, in soil research reclaimed area and soil conservation research were started, and in 1950 the paddy soil horizon survey was started by the Statistics Division of Improvement Bureau of the Ministry of Agriculture. In 1951, forest soil survey began, and in the same year a soil map in 1 : 250,000 scale was printed by the Natural Resources Section of the occupation forces. Members of our Society played a leading role in these surveys.

These movements doubtlessly promoted the active study of soil and fertilizer science, and also established its scientific basis. At the same time the cry for increased agricultural production was high, and in 1953 the Agricultural Products Price Stabilization Act was passed.

(8) Concurrent English publication period (1955–)

With the final stabilization of the Society of the Science of Soil and Manure which recovered rapidly after the war, a request arose for the evolution of the Society's publication out of the character of general magazine at the time of beginning and the Society was required to be an organization for the purely and highly scientific studies and their publications.

To meet this, a further modernization was planned in 1954, with professor Akio Fujiwara of Tohoku University as chairman, and vice-chairmans Togoro Harada, agricultural technical official, and Kazuta Takada, chief of Tokyo Fertilizer Inspection Institute of the Ministry of Agriculture and Forestry. In 1955, to cope with the sharp rise of numbers of contributed articles the bi-monthly magazine again became monthly, and to encourage young scholars, the Soil and Manure Science Society Prize was decided. Later, an award to contribution for a long time was added, and today 2 persons receive the encouragement prize and 1 recives the merit award every year.

Furthermore, to publish the achievements of our Society abroad and to receive and publish the results of studies by foreign scientists, the lpublication of an English magazine was planned. But this was quite a task for the Society then. After numerous debates the name of the magazine came to be "Soil and Plant Food" and it was to be published 4 times a year. This was due to subsidies by the Education Ministry and to our Society's account.

With the increase in membership fees, accounts of the Society began to expand, and double entry system was taken in bookkeeping and auditors were appointed to watch over the accounting. We can interpret this as one of the features of the modernization of our Society. It was disappointing however, that the plan for inviting soil scientists from China was considered too early and failed too early and failed to be materialized. It was in this period that a visit was made in 1957 by a Russian soil geologist Guerassimov.

By 1956 number of lectures increased so much that lectures at the General Conference were divided into groups to be given in each field. This was also a step modernization. In the related fields of soil science, e.g. pedology, soil microorganism study, soil physics and others, tendency of diversification and independency they conveved their own study meetings and published their own bulletins.

In this year too, a friendship meeting was held at Oji, and its effect on creating friendliness and understanding between the members was great, so that it is still continued today. Professor Keizo Hirai of Kyushu University, elected to the chairmanship in 1956, died in an unforeseen accident while travelling abroad and failed to realize his ambitious hope for the Society of the Science of Soil and Manure, Japan. This was the first time the Society lost its chairman during his term.

At the re-election held immediately after his death, Akio Fujiwara was elected chairman for the second time, and took office together with agricultural technical official, Yoshiro Imaizumi, and Ministry of Agriculture's Fertilizer Section Chief, Tadashi Nagao, as vice-chairmen.

In 1957 the branches were re-organized into 6 as we have today. Hokkaido, Tohoku, Kanto, Chubu, Kansai and West Japan (Nishi Nippon).

In 1958 professor Yoshiaki Ishizuka of Hokkaido University became chairman, and Kinjiro Yamanaka, an agricultural technical official, and Shinsaku Harama, chief of Tokyo Fertilizer Inspection Institute of the Agriculture Ministry, became vice-chairmen. At the same time Jiro Kosaka became chief secretary and reformed the office work and got fine results. Although the chief secretary system was officially adopted from this time, Seiki Moriyama, Ryuichi Shimizu, Daisuke Shimizu, Takeshi Iwata, Ryozo Yoshida and Kei Kurokawa before the war and Teruo Nakamura, Kyoichi Kumada, Akira Kinoshita and others after the war, had served in fact as chief secretary and had contributed to the management of the Society.

The first nomination of the honorary members started in 1959. Shigeru Osugi, Koji Miyake and Kazumi Kawamura were nominated and in March 1966 Unokichi Yamagata was nominated. But unfortunately Unokichi Yamagata died on October 5th of the same year.

A further step of modernization was taken when in 1960, Shingo Mitsui professor of Tokyo University, was elected chairman and agricultural technical engineers Jisuke Takahashi and Shinsaku Harama were elected vice-chairmen. First of all to overcome the congestion problem of contributed articles, with the help of the Research Institute for Fertilizer Economy a thick supplement issue was published as the 10th issue to digest the reports. And by this measure the problem of the reports being published too late was solved.

In 1961 the English versions became bi-monthly and it was widely read in South Eestern Asia too. Claiming that the name "Soil and Plant Food" was colloquial and unfit for the high-level academic publication of our Society, a proposal of renaming was made and after a wide consultation, the name "Soil Science and Plant Nutrition" was chosen. The name has been maintained to date.

In 1962 professor Kenzo Kobo of Tokyo University was elected chairman. The vice-chairmen wree, Shuichi Ishizawa, agricultural technical official, Chikgazo Konishi Chief of Second Chemical Fertilizer Section of the Ministry of International Trade and Industry. In the same year the "Committee on future plans for soil and fertilizer studies and education" was established in the academy. One of the reasons of establishing this committee was the instability of the position of soil and fertilizer science in the universities and agricultural research institutions.

That is, although soil and fertilizer science in the university is included in agricultural chemistry by customary re sons and for its method of study, there are cases when it is transferred into agronomy, because its direction of study and education is different from other fields of study in agricultural chemistry. And there is a tendency in the research institutions in the Ministry of Agriculture and in Prefectures to include some sectors of soil and fertilizer science into the department of environmental researches Kyoichi Kumada, Keizaburo Kawaguchi and others, as members of this Committee worked hard and made a number of various important achievements.

Before 1963 all of the Spring Conferences were held in Tokyo but the burden upon the staff and members in Tokyo became too heavy, and in that year it was held in Kyoto. Due to the efforts put in by the Kyoto side, the assembly was very successful. From then the Spring Conference was decided to be held in places other than Tokyo every two years.

In 1964, professor Yoshiaki Goto of Nagoya University was elected chairman, and agricultural technical officials Masatada Koyama and Shinsaku Harama were elected to the vice-chairmanship, and further development of the Society was planned. It was also at this time that the merit award of the Soil and Manure Science Society was added, and that, with the increase in number of the contributed papers at the conference, the problem of the separate reporting system arose. As a result, division chief system, whereby chief of each division controlled the reports at the General Conference was adopted in 1966 and has continued until today.

In connection with this, arguments arose on the feasibility of managing the Soil and Manure Science Society as one society, because the area of soil and fertilizer science had grown very wide and inconveniences had risen in the management of meetings.

Although the situation was similar to the time when Society of Agricultural Science gradually divided into specific societies, the decision reached after repeated discussion in our Society was that, to avoid the division of this Society, the sectional meeting system was not to be taken.

But to respect each field of study in the Society, the departmental chief system of 10 departments, as written earlier, was adopted. The 10 departments and their chief were as follows.

1st Department	Soil physics	Shigeo Yoneda
2nd "	Organic and inorganic contents of soil	Kanzo Kobo
3rd "	Soil minerals and colloid compo compounds	Shingo Funabiki
4th "	Soil microorganism	Kiyoshi Kosaka
5th "	Inorganic nutrition and nutrient absorption of plants	Shingo Mitsui
6th "	Metabolism of plants and components	Akio Fujiwara
7th "	Fertility of paddy soil	Shin-ichi Suzuki
8th "	Fertility of upland field, grassland and orchard	Kameo Nomoto
9th "	Soil development, classification and survey	Shinobu Yamada
10th "	Fertilizers and fertilization method	Yoshiaki Ishizuka

In 1966 Shuichi Ishizawa was elected chairman, with Kyoto University's professor Keizaburo Kawaguchi and Chief of Tokyo Fertilizer Inspection Institute of the Ministry of Agriculture Naoyoshi Sato as vice-chairmen.

The 11th Pacific Science Conference was held in Japan in 1966, and our Society took the occasion to participate in the section of soil and fertilizer and actively engaged in presentation of research reports and exchange of opinions. The achievements by the members of our Society received attention of the countries participating.

This symposium was held on the 5th and 6th of October 1967, and the Society of Soil and Manure Science participated in it. Our Society's members Keizaburo Kawaguchi and Akira Tanada reported on Tropical Soil, and Physiology of Tropical Rice Cultivation, respectively. The special issue written by departmental chiefs of the Society "general remarks on the development in each department" which had been planned since 1966 was published in January 1968. The publication was hailed in various fields, and more publications of this kind is looked forward to. Because 1967 is the 40th year since the first publication of the Journal, a plan to commemorate the 40th anniversary was raised in the board of trustees meeting in November 1966. After summarizing the opinions collected, it was decided to celebrate the anniversary in Spring 1968, at the same time with the Spring Conference.

After that preparations were made under Akio Fujiwara, committee chairman, Tsuyoshi Shiroshita, committee vice-chairman and chief secretary Tsuyoshi Yamamoto, and on the 4th of April, 1968, the 40th anniversary commemorative event was held in Japan City Center.

Attendance reached 500, and commendation of the Society's men of merit, presentation of the letter of appreciation and a celebration party were given. In addition to that a commemorative publication was planned to be printed.

That year Shigenori Aomine, professor of Kyushu University, was elected chairman and agricultural technical engineers Shin Nishigaki and Naoyoshi Saga were elected as vice-chairmen, and Tatsuhiko Suzuki became chief secretary.

At present, Society of the Science of Soil and Manure, Japan has a membership of 1819 and 71 shares of supporting membership, holds the annual Spring Conference and the biennial Autumn Meetings, actively presenting research results, publishes the monthly Japanese bulletin "Journal of the Science of Soil and Manure and the bi-monthly" English magazine "Soil Science and Plant Nutrition" and it also promotes various academic activities. The 6 branches too, carry on their own activities, and Society of the Science of Soil and Manure, Japan is considered one of the most influential and active academies in the agricultural field.

But are we to be satisfied with the present situation?
No, we carry serious contradictions internally and there is a slight possibility that we will crumble and disintegrate.

The increase in membership from 1400, the figure when the magazine was for the first time published, to the 1500 members around 1937 – 38 and to the 1800 in 1967 can be regarded as a very steady development. But should we be ignorant of the fact that every time the Society was modernized and purified, it had left members who were unable to follow the change? This is a very important problem to be considered.

Looking at the number of lectures given and contribution of papers to the magazine, although the number of people connected to Universities is only 20% of the total membership, the number of lectures given by them at meetings reach over 40% and the number of thesis submitted to the Journal is 60% of the total. On the other hand the number of people connected to prefectures reaches 60% of the total membership, but the number of their lectures accounts only for 20%, and the number of thesis submitted is less than 10%. This is a fact that should be reconsidered carefully.

The only balanced figure is seen in the people connected with the research organs of the *Ministry of Agriculture and Forestry.*
Their membership is 30%, the lectures 30% and thesis submittance is 20% of the total. This is a relief anyway. These facts on the surface point to the future of our Society, and at the same time hints us of the underlying problems that Society of the Science of Soil and Manure, Japan must confront in the future.

I am listing some of the problems we would face.

(1) Essence and contents of the study.

Some say that while the soil is a natural substance that exists on the surface of the earth, fertilizers are made by men, and therefore, it is not rational that the studies of soil and fertilizer do not have to meet in the same society of science, by the reason that fertilizers are used on soil.

Specialization today has progressed to the point where a specialist of one field sometimes cannot understand the report from another field. If keep standing on this point of view, we would approve the specialization, division, renewal of the Society of the Science of Soil and Manure into specialized societies of soil science, fertilizer science and plant physiology, or their unification with other existing societies. Even if we are not to be divided into these specialized fields, but to cooperate in the same study, isn't the range of the science too large to find a common place for both the basic, theoretical studies and the practical and technological studies connected to actual agriculture?

Isn't the Journal becoming too academic?

How about publishing all the academic articles in the English issues and make the Japanese Journal an introductory magazine?

How about publishing a specialized bulletin for each field and make the Journal of the Science of Soil and Manure again a composite magazine? These are opinions worth considering.

(2) Financial Independence

We could not possibly hope for financial independence under the hard condition put of management at present.

The membership fees from regular members only provides for the cost of publication, and other managing expenses are dependent on the supporting membership fees.

In the future if we are to evolve into a purer academy, the accounts should be managed by the fees of the regular members, and the regular members should bear a higher membership fee if they are to have the Society as an organ for the presentation and publication of their studies.

The problem would be much more acute if we are to divide into individual academic organs of soil science, fertilizer science and others. The establishment of the basic financial policy for the Society is an important issue in the future, and we should carefully consider the way we could lay our financial basis.

(3) Establishment of editorial policy

If we allow the division of soil and fertilizer science to different fields of study, and the Journal splits into each specific magazine, the editorial policy can be left to the individual departments, and would be comparatively easy to form, but if we are to avoid division and maintain the present situation, it would be much more difficult to set the policy.

It is a very difficult task to establish an editing policy to satisfy all of the members, ranging from the members in universities and agricultural research institutions working on basic science, to members living in local areas working as engineers close to the actual farming, and to members connected to the manufacturers who aim at absorbing a wide field of knowledge on soil and fertilizers.

Although this is a point already discussed under "essence of the study" there is the question of propriety regarding the incorporation of general remarks, news, etc., and the question of the demarcation of general magazines like the "Chemistry and Industry" and the "Chemistry and Biology" from the specialized magazine of other academies. To say more simply, the way you treat the service articles would be a problem.

(5) Management system.

In the infant stage of the Society a simple management system supported by services of the directoral staff was followed, and as the Society became more modernized the management became systematized, but it tended to be a mere formality. We should strongly reflect on the fact that it is forcibly requiring of the services of members in Tokyo district.

If we are to stop compelling members to render services to fellow members, we have to strengthen the full time workers, and it must be remembered that this will be followed by the increase of management costs and rise in membership fees.

Chronological Table

Year	Facts
(1)	Fertilizer Conference period: 1912 – 1914
1912	Establishment of Fertilizer Conference. Azabu, Imazeki, Uchiyama, Yamashita, Daikubara and others participating.
(2)	Start of Society of the Science of Soil and Manure, Japan: 1914 – 1927
1914	Renaming Fertilizer Conference of Society of the Science of Soil and Manure.
1915	Matsujiro Kamoshita nominated as the first chairman.
(3)	Vertical Column 'Kiku' format Journal period: 1927 – 1933
1922	May, Board of trustees meeting decides in favor of an official publication. Regulations for the publication of the Journal is enacted on June 17th, this marks the official establishment of the Society. October, "Journal of the Society of the Science of Soil and Manure" published ('Kiku' format, vertical column.) Chairman, Toyotaro Seki, Vice-chairman Shin-ichiro Kasugai, Participation in the first Discussion Meeting of the Society of Agricultural Science.
1929	Chairman Keijiro Azabu, vice-chairman Ichiro Kawasaki. July, 15th anniversary of Ohara Agricultural Institute. International Soil Academy Japan Branch's fellowship meeting held taking occasion of the extraordinary overall session of societies for agricultural sciences held at the Institute. Designated Experiments on Fertilizers begin.
1930	Japan Society of Agricultural Science established, first convention held, Soil and Fertilizer division participates as the 10th group and conducts lectures, total number of lectures 24.
1931	Chairman Tsunejiro Imazeki, vice-chairman Matsusaburo Shioiri.
(4)	Lateral column printing 3x3 format Journal period: 1933 – 1939
1933	Chairman Keijiro Aso, vice-chairman Shinro Itano. Society renamed to Society of the Science of Soil and Manure, Japan, publishing of Journal commissioned to Yokendo press. Bulletin renamed to Journal of the Society of the Science of Soil and Manure, Japan, 3x3 format, lateral column.
1935	Chairman Keijiro Aso, vice-chairman Yoshizo Hayashi.
1936	1st Journal published as 10th anniversary commemorative issue. Membership roster and complete appendix to the 10th volume added. Change in the rules to recognize establishment of branches.
1937	Chairman Keijiro Aso, vice-chairman Jiro Kimura. Kanto branch established, after this Kansai, Nishinihon, Formosa and Manchuria branches established, lasting till the end of the war. From the 10th volume, the publication becomes bi-monthly, 6 issues annually.

(5) Regional expansion period: 1939 – 1944

1939 Chairman Shigeru Osugi, vice-chairman Matsusaburo Shioiri.
From the 13th volume the Journal becomes monthly, 12 issues annually.

1941 Chairman Koji Miyake vice-chairman Matsusaburo Shioiri.

1943 Chairman Kazumi Kawamura vice-chairman Yoshizo Hayashi.

(6) Dormant period: 1944 – 1948

1944 December 11th. last pre-war conference, Society's activities enter a period of temporary rest. The journal is temporarily stopped after 4th and 5th issue of volume 18.

1945 Chairman Shinichiro Kasugai vice-chairman Hiroshi Kamoshita.

(7) Publication Revival Period: 1948 – 1955

1948 Revival of publication begins with the 1st issue, volume 19 of the Journal of the Society B5 format, 5 issues published this year. Kitanihon, Kanto, Kansai and Nishinihon branches established.

1949 Kitanihon branch separates to Hokkaido and Tohoku branches.

1950 Chairman Matsusaburo Shioiri, vice-chairman Shingo Mitsui. Reformation of rules to promote modernization of the Society planned.

1952 Chairman Azuma Okuda, vice-chairmans Kenzo Kubo, Eiji Matani.

1953 Summer extra meeting held in Hokkaido, later Autum extra meetings are held biennially at Shizuoka, Okayama, Kagoshima, Miyagi, Aichi, Hokkaido and Ehime. Supporting member system adopted this year.

1954 Chairman Akio Fujiwara, vice-chairman Togoro Harada, Kazuta Takada. Supernumerary trustees Commissioned.

(8) Concurrent English publication period: 1955 –

1955 Reformation in the electoral system of managers of the Society. Award of the Society Prize decided. Journal of the Society becomes monthly again. Publication of English version "Soil and Plant Food."
Adoption of the system of giving reports according to departmental divisions of the Society. Start of the friendship meeting.
Chairman Keizo Hirai, vice-chairman Yoshiro Imaizumi, Tadashi Nagao. Chairman dies while abroad. Akio Fujiwara re-elected. Shinsaku Harama later replaces Tadashi Nagao.

1957 Reorganization of branches. Present system of 6 branches adopted.

1958 Chairman Yoshiaki Ishizuka, vice-chairmen Kinjiro Yamanaka and Shinsaku Harama, chief secretary Jiro Kosaka.

1959 First nomination of honorary members.

1960 Chairman Shingo Mitsui, vice-chairmen Jisuke Takahashi and Shinsaku Harama, chief secretary Noboru Murayama. With the help of Fertilizer Economy Institute, 10th issue was a special supplementary edition to deal with increased thesis submitted.

1961 English edition becomes bi-monthly, name is changed to "Soil Science and Plan Nutrition".

1962 Commitee on future plans for the study and education of soil and fertilizer established. Chairman Kenzo Kobo, vice-chairmen Shuichi Ishizawa and science Chikazo Konishi, chief secretary Yuji Egawa.

1963 Spring conference held in Kyoto. After this time the annual Spring conference was to be held in places other than Tokyo once every two years.

1964 Chairman Yoshiaki Goto, vice-chairmen Masatada Koyama and Shinsaku Harama, chief secretary Taimei Matsuzaka.

1966 10 Departmental Chief system starts.

Chairman Shuichi Ishizawa, vice-chairmen Kenzaburo Kawaguchi and Naosuke Saga, chief of secretary Yasuo Takijima and Tomoni Gokinai.

Participates in Soil and Fertilizer department of the 11th Pacific Academic Conference. Conference.

Participates in "World Rice Symposium" planned by Japan Society of Agricultural Science.

1968 Special issue of general remarks on departmental advances under the departmental chief system published.

Chairman Shigenori Aomine, vice chairmen Shin Nishigaki and Naosuke Saga, chief secretary Tatsuhiko Suzuki.

4th of April, 40th anniversary of Society of the Science of Soil and *Manure, Japan celebrated and commemorative event held at City Center in* Tokyo.

II. Current Situation and Future Prospects of the Studies on Soil Science in Japan

by Kenzaburo Kawaguchi*

The soil science stood in the spotlight of emergent food production movement during wartime, and it met with, in tune, hardship when people talked much about animal husbandry or horticulture as a promise of modernized agriculuture. In these days however, much theoretical background and experinces have been accumulated by untiring efforts of many research workers.

No furtherly systematization of paddy field soil science has been developed ever since Dr. Shioiri had explored a system 20 years ago. But we are now on the threshold that an entirely new theoretical system may emetge in such important field of study as paddy field soil and volcanic ash soil. Today we congratulate the 40th anniversary of our Society. Let us imagine how many lectures may be presented before the floor ten years later at the 50th anniversary. This 40th meeting is an epoch which may lead to a flowering phase of the soil science.

My subject of speech is as shown on the title. The concrete contents of my study are described in a nicely abridge form in the special issue of the progress report published by the Society recently. The special issue was originally planned without connecting to the anniversary. When it was published, however, it deserved a gift to the anniversary. I read it over and again to prepare for todays lecgure. I pretend that I am one of the most well-versed one in it among members of the Society. The more often I read it over, the greater was my esteem. This book is, of course, not without minor mistakes. Nevertheless it holds more than enough informatiens about present status and future prospects of the soil science. So here I will touch upon individual research results in the last part of my speech.

2. Current Situation of the Study Groups of Soil and Monure Science

Beside Society we have many research groups each of which is consisted of members our Society of. Their activities are full of vigor and are contributing much to the progress of the soil science, which we had not experinced 10 years before.

Among them, the following 4 groups are most closely related with our Society These groups are well established as to publish their own bulletins.

Name	Bulletin	The first issue	Members
1. Soil Physics Research Group	Physical Properties of Soil	1959	600
2. Clay Soil Research Group	Clay Science	1957	506
3. Soil Micro-organism Group	Soil and Micro-organism	1960	361
4. Pedalgists Meeting	Pedalgist	1957	529

*Professor of Kyoto University

Except the "Clay Science" these bulltins do not necessarily intend to make contribution monopolized by origianl scientific papers, but often carry general views or commentaries. However, as seen from number of papers quoted by the special issue of the progress report, these bulletins rival the Journal of the Society parent even outstrip it. In spite of an important role they play in the Society, their financial conditions are weak, though with some differences, and their managements are under research workers' own hands without pay (the case for the Journal of the Society is by no means an exception) Thus, bulletins are issued 2 times in a year at best and their formats are poor-looking. In view of their vast contribution to the Society, I would like to pay a high esteem for these people and also for their further exertions.

Some person may apprehend the development of these groups side by side with such other groups as of plant nutrition or fertilizers, may make the parent Society split. I believe, however, this is groundless.

Soil science calls for an overall yet insighting knowledge of related sciences by research workers in studying in its concrete contents as well as by person who employ the results in industries. Research workers are required to confine their objectives and study them in depth. Nevertheless, they may not attain success without background knowledge on related sciences. The deeper the study in each related science, the heavier task is burdened by the Society. The Society should maintain an intimate work relations between them positively and should extend every help to them.

To illustrate a degree of contribution by them to the Society, the following table is quoted from the special issue of the progress report.

Discipine	Total No. of papers	of which, appeared on bulletin	
		of the Association	of the Societies
		%	%
1. Physics	207	17.9	14.0
2. Mineralogy	147	45.3	22.4
3. Micro-organism	88	45.5	11.4
4. Soil Genesis and Classification	151	12.6	14.6

3. Current Status of Research by Discipline

As soil science covers a wide range of disciplines, each one should be developed with harmony. Ideas meant by the word harmony may be different by person.

Current situation of research by each descipline would be reflected most readily and directly by speeches as well as by doctoral papers presented before the Society.

Discipline	Speech			Doctoral paper			$\frac{B}{A} \times 100$
	in the last 3 years		per annum	in the past 10 years		per annum	
	No.	%	A	No.	%	B	
1. *Physics*	91	6.5	30.3	8	3.6	0.8	2.64
2. Chemistry	129	9.2	43	28	12.7	2	4.65
3. *Clay, colloid*	69	4.9	23	19	8.6	1.2	5.22
4. Micro-organism	77	5.5	25.7	13	5.9	1	1.89
5. *Nutrition*, absorption	190	13.5	63.3	44	20.0	1.2	1.90
6. Metabolism	212	15.1	70.7	26	11.8	3	4.24
7. Paddy field	149	10.5	49.7	26	11.8	2	4.02
8. Upland field survey grass land, garden	175	12.4	58.3	21	9.5	2	3.43
9. Soil development classification	108	7.7	36	20	9.1	2	5.56
10. *Fertilizers*, application method	208	14.7	69.3	15	6.8	1.5	2.16

In the same manner doctoral paper presented in US in these 3 years are rearranged from the journal "Agronomy News," September, 1967.

Discipline	1955	1966	1967	Total	%
1	18	16	7	41	14.2
2	25	45	13	83	28.7
3	11	7	8	26	9.0
4	5	5	3	13	4.5
5	4	7	2	13	4.5
6	6	8	4	18	6.2
7	0	0	0	0	0
8	19	12	13	44	15.2
9	18	12	12	42	14.5
10	6	2	1	9	3.1
Total	112	114	63	289	100.0

From the above girures and also from my experience, outline by discipline is summarized as follows.

Soil physics. No body can deny a weak status of this section in our Society

Most presentations concerning physics in the Society relate to applied research in the agricultural structure improvement projects or to rheology of clay, and any presentation do not touch upon basic problem of physical properties of soil. Furthermore, basic research on soil moisture is carried out only in the National Institute of Agricultural Science. Hardly any such basic research is performed in universities.

Engineers on the spot have been faced with and challenged by physical properties of soil and by, among others, those related with fertility of soil without any support of reliable research result from universities in these 10 years. We ought to reconsider the situation frankly. Some countermeasures should be formulated at once.

As to the second one, soil chemistry, the level of research in physical chemistry or inorganic chemistry is not so high as one usually assume from its predominate position in the soil science. Relatively weak positions of physics and chemistry (excluding organic chemistry) may partly ascribe to the fact that the chair of soil science is in the agricultural chemistry division, where organic chemistry is the main current.

On the other hand, the third one, i.e. studies on mineral and colloidal complex do not suffer from such misfortune. The same is true with the fourth one. But we feel it unhappy that not any chair is allocated for the soil micro-organism at Universities throughout the country. Only one division is attached to the Institute, Tohoku University. Reconsidering its motive power for the progress of soil micro-organism study in the country, the chair for that science is urgently needed. The same is ture with the ninth.

4. Reform of Research and Education System in University

Presentations of research results to the Society in these 3 years are classified by institute: University, 37%; Experiment Stations and the National Institute of the Ministry of Agriculture, 30%; prefectural experiment stations, 31%; and others, 2%.

Researches in experiment stations which constitute 61% of the total, are inevitably not free from influences by policy and administration. They are, however, interrelated between each other and are subjected to criticism within the organization. Thus serious failures are seldom experienced. It is in universities that many difficulties are latent, even through those who are not well-informed may deem it otherwise.

No one can tell the adequate number of chairs (laboratories) for soil science university. Each university, however, has only one chair for the soil science at best Sometimes single chair covers soil and fertilizer concurrently. So research activities are liable to be dispersed with unfavorable effects for research system. In my opinion area of research in each laboratory should be further narrowed than that currently retained so that new area of study be developed therefrom. Another defect is that almost all instructors are graduated from the same curriculum.

Difficulties lie, however, not in research but in education. As compared with first and second class universities in the world whose soil science or agronomy class consists of several, sometimes more than ten, chairs in post-graduate course, any university in Japan may not be free from criticism of its inferiority in giving well-grounded and far-sighted instructions to students.

In the following table lectures on soil science are compared between Cornell University, well-acquainted with soil scientists in Japan, and my own Kyoto University. Lectures in the former are for post-graduate course and those in the latter for students specialized in soil science.

Cornell Univ. 1960–61

Lectures	Hours per week in a semester
1. Soil classification and survey	4
Exercise	2.5
2. Soil organic matter	4
3. Soil and plant management	4
Exercise	2.5
4. Soil micro-organism	3
Exercise	2.5
5. Soil chemistry and physics	4

Cornell Univ. 1960–61

Lectures	Hours per week in a semester
6. Soil and water conservation	2
7. Soil chemistry	3
8. Soil chemical analysis	3
9. Soil development morphorogy, classification	3
10. Soil fertility	3
11. Soil physics	3
Exercise	
12. Seminar	2.5

Kyoto Univ. 1968

Lectures	Hours per week in a semester
1. Fundamental	2
2. Applied soil sci.	2
3. Plant nutrition	2
4. Soil micro-organism	2
5. Radiation chemistry	2
6. Analytical chemistry	2
7. Seminar	

Besides above listed ones, lectures are provided e.g. on soil physics, for students specialized in agricultural engineering at my university. But this is the same with oversea universities. Moreover, contents of lecture in this case are not suited for students specialized in soil science to persue. Thus, comparison should be made between lectures in the agronomy or soil science class at Cornell University and those in the agricultural chemistry class at Kyoto University.

List of lectures at Cornell University refers to 1960 – 61, and I have a feeling that they are outdated to a considerable degree as seen from the present day level of soil science. That the lecture on soil mineral is included in the soil chemistry or soil development is an explanation for my observation. Not a few universities had an independent lecture on soil mineral even at that time, so we may guess the situation is changed now at such an agelong university as Cornell.

From the table I cannot but admit frankly that list of lectures at my university lag 30 years behind that as Cornell University 8 years ago. This list should have been presented not on the occasion of 40th anniversary but at the commencement day of the Society.

A view is prevailing that some part of students learning agriculture in the South-eastern Asiatic countries should preferably study at universities located under monsoon climate including Japan, and not at those under cold and dry climate like North America and Northern Europe. This may be true ideally. So far as postgraduate students are concerned, however, a well-balanced education as is given at universities in Western Countries might be difficult, to my great regret, to give in Japan.

In my opinion, research students may be allowed in enrollment regardless of their school histories, but doctor course students should be rejected because they may not attain their objective to learn soil science, though not to reject those whose objectives are to acquire titles only.

My lament should also be extended to Japanese students. But difficulties may be less for them than for foreign students because some part of defects may be supplemented by their participation in improving education in which they are engaged.

We have in fact our collegues who are prominent in research work in the fields of mineralogy and pedology where improvement of education system is badly needed. For this reason, however, we are not to be releaved from insufficient status of education. Indeed, we have at the other extreme such a high level education system in the field of bio-chemical study on soil and plant nutrition that may well rival the international standard.

A measure was once discussed that chair and laboratory for soil science was to be incorporated into the series of agricultural engineering. But this is not the solution. As an independent and wide-range science, the soil science ought to have its own faculty. The circumstances, however, do not allow an independent faculty be established in a university. Nonetheless, improvement is urgently needed and without it any progress is not anticipated for the soil science in Japan. Improvement should be done by ourselves. Nothing is left for us but to organize mutual cooperation across chairs and laboratories of soil science at every university. Chairs and laboratories concerned in soil and fertilizer in universities within the province of the Kansai Branch of the Society to which I belong total 20 in equivalent of chairs. By organizing these into 2 series of soil and fertilizer science, research activities may be replenished, field of activities coordinated and education for students complemented.

5. Current Status of Researches by Objective.

The current status of research work is reviewed according to objectives of research.

1) Research on paddy field soil

The most recent and prominent progress among paddy soil research was attained in its ecological field. As to the phenomenon of reduction of substances in paddy soil, relation between Eh change, material change, species of micro-organisms participating and energy metabolism was illustrated in its outline. Phases of leaching of materials including micro-organism from tilth are also evidenced.

As to the balance of nitrogen in paddy field tilth, nitrogen fixing by blue algae was investigated vigorously during the final stage of the second world war, then nitrogen fixing by photo-synthetic bacteria was attested and coexistence of photo-synthetic bacteria and organic nutrition bacteria, which is symbiotic with the former, was attested to increase the amount of nitrogen fixation, though data are not enough yet as to quantitatively evaluate the effect in the actual field. Inorganization of organic nitrogen in paddy field was made clear in its relation with types of organic content, surrounding condition and with physical treatment.

Regarding phosphoric acid, the type, availability and sequential change of inorganic phosphoric acid were ascertained. Also the availability of organic phosphoric acid in paddy field soil, which accounts for nearly one half of soil phosphoric acid in average, is again studied after a long recess and availability is estimated to be comparable to that of inorganic phosphoric acid.

No remarkable progress was attained in K_2O studies.

As to silicic acid, study on assessing method of available silicic acid in soil was finalized. Further soil scientific study was not performed on silicic acid.

In addition, factors to control electric potential of oxidation-reduction in paddy field soil and characteristics of substituent (clay mineral, organic matter) were illustrated in principle. Formation process of bivalence iron and behaviors of hydrogen sulfide were also studied quantitatively.

On the other hand, tremendous success was scered in the study on movement and accumulation of free iron oxide, form of bog iron in the field relationship between color and formation process, identification of free iron oxide which forms bog iron, oxidation-reduction mechanism of manganese, pattern of silting and its relation with surrounding conditions, color of bivalence iron compounds, etc.

As to physical properties of paddy field soil, empirical facts were collected out of the work of drying wet paddy field, improving basic conditions of soil and introducing farm machineries.

Distribution of micro-organism in paddy field soil and, among others, their irregularity were also attested.

It is now the time a unified theory may emerge as to the material change in actual paddy field soil in the course of synthetizing these vast and new evidences. We expect that the theorizing will be performed by fresh brain of 30 to 40 years of age having a considerable experience. We also have to keep eyes on the excellent progress in paddy field soil research succeedingly published in foreign countries recently.

As to paddy field there is another problem of the classification of paddy field soil. Practical usefulness of soil classification was one of the most repeatedly debated problem after the war. Even those who are specialized in soil science argued sometimes that an unappropriate system of classification mitigated its practical usefulness. I do not share with such a simple discussion. The soil classification, in order to be useful in practice, must be made by the soil series at least and if possible according to the minor division of soil type or soil phase. Furthermore, such classification must be completed throughout the country. The classification must be learned not only by students specialized in soil and fertilizer sciences at the university level but by all students who are concerned with agriculture. Qualification of school graduate must not be granted to students who failed to understand it thoroughly. By the time when such trained graduates keep job in each field of agricultural activities say, for, decades, results of soil classification may be reaped. We anticipate the soil classification by soil series will be completed by the proposed target year 1973.

2) Volcanic ash soil

Among on researches volcanic ash soil, those on inorganic content and, among others, on amorphous substance and crystalline mineral advanced remarkably and region-wise characteristics of volcanic ash soil in my country were almost revealed. The progress was attributed to on-the-spot survey and after 1953, when the extra session of our Society was held in Hokkaido, to a remarkable progress in analytical method. It was attributed to exchanges of research objectives and research cooperation, too. This is an example in which an advancement is attained by field survey and fundamental research side by side. For a while in the future imogolite, and its related minerals and 14 Å mineral, which are deposited not only in volcanic ash soil but also in paddy field soil, might be the focus of the attention of researchers.

Research on organic matters (humus) in volcanic ash soil also attained the worlds' topmost success, but even this attainment is left far behind that in research on inorganic matters.

This ascribes to sampling technique, the main tool of research for not only volcanic ash soil but also soil organic matter, by which only one half or less of object material is treated and clay and base, which do not correspond to deterioration of sample nor to substance of humus, may seriously affect the condition of drawing sample. For this reason, study in clay soil is entirely different from that in organic matters. The latter contributes much to qualitative research, but is not fully developed yet in case when research requires quantitative analysis. For the future development of research in soil organic matter, a research method not depending upon sample technique is to be eagerly sought.

3) Other soils

Development in antique soil research is another progress in these days. Deposits and distribution of antique red soil is now made clear. Existence of pseudo gley soil is confirmed as catena of podzol soil, acid brown forest soil, pseudo-gley soil, still water gley soil, peat soil, etc. On the other hand, sea-born acid sulphate soil, though its deposits are limited, is found on diluvial plateaus and deposits of calcareous grumusol, which were once assumed non-existent, come to be forecasted.

We find in the Tokai District deposits of black humus soil which is considered to have origins in non-volcanic ash soil. Its relation to volcanic ash soil, however, is not certain yet. There are evidences that this soil is non-volcanic. The intermediate type of this soil is also found in the Kinki District.

To our regret, only one type of soil map has been published so far for cultivated land in 1958 by the scale of 1 : 800,000.

4) Researches on micro-elements.

Researches on micro-elements from geochemical or soil scientific point of view have been done only for Mn, Co and others, and progress is far behind as compared with those from the viewpoint of plant nutrition or fertilizer application.

To serve as a milestone for the 40th anniversary, relative abundance and scarecity of elements in soil are shown in the following table. I expect with pleasure that the same table will be compiled for comparison at the 50th anniversary.

Chemical Components of Field Soil
– Their relative abundance and scarcity –

o Injury by scarcity may sometimes develop
● Injury by abundance may sometimes develop

		For Crop						For animal
		Environmental factor		Nutritive factor				Nutritive factor
		Paddy field	Upland, grassland, garden	Paddy field	Upland field	Garden field	Grass-land	
Major element	N			o ●	o	o	o	●
	P			o	o	o	o	?
	K			o	o	o	o	
	C	●						
	H*	●	●					
	H_2O	o ●	o ●					
Inter-mediate element	Ca	o	o		o	o		?
	Mg			o	o	o	o	
	S	●		?	?			
Minor element	Fe				o			
	B			o ●	o	o	o	
	Mn			o ●	o	o ●	o	
	Zn			? ●	o	o		o
	Cu			●	o			o ?
	Mo				o	o		●
	Co			●				o
	Cl	●						
Non-essential content of plant	Ni			●	●	●		
	Na	●			o			
	F							●
	Si			o				
	Al		●					
	I							o
	Se							? ?

Note:

1. This table is compiled according to the idea of Mr. K. Nomoto (1966) and with the advices of Mr. E. Takahashi and Mr. S. Kosaka.
2. Relative abundance and scarecity of nutritive factor for animal is expressed by hindrances evidenced by animal fed on crops whose relative influence on animal is not cleary shown.
3. Question mark (?) in the columns for crop signify that the evidence is clearly known in foreign countries but not confirmed in Japan.
4. Question mark (?) in the column for animal is the same with above, but include, in case for Japan, cases for "not reporting".
5. Besides above listed factors, hindrance by abundance may be questioned on bivalent iron.
6. In the future, much more deficiency disease may be detected, while on the other hand hindrances may be developed further by abundant heavy metals which will be caused by industrial contamination.

5) Others

Other research activities performed with considerable success are as follow.

i. Soil particle dispersion method in mechanical analysis of soil.
ii. Pattern of movement of water in upland field soil.
iii. Many examples of success by applying pF concept.
iv. Clarification of rheological properties of soil.
v. Type of soil phosphoric acid.
vi. Free salts in soil which cause hindrances.
vii. Response between clay and organic matters.
viii. Soil chemical research on peat soil, reclaimed land, newly developed paddy field, vinyle paddy field, etc.
ix. Pattern of volatil-dispersion of nitrogen from soil.
x. Application of results of pedology to other fields.
xi. Location-oriented significance of such analytical value as absorption coefficient of P_2O_5, CED, volume weight, etc.

6. Conclusion

As I stated at first, progress attained so far since the end of the war is, so to speak, prepared for the advance in the coming years. Now it is the time when a coordinated theoretical system should be developed with reference to soils with origin of volcanic eruption and to changes in soil substance and soil type which are caused by cultivating paddy field. This is simply because these phenomena are peculiar to Japan.

On the other hand, for the soil science in my country to be developed with harmony, current education system should be by all means improved. It is at the same time necessary that the individual research worker should confine his research objective more precisely. Along with improvement of education system, doctorships in the new system is also to be questioned. As emphasis is laid on finishing paper within a limited time, objectives of research is rather selected by handiness to write paper than by importance of the problem. As I quoted early, 35% of the total doctoral papers in chemistry took up phosphoric acid in U.S. They are apparently prejudiced in the light of soil science for U.S. agriculture. We should not repeat such a fault.

For the moment electron micro-probe method is to be introduced soon. Currently, research on the sampling method of analysis materials, on the standardization of management and on the treatment of analysis results are badly needed.

For the study on such a locality-bound subject as soil, similar soils under similar climatic conditions as well as soils under tropical or arctic conditions should be pursued for the benefit of comparison. Research should and would certainly be extended to this field.

III Present situation of studies on plant nutrition in Japan

by Noboru Murayama*

Tradition of the study on plant nutrition

The introduction of modern sciences during the Meiji Era laid the basis of the science of soil and manure, as in other sectors of natural science. This fact is summarized in the paragraphs on Soil and Fertilizer Science, "History of Development of Japanese Agricultural Sciences," Vol. 9.

Dr. Oscar Kellner of Germany, who had been invited to Komaba Agricultural School in an early year of Meiji Era, in 1881, engaged in his duty of training experts in agricultural chemistry and promoting studies on overall problems in Japan's agriculture for 11 years.

The basic stone for the development of the science of soil and manure in Japan was laid by him.

His contribution was mainly in the study of manure and its application experiments, and the German methodology in the study of agricultural chemistry, following the school of Dr. Liebig exerted ever since an important influence to studies on soil and manure in Japan.

Nevertheless, it may be properly said that the physiological and biochemical studies preceding the nutritional study of plants were rather initiated by the German professor Dr. Oscar Loew, who came to Japan a little later than Dr. Kellner.

Studies by Dr. Loew led to the introduction of plant biochemistry and study of plant nutrition of today by clarifying the enzymic reaction in plant bodies, protein formation and the lime-magnesia ratio theory, which identified the necessary proportion of magnesia to lime.

Dr. U. Suzuki, one of the immediate pupils of Dr. Loew, studied the nitrogen metabolism of plants, asparagin being the major item, and metabolic physiology of dwarf disease of mulberry. He published in 1902 a book titled "Principles of Fertilizer Science", which may be named in these days "a treatise on physiological chemistry of plants". At that time these studies were not connected directly to technology on soil and fertilizer. His study was later developed in other sectors of agricultural chemistry, e.g. in the field of vitamins foodstuff, etc. It was after about 70 years and it deserves attention that at present studies on plant nutrition as one of the branches of the science of soil and manure was flourishing in close combination with plant physiology and biochemistry.

Dr. K. Aso, another best pupil of Dr. Loew, endorsed his teacher's theory of lime magnesia ratio and on the other hand made researches on the distribution and physiology

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of manganese within the plant body. His success stimulated and opened a new field in the study of micro-elements. The existence and significance of these elements were then beginning to attract world wide attention.

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Every study of our predecessors constituted the germ or the beginning of today's study on plant nutrition, but it took some length of time for them to be fully utilized in actual agricultural techniques. The time was not ripe for the newly introduced science to establish on Japanese soil.

Japanese agriculture, being characterized by variety improvement and heavy fertilization, necessarily requires basic studies on plant nutrition. Agriculture with heavy application of fertilizers did not for the first time started in the Meiji Era in Japan.

The characteristic heavy fertilization was observed as early as at the middle of the Tokugawa Shogunate Era. Most of the noted agriculturists of Tokugawa Era, e.g. A. Miyazaki, S. Sato, E. Okura pointed out the importance of fertilization. M. Fesca said in his book "Treatise on Agricultural Products in Japan" (1891): "Japanese way of fertilization depending on application of human compost is quite different from that practiced in European countries ..... in Japan, farmers apply composts on every crops they cultivate and it is quite common to apply them several times during the growing period."

Agriculture in Japan standing on the traditional ground as stated above got into a new drive by the abundant supply of chemical fertilizers, accompanying the remarkable development of Japan's capitalist industries. The nutritional value of phosphates were recognized as early as at the beginning of the Meiji Era, when organic manure played a major role in fertilization and calcium superphosphate manufacturing industry already got under way. Organic manure rapidly gave way to inorganic fertilizers in Taisho Era, when manufacture of ammonium sulphate started as industry. Now that the quick acting fertilizers replaced the slow acting manure, application of fertilizer accordingly required new techniques and adequate knowledge about soil and fertilizer is needed for the establishment of a rational system of fertilizer application. Not only the study on soil and fertilizer but on plant nutrition becomes essential. Against such a background studies on plant nutrition in our country experienced a unique features of development using the water culture experiments as a major instrument to tackle the problem. It was not a mere coincidence that studies on plant nutrition took roots in Japanese soil about this time and led to the remarkable development thereafter. The time falls on the foundation of our Society 40 years ago.

Development of sciences do not solely affected by economic and social conditions of a country, but on the other hand it is not a right way to ignore the fact that the successful advances in our studies were backed by the steady development of agricultural production achieved through the studies closely connected with agriculture as an industry.

PRESENT SITUATION AND FUTURE PROSPECT OF STUDIES ON THE APPLICATION OF FERTILIZERS IN JAPAN

Rice, the main crop in Japan has a characteristic quite different from other upland crops, i.e. it is a marshy plant. Soil science in our country is characterized by its tradition having studies on paddy soil as the major theme. Researches on plant nutrition likewise started from the culture experiments of plants in water. Establishment of water culture experiment method led to the unique development of studies on plant nutrition. Completion of the whole history of the plant under water culture to get a yield of rice as high as in the paddy field meant the clarification of the difference in nutritional and physiological characters between paddy rice and general upland crops.

Water culture method of paddy rice thus accomplished gave force to the pursuit for a wider range of general upland crops, vegetables, and even for fruit trees, and contributed a great deal to the understanding of nutritional and physiological characteristics of various species of plants. Thus, water culture being relied upon as an effective means of analysis, studies to identify the time of needed application of fertilizers and to measure the contribution of nutrients absorbed at each stage of plant growth to the yield (formation of the concept of partial productivity) gave the direct theoretical ground to such techniques as the prewar established method of applying fertilizers at heading time and the application of phosphate as basic fertilizer. It was proved at the same time that studies on plant nutrition would generally play a very important role in the rationalization of fertilizer application.

Rice is specifically known as a plant containing large quantity of silicic acid, Physiological significance of silicic acid had been before World War II an object of examination in our country for a longer time than in any other countries in the world.

After the War, researches to clarify the physiological and ecological role of this substance were carried out in connection with the analysis of the phenomenon of Aki-ochi (Physiological setback in productivity at later stage of rice growing). Application of silicic materials was proved to be essential to the sound growth and high yield of rice. This discovery is one of the well known contributions of the soil and fertilizer science after the War. It is a unique achievement in our country that the elements not recognized so far as essential nutrients are actually applied in large quantity to the soil of farm land and are fulfilling an important task of the food production increase in the country.

Production of fertilizer fell sharply during and immediately after the War, which caused the serious suffering of the nation from lack of food as well as from the disaster of war. Studies on soil and fertilizer at this period, centering around the effort to clarify "Aki-ochi", contributed much to the steady increase in food production. In the field of plant nutrition, physiology of roots and nutrient absorption mechanism began to be studied, beginning from the analysis of root rot phenomenon. Process of the growth of rice plant was examined from the nutritional and physiological point of view to find a way to the increase in production.

All these studies as stated above contributed much to the solution of food problem by giving theoretical explanation of Aki-ochi phenomenon and affording practical guidelines and measures of production increase.

They also contributed valuable portion to the production increase immediately after the war, to the following sharp increase in yield and to the *breakthrough of the* stagnation of production in recent years. For example, the technique of water control or of supply of nutrients at later stage of growth find its theoretical ground in the results obtained in the studies so far on nutritional physiology of plants. It constitutes an important countermeasure to get out of the stagnation of yield increase.

Nutrition researches on the part of upland crops has long been executed too, but they are not adequate compared with those on rice. Among them researches on micronutrients are carried out continuously since before the War through after it.

Following the tradition from Dr. Aso they have already clarified the effect of Zn, B, Mn, Cu and Mo in the cultivated field and greatly contributed to the production increase in upland crops, vegetables and fruit.

Such elements as lime and magnesia, given position between the three major elements and micronutrients, tend to be less studied. After the War, however, with the encouragement of production of upland crops, practical importance of these intermediate elements is highly appreciated throughout the country.

As selective expansion in agricultural production is promoted, more attention is paid to the field of vegetables, fruit trees and fodder grasses and valuable results have been attained in studies on these crops. Among them, gradual establishment of standards of fertilization for each kind of crops and instruction about the undesirable effect of excessive fertilization were the most widely accepted achievements. Development of leaf analysis method for fruit trees and the practical application of gravel culture method for vegetables were due to studies in the science of plant nutrition, though few members of our Society directly took charge of researches in this field.

Thus, study of plant nutrition steadily insisted on its existence and significance and got firm ground for its "genre", through the valuable contribution to agricultural production. Japanese agriculture characterized by heavily fertilized paddy culture and infertile upland field assigned a definite task on plant nutrition studies centering around inorganic elements. Under such conditions, study on plant nutrition in our country steadily won its way, responding to requests from agriculture. The study, originally derived from the science of soil and fertilizer has naturally a close connection with fettilization technology, inorganic elements being the major item. However, since the study is principally dealing with living crop plants, further development is to be expected only whe it advances beyond the old boundary of fertilizer science.

Treatise on plant nutrition, as one of the derivatives of fertilizer science gradually introduced the biological point of view into the study during the process of development. The tremendous advances after the War especially were attained by putting more emphasis on such a viewpoint. Study on plant nutrition in our country gained its unique footing through the process as mentioned above.

PRESENT SITUATION AND FUTURE PROSPECT OF STUDIES ON THE APPLICATION OF FERTILIZERS IN JAPAN

Present situation of studies on plant nutrition

Number of reports on plant nutrition study published at the general conference of our Society increased sharply after the War. Dr. Kumada summarized the trend of study during the first decade after the War. The author is briefing here after Dr. Kumada's example on the recent trend of studies through papers reported at the conference, for the following 11 years.

Although the classification table may have no continuation after Dr.Kumada's, the rule for classification of those papers differing from Dr. Kumada's, general tendency could be discerned here.

Table 1. Number of papers reported at the conference the Society of the Science of Soil and Manure, Japan

	1956 Vol.3	1957 Vol.4	1958 Vol.5	1959 Vol.6	1960 Vol.7	1961 Vol.8	1962 Vol.9	1963 Vol.10	1964 Vol.11	1965 Vol.12	1966 Vol.13
General conference in spring	245	254	248	262	232	222	246	253	235	298	243
Regional conferences	152	133	191	111	212	175	144	125	152	160	200
Extraordinary sessions		82		102		110		131		126	
Total	397	469	439	475	444	507	390	509	387	584	443

The table shows the number of reports given at general conference in spring, at regional conference held by regional branches of the academy and at the extraordinary sessions held every two years, picked up from each volume of the glossary of papers. Total number of reports, though alternately increasing and decreasing, reflecting the addition of that at the extraordinary sessions, now seems to be approaching a limit for the last 10 years. National Conference on Science and Technology of the government published its view in 1960 that "in 10 years the number of graduates from the faculties of agriculture will be in excess of demand by 30,000 or so". Our Society expressed an opinion denying this. Judging from the fact concerning the number of reports as above stated, number of research stuff engaging in the study of soil and fertilizer science is at least for the latest years not increasing, even with fear of decreasing.

Of the total of these reports, number of reports related to study in plant nutrition is as shown in table 2.

	1956 Vol.3	1957 Vol.4	1958 Vol.5	1959 Vol.6	1960 Vol.7	1961 Vol.8	1962 Vol.9	1963 Vol.10	1964 Vol.11	1965 Vol.12	1966 Vol.13
General Conference in spring (a) (1			39	26	15	20	39	14	23	25	36
(2				32	35	35	23	31	22	40	34
(3			22	19	13	9	11	10	7	15	
Extraordinary sessions				23		28		34		45	
Total			61	100	63	92	73	89	52	125	80
Adjusted (b) total	134	147	129	131	134	137	115	131	95	174	146

Note: (a) 1.2.3. .... Divisions of studies.
1 .... Nutrient absorption
2 .... Inner metabolism
3 .... Special elements
3 was abolished in 1966.
(b) Total was adjusted by adding a number of papers according to their contents regardless of their entries.

Generally speaking, reports on plant nutrition accounted for roughly a third of the total, and this percentage seemed invariable for these 10 years. Examining more in detail, however, we find the percentage is apparently lower in 1963 and 1964. The reason is not clear, but it could be said probably this decrease may have relation with the circumstances that the peak of good harvest in 1962 made an epoch and since then the change in agricultural policy was discussed and promotion of mechanized labor saving cultivation got highlighted. Since research stuff of experiment stations of the government and prefectures occupy major part of the reporters it can not be denied that these reports are more or less affected by the trend of administration policy of the Ministry of Agriculture and Forestry.

Influence of agricultural policy on studies may also be found in table 3, where reports are classified according to the kind of crops treated.

Table 3

Crop	1956 Vol.3	1957 Vol.4	1958 Vol.5	1959 Vol.6	1960 Vol.7	1961 Vol.8	1962 Vol.9	1963 Vol.10	1964 Vol.11	1965 Vol.12	1966 Vol.13
Rice 1)	65	61	63	51	54	68	42	45	30	48	48
Wheat & barley 2)	13	17	15	10	10	6	10	7	3	6	10
Pulses 3)	1	1	2	4	2	1	3	7	6	5	4
Potatoes	1	1	1	0	0	0	2	3	5	3	0
Fodder grass	0	0	1	0	3	2	4	5	7	10	9
Fruit tree & Mulberry	5	4	5	10	10	6	3	9	3	16	15
Tea	2	1	3	0	2	2	2	1	1	3	3
Tobacco	7	8	8	11	13	10	11	8	3	6	7
Sugar beet	0	0	1	1	3	5	3	3	3	9	4
Vegetable	3	6	6	13	16	12	12	13	8	21	16
General upland crops	15	10	2	7	2	5	6	11	4	5	5
Flower	0	0	0	0	0	1	1	1	1	5	2
Others	2	2	2	6	3	1	4	3	3	5	1
Not specific	21	32	14	17	14	20	15	16	17	26	22
Total	135	143	123	130	132	139	122	132	94	168	146
No plant	2	5	7	2	3	0	0	0	1	3	2

Note: 1) Paddy rice and upland rice.
2) Wheat, barley, naked barley, beer barley, oat.
3) Including soybean, azuki bean, kidney bean and peas

A report relating to two or more crops is included in more than one column. Accordingly, total number does not coincide with the number of papers reported.

In general, reports concerning rice, wheat and barley, which once occupied the larger part of the studies, diminished in number in recent years and fruit trees, vegetables, feed crops and grasses are replacing them. Even with such a trend rice still holds the first place and occupies more than 40% of all reports, showing the characteristic aspect of Japanese agriculture.

Recent trend of plant nutrition studies is that, as seen from the table above, major object of study is shifting from rice, barley and wheat to fruit, vegetable, feed grass, flower, etc. and at the same time kinds of crops are increasing in number including even lower plants such as algae and fungi. The sphere of study is enhancing taking up a wide range of crops. This is not due to the increase in research stuff but to the shift within the old frame, showing that the firm footing of studies is still to be sought.

Table 4 classifies objects of studies by chemical element.

Table 4 Classification of studies by element.

(1) on inorganic nutrition and nutrient absorption.

	1956 Vol.3	1957 Vol.4	1958 Vol.5	1959 Vol.6	1960 Vol.7	1961 Vol.8	1962 Vol.9	1963 Vol.10	1964 Vol.11	1965 Vol.12	1966 Vol.13
N	4	6	5	9	7	9	14	14	15	26	15
P	6	9	12	4	6	6	7	8	5	11	4
K	7	12	5	4	6	10	7	6	7	18	8
Ca	6	10	9	8	3	5	2	3	3	7	6
Mg	4	7	5	5	–	–	–	–	1	1	–
S	3	5	3	2	5	4	3	–	2	1	1
Cl	–	4	–	1	1	5	3	3	2	2	1
Absorption in general	19	22	25	19	25	25	21	16	8	23	10
Total of macronutrients	49	71	64	52	53	64	57	50	43	89	45
Fe	2	1	1	1	4	2	4	8	2	9	5
Mn	2	2	–	2	6	6	5	4	2	4	9
Cu	2	2	1	2	–	1	2	5	1	5	3
Zn	–	1	–	–	–	1	–	2	2	1	4
B	5	6	4	8	2	4	2	3	3	4	6
Mo	6	6	1	4	2	2	1	1	–	3	–
Other micronutrients	2	–	4	1	4	6	2	3	6	9	4
Total of micronutrients	19	18	11	18	18	22	16	26	16	35	31
Si	21	4	10	11	6	7	4	7	2	1	5
Pollution	5	7	3	6	2	5	2	1	4	1	3

Difference between years is so large that no definite tendency can be found from the table, but it can be said that nitrogen has been always the principal object and studies on nutrient absorption in general has accounted for considerable percentages. This is one of the characteristics of studies in this field after the War. Moreover, as the recent trend of study, almost all the essential elements including a wide range of micronutrients have been treated in some way or another every year. Studies on micronutrients sharply increased in number in 1965 and 66, which may show that this sector is to expand in the future.

From the viewpoint of inner metabolism and metabolic element, reports of studies are classfied as shown in table 5.

Table 5. Classification of studies by function

(2) on inner metabolism and metabolic components.

	1956 Vol.3	1957 Vol.4	1958 Vol.5	1959 Vol.6	1960 Vol.7	1961 Vol.8	1962 Vol.9	1963 Vol.10	1964 Vol.11	1965 Vol.12	1966 Vol.13
Enzyme activity	1	4	–	–	4	2	2	4	1	7	4
Photosynthesis and assimilation products	2	8	8	6	7	11	7	12	8	11	9
Respiration	–	–	2	3	2	1	6	3	2	5	3
Nitrogen metabolism	12	9	10	16	11	7	11	9	9	16	15
Phosphate metabolism	4	5	7	5	3	5	6	6	2	5	5
Pigments and plant body components	1	6	4	7	4	3	4	5	2	8	3
Physiologically active substances	1	2	5	1	1	2	2	3	7	10	7
Production and metabolism	18	17	19	16	13	14	11	16	11	14	17
Other physiological items	3	4	2	1	3	6	3	1	–	4	5
Sterilized tissue culture	1	2	–	–	–	1	–	1	4	2	3
Public nuisauces, etc.	–	2	2	–	–	3	1	1	–	8	9

On the ground of the clarification of physiological mechanism directly connected with inorganic nutrition such as nitrogen and phosphate metabolism, researches on photosynthesis, respiration, enzymic reaction and other physiological and biochemical studies are increasing and the expansion of the study on physiologically active substances attracts keen attention. Considerable part of studies is dedicated to the pursuit of dynamics of assimilation products and of analysis of organic compounds within the plant body. This fact reflects the situation that they are always relying as before upon chemical measures. Studies in plant physiology and ecology, especially those on root as basic agent of nutrient absorption, are of course the essential requirement for the development in this field. To sum up, the studies are not confined within the old border of soil and fertilizer science. They are dealing with a wide range of subjects, from the basic physiological phenomena to a variety of social phenomena such as the pollution and public nuisances, from the viewpoint of nutrition using methods in nutritional analysis, thus extending their domain in this field.

The trend of expansion of the range of subject matters is to be highly appreciated as a conspicuous development, in contrast with Dr. Kumada's indication 10 years ago that "range of subject matters is rather limited".

Studies on plant nutrition has established their reason of existence by virtue of their achievements through the unique water culture experiment method and relying upon chemical way of treatment. They endeavoured to systematize themselves by introducing the concept of biology gradually instead of the viewpoint of fertilizer science in earlier days. After the War, stimulated by the advances in neighbouring sciences such as plant physiology and biology they put greater emphasis on the direction toward physiological and biochemical way of study, positively introducing various new instrument and equipment for analysis and adopting the new method of isotope tracing. This direction did not change so far, being ever more thought of. As Dr. Kumazawa pointed out, studies got out of the phenomenal stage and stepped on the stage of substantialism. There is no doubt that the more eagerly the mechanism of phenomena is sought for, the more powerful this methodology proves itself.

Accompanying this, there is a tendency of change in the level of study subject, from individual to tissue, from tissue to cell and further to the granule inside the cell, following the way of differentiation and micro-study. On this way even the methods in molecular biology are tried to employ. As I said at the beginning of this lecture, the combination, which our predecessors dreamed 70 years ago, of fertilizer science, plant physiology and biochemistry is now at hand to be realized.

The position, where studies on plant nutrition will be able to meet most effectively the request from agricultural production is perhaps not at the level of study on individuals but at that of study in the field dealing with plant colony. Studies on individuals is differentiating into studies on cells on one side and into those on colony on the other. This is probably an inevitable course for us and the studies in our country are actually going to proceed into this direction. The fact has a profound significance for the development of our science. Here, viewpoint and methods of plant ecology is receiving special emphasis. I dare not state about the contents of recent researches in the three main fields of study on plant nutrition; inorganic nutrition, nutrient absorption and inner metabolism, as they were published in another publication of our Society. I only add to this a little indication that in the field of inorganic nutrition new development in the identification of physiological role of micronutrients is being seen, while on the nutrient absorption subtle researches to clarify absorption mechanism are carried out following the course of phenomenal study to substantial one. In the field of inner metabolism, which primarily started from the analysis of growing process of crops, differentiation of studies into two directions, one toward biochemical analysis in metabolic physiology and the other toward nutritional analysis of crop colonies introducing ecological point of view, is to be noted.

In table 6 is shown the list of titles of studies, which got prize of our Society. Besides these studies there are many that deserve high appreciation, but this list can also indicate the trend of studies in the sector. As is found in the list many of the prize-winning studies were made in later years and this fact shows that studies in this field are still young and new involving a big expectation of development in the future.

Table 6 Papers granted with Society's prize in the field of plant nutrition

Prize of the Society of the Science of Soil and Manure, Japan

At the second conference (April 1957) Kasai, Z.:
On the Behavior of Inorganix Nutrients Absorbed by Crop.

At the 3rd conference (April 1958) Ozaki, K.:
On the Nitrogen Metabolism in Paddy Rice

At the 4th conference (April 1959)
Tanaka, A.: Nutritional and Physiological Study of Rice Leaves.

At the 5th conference (April 1960)
Motoya,K.: On the Improvement of Rice Culture in the Paddy Field of Humus Containing Volcanic Ash Soil in Tohoku District (Northeastern Part of Japan).

At the 9th conference (April 1964)
Okajima, H.: On the Physiological Functions of Root System of Rice
Yoshida, S.: On the Silicon Nutrition in Rice

At the 10th conference (April 1965)
Tensho, K.: Study on the Contamination by Radiation and Its Elimination from the Standpoint of Soil and Fertilizer Science with Special Reference to Its Relation to Rice Plants.

At the 11th conference (April 1966)
Yamashita, S.: On the Effect of Plant Nutrients to Flower Bud Formation
Yamazoe, F.: On the Damage by Hydrogen Fluoride Smode, Its Actual Situation and Mechanism.
Yamamoto, M.: On the Boron Deficiency of Rape, etc.

At the 12th conference (April 1967)
Kumazawa, K.: On the Organic Acid Metabolism and Its Role in Rice Roots.
Tsutsumi, M.: On Micronutrients.

At the 13th conference (April 1968)
Harada, I.: On the Nutrient Absorption Process of Forage Grasses and Rational Fertilization Method Suggested Thereby.
Hirata, K.: Physiological and Chemical Study on Potassium Absorption of Plant Roots.

Prize granted by Nihon Nogakukai (Japanese Society of Agricultural Science)

1950 Ishidzuka, Y.: Basic Studies on Growth of Wheat Plant and Its Nutrient Absorption and Utilization
1954 Yamazaki, D.: Edapho-chemical and Plant-physiological Study on Moisture Damage of Upland Crops.
1956 Hirai, K.: Soil and Fertilizer Science Study of Micronutrients.
1960 Mitsui, S.: Dynamic Study on Nutrient Absorption of Crop Plants.

Prize by Japan Academy of Science.

1967 Mitsui, S.: Physiological and Chemical Study on the Absorption and Assimilation of Plant Nutrients.

Prize by Nihon Nogyo Kenkyusho (Japan Institute of Agricultural Research)
1967 Ishidzuka, Y and A. Tanaka: On Nutrition Physiology of Crop Plants, with Special Reference to Rice.

Evaluation and future prospects of the study on plant nutrition.
As the study develops and become more specialized, the contribution of each individual study to agricultural production becomes less concrete. In the study on plant nutrition too, as the subject of study becomes more minute and microscopic, there evolves fanxiety for the present situation and the future. But, speaking of the present situation of plant nutrition study, for the most part, the aim is set at deciding the propriety of fertilizing method and at grasping the characteristics of soil with the plant as an index.

I believe that there is no fear of the study on plant nutrition being isolated from agricultural production. Rather, to ensure further development and effectiveness of the study on plant nutrition, we should refrain from hasty connection to practical application and should promote the basic studies.

As long as science aims at clarifying cause and effect, it is inevitable that it will proceed in the direction to a simpler system where the conditions can be controlled and reproductive results be obtained. This is, as Dr. Kumada pointed out formerly, similar to the direction of beaker ecperiments in Soil Chemistry. Here a road leading to a universal, though more abstract, principle is open. But, because it is abstract, it looks quite vague and far from requirement of the complex agricultural production. But this is the way we must follow in order to establish a systematic and fundamental theory. We should not evaluate it short-sightedly from the side of practical use only. Far from that, we should be careful in taking advantage of the concept that our field is science for agriculture, which might be satisfied with applied results, not always requiring strict theoretical ground.

So far, problems of crop production in the complex, high dimensional farm fields have been studied by analysis at the level of individuals. But, when individual bodies combine to form a group, it does not meant that colony is only the aggregate of individuals. The mutual relationship between individual bodies produces entirely new problems that did not exist in individual bodies. For instance, take the concurrence of nutrition and mutual shading of leaf layers. The relation becomes more conspicuous as the growth yield of the group increases. There a new set of principles and rules, that were not clarified at the individual level, appears as the controlling factors of the growth yield. To find out the rule of production in the field, we need pursue themes in the colony. We should also be prudent to feel confident that we are doing effective studies for agricultural production just because we are doing field experiments.

To pursue nutritional themes in crop colonies in the field, establishment of a new methodology is needed and new practices in experiments should be adopted. Even if the existence of the problem is clear, as long as adequate methodelogy and experimental practices are not established, the problems will remain as an urgent but a difficult problem. A new path is being opened by the advances in exology. I feel it is quite important to learn from these achevements and continue to pursue the theme of crop production in the field from the viewpoint of plant nutrition. Dr. Ishizuka and Dr. Tanaka concretely pointed out the importance of this direction, in "The Direction of Development of Crop Nutrition Study". We also look forward to the proposal of new problems from a new point of view, both at the individual level or at a more minute level of study.

The study of inorganic nutrition developed by Dr. Liebig later contributed greatly to agricultural production, by the detection of various nutrient deficiency diseases. This is also true in the agriculture of our country. But some people say that today, when most of the necessary elements have been discovered and all of them not only the 3 main elements but also the various microelements, can be supplied as fertilizer, the future of the study on inorganic plant nutrition does not look so promising.

As is seen in the paddy yield contests in recent years the trend of heavy fertilization is becoming pronounced, and now the problem is not the supply of lacking elements but the theme of how to make the plants absorb larger quantity of nutrients in a balanced and productive way. To answer this theme, we can not stop at the study on nutrient deficiency.

The soil control and fertilizer application technique aimed at finding out and supplying the lacking nutrient, is urged today to develop to the stage where the question of realizing the maximum productivity of crop is discussed.

Though it is needless to say that study in our country on plant nutrition has contributed from early days to this field, the direction of raising production by increasing the crop's growth volume has reached a limit as is shown by the recent stagnation of the increase in paddy yields.

The fact that recent fertilization techniques lay emphasis on controlling and managing crop's growth shows that it is facing a new direction to meet the demand for a big increase in production. Here we see the aim of artificially controlling the growth of a crop group through various techniques, and creating a crop colony with maximum productivity, and as a result realizing high yield under heavy fertilization, not directly aiming at getting abundant crop by abundant fertilizer.

The utilization rate of solar energy by plants reaches only a few percent. But if we can artificially control the growth of a crop group and their growing process, we can raise the rate greatly and remarkably increase the yield. It is true that the limiting factor in crop production is changing from fertilizer elements to light energy, with the abundant supply of fertilizers. And for that reason recent yield raising techniques consider about the photosynthesis and dry matter production of crop colony in the field.

But to develop a crop colony with high capacity of photosynthesis and dry matter production and realize its full potential, the soil and fertilizer managing techniques will be the basis. We can anticipate further development of nutritional analysis in crop colony.

Furthermore, it would be very helpful if techniques for a free control of nutrient absorption were developed, so that the growth stages of crop can be artificially controlled and thus ensure the pursuit of the nutrient absorption mechanism. The minute pursuit of the process of inner metabolism is thought today as being farthest from actual agriculture, but the advance in the field of physiological biochemistry is remarkable. Clarification of the inner metabolism in living bodies and the control method thereof affords us the possibility not only of realizing chemical control, but also of improving the quality of agricultural products, and make us dream of a completely new crop production in test tubes.

Aside from dreams of future, there are many things in the study on plant nutrition required by the agriculture of our country at present. One of them is the establishment of the method of nutrition diagnosis. The nutrition diagnosis of plants has been a major theme in this field, following the inorganic nutrient deficiency diagnosis of plants. Today a satisfactory method of the diagnosis is needed as a guideline for soil treatment and fertilization management as well as for production increase. As these agricultural technology evolve from empirical techniques based on experience and perception, and strengthen their scientific aspect, the establishment of a simple and fast method of diagnosis will increase importance.

I feel that study of plant nutrition in the future should, in with the future of agricultural production and the soil and fertilizer techniques as stated above, strengthen its fundamental pursuit in the fields of inorganic nutrition, nutrient absorption, inner metabolism and colony nutrition. Studies like this will clarify the way in which plant growth and crop production process can be artificially controlled. We can also hope that this will be a foundation for the advance of tomorrow's soil and fertilizer techniques and agricultural production. In this way, the study of plant nutrition as a branch of soil and fertilizer science should secure the harmony and cooperation with plant physiology, biochemistry and plant ecology.

I need not say that this should be backed by international exchange of knowledge as well as domestic. On the other hand, we must tighten the link between branches of study on soil and fertilizer in the soil and fertilizer science. The study of plant nutrition has reached its present stage of development by severing the relation with soil by means of the water culture and by introducing biological viewpoints. But to get close to a higher and a more complex subject, we should come back again to the pursuit of the "soil conditions and plant growth system" or further to "soil, plant and atmosphere relationship system". Thus by grasping the environmental conditions quantitatively, we must analyze the reactions of plants.

The future of the study cannot be guaranteed only by hopeful expectation. We should, for the development of the study, take care to establish the methodology and practical experiment method, search for the conditions to guarantee the future and help remove the impeding factors. Dr. Kumada points out that in the past soil chemistry created new techniques by systematizing, verifying in actual fields, the abstract theories developed in beaker experiments. Furthermore, it was noted that these achievements were attained through simultaneous and parallel researches by a single researcher. But in these days when the specialization of studies and researchers are conspicuous, it is almost impossible for a single researcher to pursue the fundamental theory and at the same time carry out the test for the verification in the field simultaneously. Here we see the necessity for the active communication and exchange of knowledge between researchers, to work for an organized and systematized development.

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IV Present situation and future prospect of studies on the application of fertilizers in Japan

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1. Preface

The studies on the application of fertilizers aim practically at increasing the yield of crops by the applying fertilizers. Its ultimate goal is to find out a practical standard for the application of fertilizers and thereby contribute to production.

The characteristic feature of Japanese agriculture is an intensive farming with heavy application of fertilizers. Our country, having a population of one hundred million, is small in area and the land is mostly hilly with little cultivated land. The climate is humid with abundant rain. This, combined with the fact that the land is hilly, tends to cause the base to be wahsed away. As the mother material of soil volcanic ashes are dominant. There is also a large thin area of allophanic soil. And unlike Western countries, reproduction of soil fertility by means of crop rotation and stock raising within the management, is difficult. As a result, production of foods for the population has to be supported by abundant fertilizers and intensive farming. As it is widely known that on a land of low fertility the effect of fertilization to production increase is very large, significance of fertilizer application and fundamental study on fertilization techniques to the agricultural development in our country is very important.

In our country, importance of the study on the application of fertilizers has been realized from the early Meiji era, and a large number of research workers are distributed among the national and prefectural experiment stations and universities. Cultivated crops are numerous ranging from paddy rice, upland crops, fruits, vegetables, mulberry tea, feed crops and grasses to forest trees. Formerly, emphasis was laid on the study on paddy, but in recent years all of the crops mentioned above have been widely studied. As the study on the application of fertilizers has to be studied in accordance to the characteristics of crops, the study is done on each respective crop and the level of study is generally high, but the effort put in differs by the economic importance of crops. The present technical level achieved in the application of fertilizers has a rather large difference. As you know, modernization of agriculture is being strongly urged, and all the different fields of study concerning agriculture are showing new progress. This is also true in the study on the application of fertilizers.

Following is the present situation of the study in our country on the application of fertilizers, and its future outlook.

2. The progress and present situation of the study on the application of fertilizers in Japan.

The main characteristic of the green plants cultivated in agriculture and fore try is that they collect and store the energy as a potential by photosynthesis. Inoi...nic

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nutrients are important in making possible and promoting this process of photosynthesis.

Necessary elements for a crop are the 15 elements (C, O, H, N, P, K, Ca, S, Mg, Fe, Mn, B, Zn, Cu, Mo) shown in Table 1. Of these, 9 elements from C to Mg are the macro-elements, which are absorbed in large quantity by the crop, while 6 elements from Fe to Mo are the micro-elements, required less by the crop. C and O is absorbed from CO_2 gas contained in the atmosphere, and H is absorbed from water, in both cases unlimitedly.

Table 1 Necessary elements of crops

Macro-elements			Micro-elements		
1.	Carbon	C	10.	Iron	Fe
2.	Oxygen	O	11.	Manganese	Mn
3.	Hydrogen	H	12.	Boron	B
4.	Nitrogen	N	13.	Zinc	Zn
5.	Phosphoric acid	P	14.	Copper	Cu
6.	Potassium	K	15.	Molybdenum	Mo
7.	Lime	Ca			
8.	Sulfur	S			
9.	Magnesia	Mg			
	(Silicic acid)	Si			

Crops spread roots in the soil and absorb necessary elements (nutrients) from the soil. In the stage when the yield is low, all the necessary nutrients can be supplied by the soil. But when cultivation becomes intensive, or if larger yields are required, the supply by the soil is not enough, and there arises the need for artificial supply, namely the application of fertilizers. The shortage in nutrition of crops start with macroelements, especially N, P and K, which are needed extensively. Next comes Ca, Mg Si and then comes micro-elements. As the number of elements increases, so does the quantity required. In this case, there are both antagonizing and complementing actions between the nutritious elements, both macro-elements and micro-elements alike. Especially, under excessive application of fertilizers, the important problem is not the quantity, but rather the balance between elements. The nutrient supplying power of soil differs by type of soil and the way the land is used. Compared with paddy field whose fertility can be sustained by irrigation, the nutirent supplying power of upland field is much smaller, especially in fields where the reproduction of fertility is not considered within the management, and there lack in nutrition. Originally the application of fertilizers began as a means to amend the lack of supply of nutrients from the soil. But the present situation in our country is that priority in supply of nutrients is concentrated on the application of fertilizers.

Looking from the point of view of fertilizer application, the soil can be considered as a part of nutritive system. In a large soil area, there is a continuous cycle of global chemical transmigration concerning the rearrangement of the form, quantity and place of various earth crust's elements. And there is also a continuous transmigration of agro-chemical elements in each farm land. Concerning this transmigration, an effort must be made to improve fertility by definitely grasping the mutual rules, in ordinary farmland, *between soil and plant with man as a medium, and in grassland, between soil, plant and animal.*

Taking the field for example, the relation between the application of fertilizers and soil fertility can be shown as thus;

$S + F = C + L + S'$
(when whole crop is taken out of the field)
$= C' + L + S''$
(when a part of the crop is taken out of the field)
$= L + S''$
(when all of the crop is returned to the field)

S ...... Nutrients contained in soil
F ...... Quantity of nutrients supplied by the application of fertilizers
C ...... Quantity of nutrients absorbed by the crop
C' ...... Quantity of nutrients taken out by part of the crop
L ...... Quantity of nutrients lost by leaching, etc.
S', S'', S'''. Quantity of nutrients remaining in the soil

In this case, if S is large, then F can be small, but is S is small, there needs to be a large F. The size of S', S'' and S''' depends on the size of F, L, C or C'. Although $S' < S'' < S'''$, S has to be smaller than S', or the soil gradually loses its fertility. To expand and reproduce of the soil productivity there must be proper application of fertilizer and usage of land, to guarantee that $S < S'$, S'', S'''.

According to Mr. Kayo, farming method in Europe developed from cereal crop system to grain and grass system, and then to rotation crop system. This is significant as a process to the reproduction of fertility. In cereal crop farming (typically the three-field farming), cattle was let out to graze in the large adjoining natural grassland, and by changing the grass of the land into manure through cattle, and by transporting it to the farmland, the fertility movement from grassland to farmland was completed. In the grain and grass farming, which came next, a part of the farmland was transferred to permanent pasture, and after a certain time transferred back to farmland. By this method of alternating farmland and grassland, a higher stage of fertility reproduction, compared with the former farming method, was reached. Then by the so called rotation system, with the insertion of crops other than grains, like grass and tillage crops (root crops), the *rotating cultivation system* was established. The formation of the rotating farming system meant increased production of fine quality feed — increased productivity of cattle — increase in manure — increased productivity of crops, which established the expanding reproduction system.

In this way, the Western concept on the application of fertilizer put implıasis on the increase of soil fertility in connection with stock raising and deep tillage,. and application of fertilizer had only a supplementary significance. But in our country the reproduction of soil fertility was neglected, and heavy fertilization policy has dominated. Table 2 shows the amount of chemical fertilizers used per unit area in our country, compared with those in Europe and America. Although the amount is less than in the Netherlands and Belgium, it can be seen that the amount used is farly large.

Table 2

Quantity of chemical fertilizers used per hectare of farmland, in major countries

Country	1938			1957		
	Nitrogen	Phosphoric acid	Potassium	N	P	K
Belgium	60.06	96.65	58.72	89.49	120.50	145.66
Czechoslovakia	3.48	7.67	4.93	17.08	20.77	40.00
Denmark	18.86	23.64	16.84	35.64	36.94	57.85
France	10.52	14.35	14.77	22.92	35.65	32.10
Italy	9.88	20.15	1.37	17.03	24.35	4.40
Netherlands	96.75	107.31	121.52	198.58	104.27	143.78
Norway	12.37	18.02	25.32	54.25	54.13	52.57
Sweden	7.94	14.22	14.78	23.32	27.47	23.19
Switzerland	4.55	25.49	16.21	26.97	92.13	60.67
U. K.	11.72	33.22	14.65	44.39	50.04	49.93
Canada	0.42	1.54	0.90	1.40	3.10	1.89
U. S. A.	2.49	4.86	2.57	10.76	11.40	9.15
India	0.64	0.05	-	1.16	0.15	0.08
Japan	41.80	53.42	18.60	124.62	57.53	63.57

Source: Nobufumi Kayo: "The pattern of fertilizer consumption in Japanese agriculture", 1964.

The application of fertilizer is only a part of the production technology. It needs to be harmonized with the whole system of cultivation technique, and its importance as an element in the system of cultivation technique depends on the degree of advancement of other elements. In the stage where the study on the application of fertilizers is advancing foremost, the application of fertilizers holds a strong initiative over others. In other stages the application of fertilizers has to be harmonized with other elements.

As I already said, crops spread roots in the soil and absorb necessary nutrients and water, and photosynthesis proceeds. The product of photosynthesis is stored inside the crop and enhances the vegetative body, and advances on to reproductive growth. This process of growth in a crop is, as proven by plant nutrition study, the complicated chain of advancement of biochemical reactions. To make the crop grow normally, it is necessary to supply nutrients required by the crop, in the density and proportion required, using a specific process according to the crop's characteristics. The sources for this nutrition are the soil and the fertilizers applied.

So, the study on the application of fertilizers is based on:
1) the study on soil especially the study on the productivity of soil, 2) the study of plan nutrition. The advance in the study on the application of fertilizers relies on the progress and development of these studies. Furthermore, because the application of fertilizers is practical technique by man, it advanced corresponding to; 3) the supply of fertilizers and 4) the development of agricultural circumstances. It aimed at larger effect and higher efficiency in the shape of increase in yield, stability, and efficient production. For example the application of fertilizers on paddy in our country developed as shown in Table 3. The corresponding quantity of fertilizers consumed and the agricultural circumstances are shown in Table 4 and 5. If the highest pre-war figure is set at 100, the amounts of N, P_2O_5, K_2O have all increased, and the index figure for 1966 reads 220,190, and 510 respectively. The ratio between these three elements have balanced out at N:P_2O_5: K_2O = 75:62:62, compared with the pre-war tendency of N priority.

The chemical form of fertilizers too, have become more diversfield, combined, concentrated or granularized. And slow working types, as well as quick working types, began to appear.

Table 3. Change in the application of fertilizers on paddy

Change in : in application method	Important experiments and studies	Programs of the Ministry of agriculture and forestry
1. Meiji Era Empirical fertilization-application of fertilizers, mainly organic fertilizer (fish-meal, oil meal, rice bran, compost, manure.) Beginning of production and use of chemical fertilizer (superphosphate)	(experiments on the effect of fertilizers. three elements, quantity test)	
2. Taisho Era Application of fertilizer with the increase of chemical fertilizer (phosphate, sodium nitrate, ammonium sulphate)	Experiments on, the effect of fertilizers, three elements, quantity test. (The effective use of fertilizers)	Standard fertilization survey.

3. Early Showa Era up to the Pacific War. Rationalization of application of fertilizers in comection with the rapid increase in chemical fertilizers (ammonium sulphate, calcium superphosphate, potasic fertilizer), and the rise in the consumption of chemical fertilizers. (The application of N fertilizer to all layers, fertilization at heading stage).	The studies on chemistry of soil in paddy fields, and the improvement of the application of fertilizers. (The study of chemistry of soil in paddy fields. The study on total layer fertilizer application. The study of potential fertility of soil in paddy fields. The study on aged fields' soil. The study on the fertilization at heading stage. (Increase in fertilizer efficiency)	Standard fertilization survey.
4. Pacific war to present Bigger increase in chemical fertilizers (urea, ammonium chloride, calcium silicate, synthetic fertilizer). The appearance of slow working N fertilizer, fertilizer containing *nitrification retarding* agents and pesticides prevention fertilizer and fertilizers.	The study on the analysis and increase of soil productivity. The study on the cause of change of soil organic matter into inorganic substances.	

Table 4. Recent consumption of fertilizer components in Japan

Years		N			P_2O_5			K_2O		
		Actual figure		Index	Actual figure		Index	Actual figure		Index
Calendar year										
Showa	10	305			290			104		
	11	371	339	100	329	327	100	104	121	100
	12	340			361			155		
Fertilizer										
year	30	561		165	392		120	395		326
	31	581		171	413		126	397		328
	32	582		172	393		120	386		319
	33	596		176	407		124	454		375
	34	659		194	464		142	514		428
	35	665		196	493		151	535		442
	36	633		187	470		144	509		421
	37	660		195	493		151	541		447
	38	688		203	532		163	576		476

	N		P_2O_5		K_2O	
	Actual figure	Index	Actual figure	Index	Actual figure	Index
Fertilizer Year 39	668	197	535	1641	583	482
40	691	204	574	176	601	497
41	746	220	620	190	617	510

Table 5. Recent development of circumstances surrounding Japanese agriculture

(Year) The change in basic policy	Moves in agriculture		
Pacific war	Small scale management (Tenant farming)	The devastation of agriculture by the war.	
(1947-1951) (end of war) Land reform	Small scale management (Owner farming)	The increase in the enthuasism for production.	
(1961) Enforcement of Agricultural Basic Law.	Enlargement of farm scale (aiming at promoting independing farmers) Independent fully engaging farmers : Increase in part-time farmers	Widening of income gap between agriculture and other industries. Change in demand for agricultural products. Liberation of foreign trade. Decrease in number of persons employed in agriculture	Rise in productivity. Selective expansion. Improvement in the structure of agriculture.
(1967) Basic policy of structure improvement	Collectivization	Increase in income gap between agriculture and other industries. Change in demand of agricultural products. Liberation of foreign trade. Decrease in number of persons employed in agriculture	

As regards the change in agricultural circumstances, there was a devastation by the Pacific war. But by the land reform after the war, new owner farmers born out of it had high enthusiasms for production, and this together with the increase in the supply of fertilizers and progress in agricultural techniques, brought about an increase in productivity, and thus food was secured. This helped the rebuilding of the whole economy. But because of the small scale management, the income gap between agriculture and other industries widened with the high rate of growth of production. With the change in demand for agricultural products, the liberation of trade and the decrease in the number of poeple employed in agriculture as the background, the Agricultural Basic Law was enforced in 1961. Plans for increase in productivity, the selective expansion of production, the improvement of agricultural structure, were to be adopted. This was aimed at promoting up-to-date owner farmers and co-operatives. But as it proved out later, the number of part time farmers increased. And at present, the need of co-operation is being strongly advocated.

The standard for the application of fertilizers, which is the result of the study on the application of fertilizers, must be scientific as a technique. Details of application of fertilizers must be cleared qualitatively and quantitatively according to specific conditions like, "Where", "On what crop", "With what kind of fertilizer", "When", "How much" and "In what way", the fertilizer is to be applied. For this standard to be a universally scientific standard, and not the one based only on experience, it must be backed by studies on the productivity of soil and plant nutrition, such as the quality of fertilizers, the characteristics and dynamics of soil, the nutritional physiology of plants especially environmental factors and absorption of nutrients, metabolism and the physiological characteristics of individual crops. This means that the most effective and efficient way of application must be searched for each individual soil and crop, in accordance with the characteristics of the soil and crops.

"Where", is the location relating to soil and climatic elements. By soil survey the classification of soil has been done in soil research projects. Types of soil are quite numerous, and it is thought that the soil series classified by mother rock, sedimentation and cross section, number up to several hundreds. These soil series, as shown by the classification formula in Table 6, are different in thickness of surface soil, depth of effective soil layer, humidity of soil, natural fertility, quantity of nutrients contained, impediments, inclination and erosion. And the series usually show clear difference in their soil productivity (the difference in the form and degree of limiting and impeding factors in soil or of the danger of deterioration). Numerous soil series (and the types under each series), differing in their potential soil productivity, necessitate local differentiation of fertilizer application.

Though the soil is providential, it is not permanent. And the farm soil, used as production ground, has had its suppressing and impeding factors alleviated by land improvement (drainage soil dressing, enhancement of land blocks, irrigation, etc.) and soil improvement.

Table 6. Classification formula according to soil characteristics

Grade of potential soil productivity.	Example		
	(II)		(III)
Thickness of surface soil	t	I	I
Depth of effective soil	d	II	II
Gravel content of surface soil	g	II	I
Difficulty of cultivation	p	I	II
(nature of surface soil)		1	2
(adhesiveness of surface soil)		1	1
(hardness of air-dried surface soil)		1	(2)
Humidity of soil	w	II	(III)
(water permeability)		2	1
(soil keeping capacity)		2	3
(moisture)		1	1
Natural fertility	f	1	I
(fertility keeping capacity)		1	1
(fixing capacity)		1	1
(condition of base in soil)		2	2
Quantity of nutrients	n	II	III
(replaceable lime content)		1	1
(replaceable magnesia content)		1	3
(replaceable potassium content)		2	2
(effective phosphoric acid content)		2	2
(minor-elements content)		1	1
(acidity)		1	1
Impeding qualities	i	II	I
(chemical impedance)		1	1
(physical impedance)		2	1
Inclination (slope)	s	II	II
(natural inclination)		2	2
(direction of inclination)		S	S
(artificial inclination)		-	-
Erosion	e	II	II
(degree of erosion)		1	2
(degree of resistance to water erosion)		1	1
(degree of resistance to wind erosion)		2	2

Furthermore, improvements have been made toward eliminating these factors, and it seems likely that improvements will be made in this direction. That is to say, that by land foundation consolidation with land improvement and others as the nuclei, the soil conditions of farmalands will become inproved and simplfied. This move is in the direction of improving soil productivity, increasing the fertilizer recipiency quantity and also increasing effectiveness of fertilization. Moreover, it is also a move towards the expansion of edentical fertilizer application range.

Next, the climatic factors, that is closely connected with the growth of a plant, is daylight length and temperature. Because our country is situated in a long distance from north to south, and has a complicated lay of land, both the daylight length and temperature very greatly. Besides the regional difference, there is also a great annual difference of climate in each area. And it is still very difficult to predict the change accurately. Here lies the necessity for the extemporaneousity of the fertilization techniques, based on unstable conditions.

About the crops, breeding projects with the aim of cultivating crops with greater yields, is being carried out. There are already many excellent varieties in all crops. The movement in the planting of paddy varieties, by the improvement of crops, is shown in figure 2. The high-yielding types usually have a higher nutrition absorbing capacity, and needs more fertilizer. So the adequate quantity of fertilizer also rises as shown in figure 2.

The improvement and consolidation of land accepts high-yield varieties and lets their potentialities develop. On the other hand, the high-yield varieties require further consolidation of land. Through this mutual process, the quantity of fertilizer applied increased and raised productivity in our country.

Application of fertilizer has regional characteristics as already shown. So the agricultural regionality needs to be clarified, and the division of fertilizing area based on it is important. And the standard of fertilization satisfying the needed conditions for the crop's normal and anticipated growth, must be pursued according to fertilizing area division, the crop, the varieties, and by the rate of yield. Taking the case of the regional difference of technique in the Tohoku area for example, it can be said that 1) a yeild of up to 600 kg can be attained using the present technique and, without much soil treatment, 2) in some areas, there is a difference between the techniques in their significance in production - when the temperature is low, water permeability holds little importance, 3) fertility and permeability are closely connected each other, and if these are abundant, a yield of up to 800 kg can be attained without top soil, 4) for yields of over 900 kg, favourable climate plays the leading role.

A) Present situation of studies on the fertilizer application to paddy rice.

The main subjects in the study of fertilization method for paddy rice at present are as shown below. In accordance with the locality, variety, crop season, cultivation method any yield level, a harmony as the comprehensive technique for modernizing paddy rice culture is being aimed at.

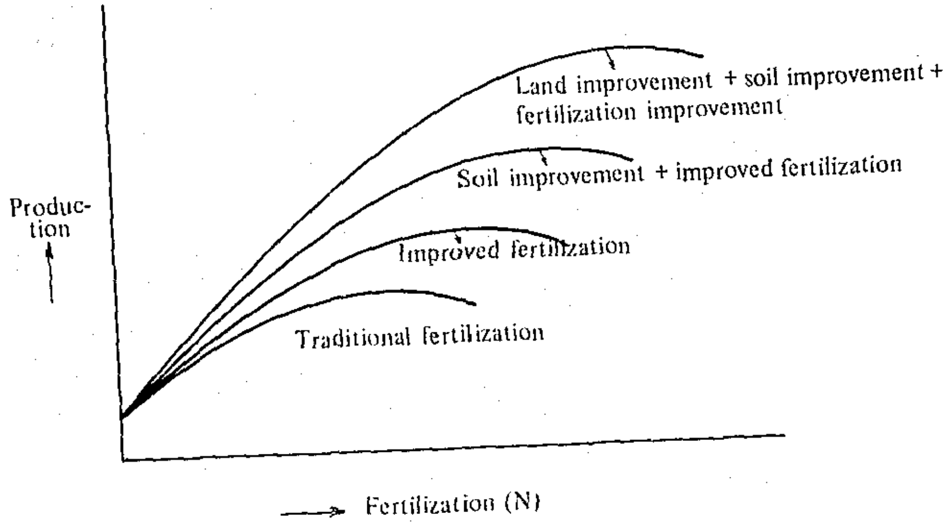


Fig. 1 Land improvement, soil improvement, fertilization improvement and production

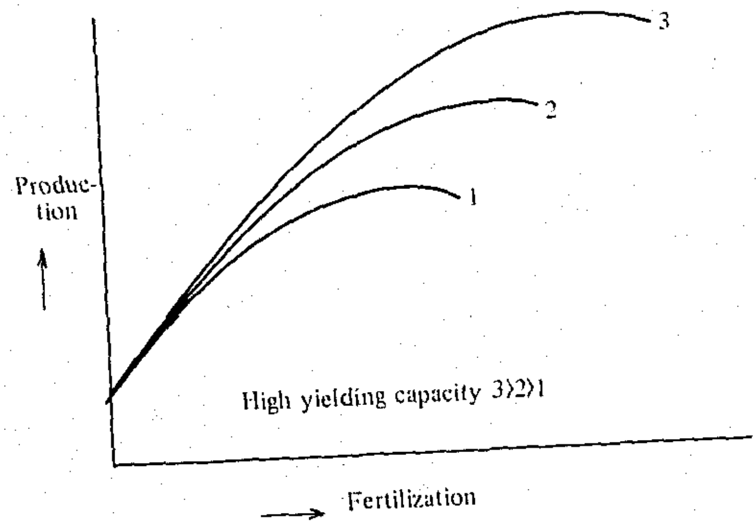


Fig. 2 Relation between variety improvement and rise in fertilization standard

Major objectives of the studies are high yield, stability and efficiency.

The main features could be summarized as follows:

a) On field consolidation.
   (1) The leveling of soil fertility at a high standard in the consolidated fields.
b) On increasing production.
   (1) Fertilization method, especially of nitrogen;
   fertilization with emphasis on additional fettilization;
   letter shaped fertilization; deep layer fertilization;
   securing later stage nutrition by slow working nitrozenous fertilizers.
   (2) Examination of the significance of nitrate form nitrogen.
c) On increasing productivity.
   (1) Assessment of the effect of and establishment of application methods for slow working fertilizers, fertilizers containing anti-nitrification in ingredients or pesticide chemical.
   (2) The flow-in application method of liquid fertilizers;
   mechanized fertilization for direct sown paddy.
   (3) Use of fresh straw.

Rice growing campaign is highly promoted recently and is getting results through collective practices, etc. The improvement of fertilization always holds one of the main roles in production increase technique. From the campaign we have learned that agricultural techniques become more effective as production advances from small individual production to larger collective production, e.g. by cooperatives.

B) Present status of studies on fertilization methods for upland crops.

Number of crops grown in upland fields are nemerous. In our country's agriculture upland crops hold secondary place after rice, and studies on them are carried on with emphasis on increasing production, against the background of the cultivation in small scale, dispersed land, plots with toiling labor. Although the yield per unit area has gradually increased, the productivity is far lower than in advanced foreign countries.

Recently, with the move to open economy, crops with low profits are decreasing rapidly in area and the trend toward extensive cultivation on land not carefully prepared or fertilized is becoming conspicuous.

Formerly the increase in yield of each crop directly contributed to the improvement of upland farming, but it is now taking the course of increasing total agricultural income by combining common crops with intensive ones, improving overall productivity through the increase in land fertility as well as the prevention of damage by sick soil.

Today studies on major crops should aim at maintaining production against foreign competition, through the increase in production and the improvement of productivity.

With these in the background, studies on fertilization methods for upland crops at present is rather inactive, but the more difficult the conditions are, the more important is the study to overcome them.

Most of the fields in our country are not fertile. For the improvement of productivity, we must first prepare a highly productive field through deep tillage and enriching the soil with base, phosphoric acid, and organic substances, and thereby eliminating growth inpeding factors. Then a rational system of cultivation and management should be established. Although it is clear that the use of organic substances is very effective for improving fertility and increasing the effect of inorganic fertilizer, organic matters are sharply decreasing in use. In connection with mechanization straw and stalks which are left in the field after harvest should be utilized positively as a substitute for barnyard manure to increase land fertility. Studies in this field are being carried out.

The improvement of land conditons, which enables efficient control of water in the field is highly appreciated and effective fertilization method to adapt such situation is also studied.

From the viewpoint of increasing productivity of fields, stress is put on mechanical cultivation of field crops, and as a part of it mechanized fertilization and use of refuse from mechanized reaping is becoming a problem as I stated before. Regarding mechanized fertilization, technique of increasing efficiency of fertilizers by applying them at proper position, and of taking advantage of the effects of slow acting fertilizers to avoid overconcentration resulting from heavy fertilization are being sought and is showing results. The hazards of repeated planting of field crops in the same field are complicated and multifarious. They are being analysed and put in order from the viewpoints of soil microbiology, planting system and plant nutrition.

C) Present status of study on fertilization of fruit trees.

The planted area of fruit trees expanded rapidly in recent years. Full scale study as they are perennials, there are many points yet to be clarified regarding their nutritional physiology such as the absorption of nutrients and the present fertilization method still contains many empirical factors. Generally speaking, fertilization at present is excessive, and there are many orchards threatened by dilapidation because of this.

It is important to increase and stabilize production through the pursuit of a scientific fertilization standard (adequate quantity of fertilizers and effective method of fertilization). Fertilization has at the same time a close relationship with the quality of fruit. This is another point to be examined carefully.

Recently the number of researchers studying fertilization of fruit trees has increased, and a system for large scale fertilization experiments to be continued over a long period is being consolidated.

With these facts in the background, studies on fertilization of fruit trees have been strengthened, and numerous basic studies in nutrition physiology especially on the process of nutrient absorption, relation between evironment and nutrient absorption, nutrient abosrption and internal metabolism, nutrition and growth, flower bud formation and fruit-bearing are being carried out using R.I, and the nutritional, diagrosis by leaf analysis is being established.

Many facts have been clarified concerning the assessment of effect of various new fertilizers including slow acting fertilizers and method of their application, the judgement of the lack of micro-elements and special elements and their effectiveness.

Studies are made on quantity of fertilizer applied, year-round distribution of fertilization, the effect analysis of organic fertilizers that have long been believed to be of special effect nad the relationship between fertilization and fruit quality.

Orchards in general have strong acid soil, resulting from heavy fertilization, and this causes various hazards of abnormal growth of fruit trees. Studies on this phenomenon are being promoted through the dynamic analysis of micro metal elements in orchard soil and their abnormal absorption. And it has been made clear that the internal bark necrosis of apple trees and the anthracnose disease of Satusma orange trees are caused by the excessive absorption of Mn that accompanies strong acidity of soil. Positive heavy application of fertilizers to the planting pit for young trees, and the relationship between grass covered culture and soil fertility are also being studied.

D) Present situation of fertilization method for vegetables.

With the rise of living standard the demand for fresh vegetables is steadily increasing. There are so many kinds of vegetables, and vegetable production of today is largely empirical, with abundant fertilizers and labor. As a result, not only is the fertilizer wasted, but also various growth impedance and desolation of land after havest often occur. The improvement of soil fertility of vegetable garden and the stabilization of production and high yeild through the research on scientific fertilization standard are most urgently needed.

In recent years there is a growing tendency toward cultivation with equipments, e.g. green house culture and gravel culture. Specific fertilization methods according to various conditions should be devised.

Present situation of vegetable fertilization has been strengthened on many sides. Because of the large number of kinds, studies on the nutrition physiological characters of each vegetable – especially the process of nutrient absorption, environment and nutrient absorption, nutrient absorption and inner metabolism, are slow to advance but these themes are being earnestly worked on and nutritional diagnosis is also studied.

Researches are continuing on: the prevention of hazards of over concentration due to excessive fertilization, the effect assessment and application method of slow acting fertilizer and liquid fertilizer aimed at reducing times of fertilization and improving efficiency, the method of judgement of the deficiency of micro-elements and special elements, and the balanced fertilization.

There are also researches on: the quantity of fertilizer, the distribution ratio of basic fertilizers and additional fertilizers, the analysis of organic fertilizers and substitution techniques, the clarification of hazards of over concentration and its prevention, the deterioration of soil caused by fertilization and its prevention, the fertilization method for mechanized cultivation in the main producing areas aimed at improving productivity.

In the fertilization for equipped culture under glass there is no leaching of nutrient and because of the utilization of soil moisture through capillary, concentration of salts on the soil surface is prominent and is likely to cause density hazards, sometimes gas hazards. And so the determination of standard of fertilization, kind, quantity, application method of fertilizers, and the clarification of mechanism of and method of prevention against density hazards (gas hazards) are being studied and is showing results.

The irrigating application of liquid fertilizers and the effects of CO_2 gas application are being studied. Together with glasshouse cultivation gravel culture is extending. In the case of gravel culture, nature of the gravel and the adsorption, the constitution, density of culture solution, renewal and circulating method are the main themes of researches.

E) Present situation of studies on the fertilization of grass and feed crops.

The demand for milk, dairy products and meat have risen sharply in recent years, and consumption is increasing every year. Milk production tripled during the last 10 years (1956 - 1966). Most significant move in the field of dairy farming today is the toward the expansion of the scale of dairy cow management.

Our country's grasslands are generally poor in soil nature. Unless there is adequate soil improvement and proper fertilization and management, establishment and maintenance of good grassland can not be expected. To promote stock raising, securing of good quality feed is essential. For this purpose the exploitation technique of unused feed resources, increase in production on existing grassland and farmland and advanced usage techniques are required.

Furthermore, in the vast areas in Hokkaido, Tohoku and part of Kyushu where dairy farming is likely to develop, the adoption of grazing method or the lowering of cost by mechanization is important. The study of grassland fertilization and management in our country has rather a short history, but the number of researchers has grown rapidly in recent years and studies has been already on the right line, and accomplishments are steadily accumulating.

Studies on grasses and feed crops are numerous in number and are covering a wide field. The nutrient absorbing capacity and characteristics of each variety of grasses and feed crops are being clarified, but these plants usually contain a large quantity of nutrients and by the big amount of harvest the nutrients in soil are enormously robbed off. So, unless the nutrients taken from the soil are replenished, yield is sure to drop sharply. The basic idea of fertilization is nothing but to replenish the nutrients thus taken off.

The pattern of nutrient absorption by plant and growing period, the response to fertilizer elements and the role of basic fertilizer and additional fertilizer were made clear. If the balance between three elements is lost, the yield decreases rapidly. Proper ratio of grasses to pulse crops can be maintained by the balance of nutrient elements. It is important to establish the technique to attain vigorous growth and regeneration of forage crops throughout the year. Attention is drawn to the nutritive value of forage grasses. Micro-elements not only affect the vegetative growth, but have close relation with the mineral nutrition of animals, and soil-plant-animal relation, especially in the case of grazing is being studied.

On cultivated land and intensive grassland, production of high level is aimed at, and rational fertilization technique, especially to elongate the life of grassland is studied. On the other hand, for extensive grassland and slope lands establishing low cost grassland, especially grazing and large scale mechanized fertilization as a part of the large scale mechanization technology is sought for. With the development of the management keeping a large number of animals big amount of the excreta is a problem, and studies for the rational utilization as manure is being investigated.

F) Present situation of studies on fertilization methods for mulberry.

The demand for silk was stagnant for a while but recently it has been increasing again. Experiments were made under the Mulberry Farm Fertilization Improvement and Rationalization Programme and the role of organic substances for improving acid soil was clarified. It became also clear that coarse calcium carbonate is very effective to soil improvement and the use of phosphates, lime and potash for red and yellow soil of mulberry farm were found to be very efficient. Increased application of phosphates, lime and magnesia on volcanic ash soil of mulberry farm proved highly effective too.

G) Present situation of studies on fertilization method for tea.

Tea is grown on infertile slopes and usually gives a low production. To increase production, deep tillage, input of organic matters and the improvement of the composition of bases are very effective. To improve fertilization, the absorption of nutrient and the translocation of applied nutrients are studied. It is also becoming clear that the crop readily absorbs low soluble phosphates of Fe type in the soil.

Moreover in recent years, the growth retardation in tea gardens are becoming distinct, and investigation of the cause and the measures for its remedy are being studied from the side of micro metal elements. From the viewpoint of increasing productivity, as a part of the move to save labor and mechanize works in tea garden management, studies aimed at reducing the number of times of fertilizer application are made, and experiments on the effect and application time of various slow-acting fertilizers are carried out. Researches on the place of application by fertilizing machines and the use of liquid fertilizers are also carried out.

H) The study on the fertilization method for forest trees.

Formerly we have relied mostly on natural fertility in forests, but to positively increase production of forests the establishment of fertilization technique for them is important as a foundation of an intensive forest management. Although the study on fertilization of forests began only around 1955, it has already been proven that fertilization is very effective to young trees of important species for afforestation, e.g. Cryptomeria, pines, etc. and the fertilization is already practised in both government and private forests. At the time of planting, side fertilization usually get better results. The effect is higher when the soil contains adequate moisture and the plant has healthy roots.

Fertilization for grown trees too are being studied and with the help of R.I we are gaining new knowledge on the place to apply the fertilizer, the movement of nutrients in the soil and the nutrient absorbing capacity of trees.

Regarding nursery experiment on nutrient absorption of plants and measures for the improvement of fertilization for various types of soil of the nursery beds are being carried out.

3. Future prospect of the study on fertilization method.

It is sure that modernization and mechanization of agriculture will be accelerated in the future. The scope for the study of fertilization method would be to correspond to the agricultural revolution and to bear responsibility for it. We should rapidly raise the scientific level of fertilization and actively help increase the production, improve productivity and raise the quality of products. As I have said in Section 2, studies in our country had the emphasis laid on increasing production by abundant fertilizer and labor. By this we reached quite a high production level but the productivity is much lower than in the advanced countries of Europe and America.

Recently in our country, productivity also is becoming to be regarded very important and stress is laid on the studies aiming at enhancing the scale of management by mechanization. We can safely say that agriculture will advance in the direction where, both the increase of production and improvement of productivity are aimed at. How to get a high yield by the use of machines, is an important theme to be studied. The role of the study on fertilization method in this respect is very important.

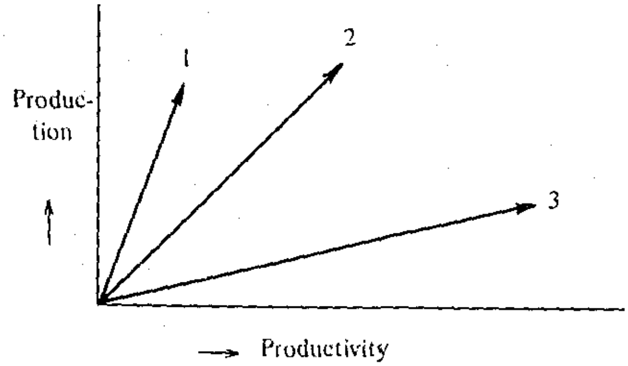
The advancement of the study on fertilization method in the future will have their ground on 1) the study of soil productivity. 2) the advances in the study of plant nutrition, corresponding to 3) the improvement and development of chemical fertilizers and to 4) the development of environmental factors of agriculture and in this respect the situation will not be so much different from that before.

Formerly, small scale farming on scattered small plots of land was prevalent depending solely upon hard labor and nature's caprice. But from now on the complete clarification of regional differences and the improvement of basic land conditions will promote the leveling of soil conditions at a high standard (the enhancement of production possibility and expansion of the domain where a uniform technique can be applied). On the other hand increasing accuracy of 'weatherr forcasts will hlep adjust cropping season and crop growth (including acceleration and control of nutrient absorption) making accurate diagnosis on plant nutrition, improving water management and improving crop variety, and thus we can overcome adverse weather conditions or completely cope with the change in weather. Agriculture will develop toward a large scale, planned and mechanized production, or an industrialized biological production, aiming at higher yield, stablity and better quality, under a better condition for fertilizer receiving, using adjustable fertilizers according to the demand of plant effectively.

At this stage, the dependency of nutrient supply on soil will be comparatively reduced, and the importance of fertilization will be much larger. As healthy growth of roots, which controls nutrient absorption, is the essential condition, the improvement of soil conditions will be important, and the necessary conditions for desirable soil structure, water permeability, moisture keeping capacity will be clarified qualitatively as well as quantitively. While consolidation of basic land conditions is promoted, substituting techniques for it will also be developed, which will make the conditions all the more convenient to realize this. As to our country's industrial advancement, according to the predictments by specialists in the field, the high growth rate of economy will continue further, the industrial population will be re-distributed, and as concentrating of population to cities advance, through the regional development program of the government the formation of main producing areas in agriculture would advance. Establishment of modern owner farming or collective cultivation will be promoted, and agriculture will move from small scale management to large scale one. Under this condition, the possibilities found through studies can be realized in technics and will be utilized without delay in production as in industry.

So far, it was rather usual that a large number of studies on fertilization method were tested at numerous locations, including field tests, for a long period of years and by accumulation and induction of data a conclusion was reached, but now it is already out-of-date to rely solely upon a process of this kind. In the future, we should get out of the experiment principle carried out under the unstable climatic conditions outdoors.

We should add, parallel to the outdoor experiments, the complete physiological and ecological study by the use of a proper facility which can control climatic, soil and



(1) Present situation in Japan
(2) Future direction
(3) Present situation in European and North American countries

Fig. 3 Future direction of technology

Industry	Progress in studies (fast)	Potential production (high)	Level of production technique (same as potential)
Agriculture	,, (slow)	,, (low)	,, (much lower than level of potentiality)

Fig. 4 Comparison of present situation of studies and techniques in agriculture and industry

other conditions (for example Phytotoron), and by the deductive method reach a more accurate conclusion within fewer number of years and experiments. At least for annual crops, we should make the fact a fable that we devoutly kept the same fertilization test for many years.

At present, experiments on fertilization method are being carried out by numerous technicians, other than the members of the Society of the Science of Soil Manure and often getting fair results. Some farmers carry high level fertilization experiments by themselves. We have to reconsider at this time, what kind of studies should be the one which the members of our Society will undertake exclusively. That is to say, whether our studies patternized and fallen under mannerism or not should be reflected now. Can the present situation of our study, way of thinking or studying not for the fertilization method, but for the whole area of study of soil and fertilizer science be deemed satisfactory? Recently in other fields of study, with the introduction of biochemistry and other basic studies, the feature of study has entirely changed, and epoch-making results both theoretically and practically are found one after another. Isn't the utilization of the knowledge in biochemistry, the science supposedly very close to us, so minor in our field? I deeply feel the necessity of introduction and fortification of biochemical and other basic concepts in our field and also of exploitation and expansion of border areas of our studies to promote future advancement. I hope, through the development of original studies, we can not only contribute to the development of agriculture in our country but also in a wider contribute to the agricultural development of Southeast Asia.

V Historical Review of Fertilizers in Japan

by Shingo Mitsui

1. Production, Consumption and Export of Major Fertilizers in Japan

Since the Meiji period the use of fertilizers in Japan made the following changes. First, during the middle of Meiji 'organic fertilizers' were used. At that time fish cakes, rapeseed cakes, cottonseed cakes and rice bran largely made up the 'commercial fertilizer'. From the end of the Meiji period soybean cakes, which came from Manchuria in a large quantity, began to be very important.

In the meantime, 'chemical fertilizer industry' was established in Japan. Calcium superphosphate was first produced, followed by lime nitrogen and ammonium sulphate. By 1937 when the China Incident broke out inorganic chemical fertilizers domestically manufactured had accounted, in case of nitrogen fertilizers, for about 70 percent (in terms of nitrogen component) of all types of nitrogen fertilizers. 1937 was the record year for fertilizer consumption before the Seconc World War. Since then it was sharply reduced reflecting the progress of the war. In 1945 when the war ended the consumption of nitrogen fertilizers was estimated to be only about 340,000 tons in terms of ammonium sulphate and that of phosphate and potash fer6ilizers was almost none.

However, the Japan's fertilizer industry made a remarkable recovery from such devastation. The recovery was made possible through the designation by the occupation authorities as priority reconstruction industry. By 1951 it had regained the prewar level. Its growth has continued on to present day.

Here I use some figures in order to present a general picture of the fertilizer industry although you can easily do so by looking up the statistics. In addition, some of you may be quite familiar with these figures. The statistics I quote here covers 1966 calendar year.

(A) Nitrogen Fertilizers

The production and exports of nitrogen fertilizers in 1966 were as follows:

* Professor of Tokyo University

	Production ....1,000 tons	Expert	%
Ammonium sulphate	2,650	1,480	52
Urea	1,450	1,020	70
Ammonium mulate	550	330	60
Nitrogen Cyanamide	380	40	10
Total (Equivalent of Ammonium sulphate)	7,090	4,300	61

To compare with prewar figures 1966 production is about 3.5 and 35 times, respectively, as much as in 1937 and 1921. In 1937, when, as mentioned earlier, the prewar record was made for fertilizer consumption, the total production of soybean cakes and other inorganic fertilizers was 1,960,000 tons in terms of ammonium sulphate. It was in 1921 when fertilizer statistics was first published. Fertilizer production in the earlier year was a total of a little more than 200,000 tons including only 95,000 tons of ammonium sulphate and 99,000 tons of lime nitrogen.

Compared with the rest of the world the composition of nitrogen fertilizers produced in Japan brings out a few distinctions. First, urea accounts for a greater part of nitrogen fertilizers in Japan. Secondly, ammonium sulphate is not generally used as fertilizer in the world eccept in Japan; it is no exaggeration to say that its use is totally limited to our country. Thirdly, farmers in foreign countries consume a large amount of ammonium nitrogen whereas Japanese counterparts make little use of it although there is some production of ammonium nitrogen in Japan.

(B) Phosphatic fertilizers

In 1966 1,370,000 tons of calcium superphosphate including double superphosphate were produced, of which 40,000 tons were exported. In addition, 350,000 tons – a little more at present, I presume – of fused calcium magnesium phosphate were exported. In 1937 the consumption of calcium superphospate totalled 1,640,000 tons. Thus there was seemingly no significant increase. However, a large amount of ammonium phosphate is used as a material for compound fertilizers; ammonium phosphate is made from phosphate rocks through phosphoric acid solution.

No foreign countries use such a large amount of fused calcium magnesium phosphate as Japan. This is a main characteristic with regard to phosphate fertilizers.

(C) Potassic fertilizers

Japan solely depends on import for material of potassic fertilizers. During the war when its import totally halted they attempted to make fertilizers from high potassium content rocks found in Japan and Korea. These rocks were powdered and burned in order to change potassium into soluble from. But content of potassium they could obtain was as little as one-tenth of potassium salt. These attempts were discontinued after the war as they could not produce on paying basis.

In 1966 the consumption of potash fertilizers totalled 1,100,000 tons (840,000 tons of potassium chloride and 260,000 tons of sulphate). Of 260,000 tons of sulphate 160,000 tons were changed from potassium chloride. Thus, potassium chloride accounts for an overwhemingly large part of potash material import.

Change has been seen in the ratio os potassium sulphate vs. chloride:
In 1937 the former was 140,000 tons and the latter 110,000 tons, totalling 260,000 tons. Total was only 110,000 tons in 1921. Characteristic about potassic fertilizers is the growth in the consumption of potassium chloride relative to sulphate.

(D) Complex fertilizers

According to the definition of the Ministry of Agriculture and Forestry complex fertilizers consist of 'mixed' and 'compound' fertilizers. Their components and ratios of fertilizer materials differ greatly by products. Production in 1966 amounted to 4,260,000 tons. Although data are not available the production of complex fertilizers, especially high analysis compound fertilizers, is rapidly growing in Japan.

The share of the components of complex fertilizers in total fertilizer components is called 'complex fertilizer ratio'. This ratio is very high in Japan: 63.7 percent for N, 74.4 percent for P_2O_5 and 74.9 percent for K_2O. To compare complex fertilizer ratio of N, in West Germany, it was 23.3% in 1963–1964, while in the U.S. it was 31.8%. As regards P_2O_5, 48.1% in West Germany and 80.7% in the U.S. For K_2O the ratio was 85.5% in the U.S. Thus the complex fertilizer ratios of N, P and K are about the same and are very high in Japan whereas that of N in the two foreign countries is low and those of P_2O_5 and K_2O is either the same or lower than Japan.

So far I have summarized the production, consumption and export of major chemical fertilizers in Japan today (data cover 1966). Now I will turn to the subject of how the senior, fellow and junior members of the Society of Science of the Soil and Manure have contributed to these developments.

2. Study on Soil Fertility and Plant Nutrients and the Development of Fertilizers in Japan

(A) Study on acid soil (including poor volcanic ash soil) and growth of neutral or alkaline fertilizers

The results of very old studies, i. e. those on acid soil by Dr. Daikubara, Dr. Osugi, etc. and those on poor aluminous soil by Dr. Seki and Dr. Shioiri showed that such soils spread widely in Japan. Lime fertilizers have been applied to neutralize acid or check activated aluminum. In 1965 the production of lime fertilizers amounted to 1,190,000 tons including 120,000 tons of caustic lime, 310,000 tons of slack lime and 760,000 tons of calcium carbonate; the last named accounted for an overwhelmingly large share. Silica lime can also be used as neutralizer although its consumption increased mainly because of its use as silica fertilizer for paddy fields. Lime nitrogen, fused calcium magnesium phosphate, etc. serve as a neutralizer, too. They help correct acidity and supply lime. It can be said that urea, physiologically neutral fertilizer, also contribute indirectly although it does not neutralize directly.

(B) Studies on Akiochi and growth of non-sulphate radical and silica fertilizers.

Here we are concerned with studies on Akiochi (literally autumn dropping). They are a newer study than those on acidity. Around 1940–41 decomposition of rice plant roots occurred in the alluvial fan of Izumi sandstone in Kagawa Prefecture. Dr. Shioiri's studies revealed that it was caused by the same reason as Akiochi and that it affected more or less 20 percent of all the paddy fields in Japan.

Investigation of the cause led to findings of various improvement measures. In the field of chemical fertilizers 'non-sulphate radical fertilizers' came into being after the war. According to statistics urea production started in 1948. (It is told that the Sunakawa Plant of Toyo Koatsu Industries, Ltd. produced 300 tons of fertilizer grade urea in August 1948). Ammonium chloride and fused calcium magnesium phosphate appeared in 1950. The production of these fertilizers made a rapid increase. Demand for lime nitrogen increased shaply as it was the sole existing non-sulphate radical fertilizer when the first measure against akiochi was launched. It reached a peak of 510,000 tons in 1955, since then it has been declining.

As mentioned earlier sulphate of potash is converted into muriate although this involves price problem. After several years from the ammonium hydrogen problem studies on akiochi led to a finding that silica slag was effective for akiochi paddy crop. Research carried out by Mr. Ohta of Yamanashi University, Mr. Okuda of Kyoto University and many others revealed that silica fertilizers would have a special effect on akiochi paddy crop. As early as in 1944 our staff, too, noted that akiochi paddy crop analyzed lacked, among others, silicic acid. In 1946 we conducted a test to put silicic acid in akiochi paddy field at Tatomi Village, Yamanashi Prefecture. But it failed through my mistake: I put only one-tenth as little of silicic acid as required. Rice plants contain by far greater amount of SiO than any other ordinary fertilizer elements: 5 to 18 percent of it is found in air dried matter of stems and leaves of rice plants. As its effects were found the production of calcium silicate has grown rapidly. It reached 510,000 tons in 1965. I would not be surprised if it exceeds a million tons in near future.

Increase in the production of non-sulphate radical and silica fertilizers is a characteristic of Japan. In western countries rice is a minor crop. Therefore this type of research is not generally carried out. Such fertilizers could only be increased in Japan, which excels in the studies on soil fertility and has the most advanced fertilizer industry among rice growing countries.

Next, I will turn to the development of urea, which necessitates me to speak my own experience. In 1946 or 47 when I still worked at the National Institute of Agricultural Sciences, the Kanto Branch of the Japan Chemical Industries Society made me a request; they wanted to have their branch meeting at the auditorium of the Institute. Its subject was urea. When I asked why they wished to hold the meeting at Nishigahara, they answered that was because they would like me to give a lecture on urea. I was to talk about the role of urea in the development of Japan's agriculture if it became a fertilizer. Mr. Shibata, the then President of Toyo Koatsu Industries, Ltd., would speak along with me on production side.

At that time the fertilizer industry was suffering from a temporary shortage of sulphuric acid. Ammonium could be produced as much as desired, but it could not be converted into ammonium sulphate. GHQ ordered to try to develop fertilizers which would require no sulphuric acid. On the other hand, urea for industrial use, e.g. adhesives, had been produced, even before the war, in Japan. But its cost was about ten times higher than that of nitrogen in ammonium sulphate. Thus technically they could manufacture fertilizers which would require no sulphuric acid. The problem was how to cut the cost in order to utilize it as a fertilizer. If I remember correctly Mr. Shibata said then that various research had so far led him to believe that the cost could be cut down in near future to 2.5 times higher than that of nitrogen in ammonium sulphate. The meeting provided an official occasion to discuss each other's stand between the fertilizer industry and the researchers representing users – between leaders. I believe what is needed today is more opportunity to duscuss problems on fertilizer production and use between the top level people of the industry and us. By top level people I mean those people who are really responsible for operation.

Anyway, I don't know how much my lecture contributed to the industry as I have heard nothing afterward. But the Sunakawa Plant of Toyo Koatsu Industries, Ltd. produced 300 tons of fertilizer grade urea in August 1948.

There is one thing to which we should pay attention regarding sulphur problem. In recent years not a few people have remarked that sulphur deficiency might be occurring. I think such occurrence is not strange, for S is originally an essential nutrient of plants. I consulted some books to find out that it requires about the same amount as phosphorus this is not a small amount.

We should consider what is the supply source of S in soil. In soil there is S in organic form. It may be changed into sulphuric acid by microorganisms. In paddy field it may be changed into hydrogen sulphide. But it cannot be absorbed. Thus sulphuric acid becomes required. It is said sulphuric acid, like ammoiium nitrogen has little soil adsorption. Thus loss through drain may be remarkable. Therefore the occurrence of S dificiency should not be strange as long as non-sulphate radical fertilizer is repeatedly used where the stock of S is not sufficient.

Another aspect to which I would like to call your attention is symptom of S deficiency. According to some books it is similar to nitrogen deficiency; plant becomes slightly less greenish. Thus it may be left unnoticed unlike magnesium or iron deficiency, which you can easily observe by its characteristic chlorosis or makings. I believe the use of non-sulphate radical fertilizers has not been wrong, but no one can say for sure their overuse might not cause such deficiencies. We should pay attention to these problems.

(C) Studies on trace element and special component deficiency areas and the appearance of corresponding fertilizers

The discovery of symptom cuased by deficiency in trace elements, e.g. boron, manganese, iron, copper, zinc, and molybdenum, or special components, e.g. magnesium, has led to the development of corresponding fertilizers. Here I will not go into detail.

(D) Growth of slow acting nitrogen ferilizers in accordance with decrease in organic fertilizers

What I am concerned here is a matter of present and, at the same time, of future. That is 'slow acting' nitrogen fertilizers. It is also used in foreign countries, but Japanese way of their production possesses a characteristic or follows the fashion. All fertilizers put on market at present are manufactured with emphasis on changing combination form. Take urea fertilizers for example, many types are made by changing, in various ways, aldehydes accompanying them by controlling the conditions of reaction of combination. Ureaform, polymerized formaldehydes, appeared first. Of course ureaform existed in foreign coustries. Some combined isobutylaldehydes, which is called IB. The combination of acetoaldehyde produces CDU and urea-Z. Although they are not urea group, oxamides and guanylic urea on which research is in progress are based on idea of slow action through slowing down, by changing combination form, the degree and speed of hydrolysis or dissolution by microorganisms.

However, a wider means is of course available for attaining slow action. For example, if the granule is made larger its dissolution speed naturally becomes slower In addition if the amount applied is the same, the possibility for roots to reach it becomes less, with the result of slowing down action. The simple method of enlarging granule results in slow effect. In fact, when IB is applied in paddy field it is said that they make the granule larger. In this sense the old established solid fertilizer embodies the idea. It is said that in Aomori Prefecture they apply solid fertilizer deep into soil. When I heard, it reminded me of the first time I saw solid fertilizer. I thought it was the same practice as putting a cut and dried herring in the center of four hills of rice plants practised in Hokuriku in former days. Apparently this method was not only slowing effect but the loss of denitrification was small.

A future theme is to coat the surface physically. The problem is the choice of suitable materials and the technique of coating granulated fertilizers. I think increasing products of petroleum chemistry will solve the first problem. As for possible way of coating we may use semipermeable membrane, or impermeable membrane with small holes, or membrane which breaks when the granule swells to a certain extent. Even these physical methods alone would serve the purpose of slow action. The combination of these methods and chemical transformation method is also thinkable.

There are so many ideas for development that it is too hasty to conclude that the present slow acting fertilizers are final products. Ideas for slow acting nitrogen fertilizers originate from how to adopt the merit of organic fertilizers into industrial products. With regard to this I will introduce some unpublished data.

Some of you may remember this as a number of people then working at Nishigahara are now present here, and I worked together. The outbreak of the China Incident sharply reduced the import of soybean cakes because of transportation difficulties.

Farmers raised cry for fertilizers as the shortage became apparent. Fertilizers were the first goods to be put under control. With such background Director Ando of the National Institute of Agriucltural Sciences ordered the following project. Many people participated in this with Dr. Shioiri at its head. The project was to calculate increase in brown rice yields when soybena or fish cakes were used in paddy fields instead of nitrogen fertilizers. Data were collected from the Agricultural Experiment Stations all over the country. At the same time we gathered the results of analysis of soybean and fish cakes from reliable books. The results were as follows: 14 kan 500 momme * of soybean cakes and 11 kan 135 momme of fish cakes were equivalent to 1 kan of nitrogen if they were applied in paddy fields. On a national average 1 kan of nitrogen applied would increase yields of brown rice by about 12 kan 500 momme. The calculation of components showed, in terms of caloric, 179,900 cal. for soybean cakes, 132,700 cal. for fish cakes and 168,300 cal. for brown rice. It means they were almost the same. From a viewpoint of components the largest change occurred in gross protein; 6.27 kan for soybena cakes and 6.05 kan for fish cakes against 1.10 kan for brown rice – a decrease to 1/6. On the other hand, in case of soluble non-nitrogen, i.e. starch change was as follows: 3.78 kan for soybena cakes and almost none for fish cakes against 9.20 kan for brown rice. Therefore it meant growing rice with these organic fertilizers on top of laborious work resulted in only changing protein into starch with no significant change in calorie. These results were not published. I presume Director Ando must have thought soybena and fish cakes should be given to people, if worst came, rather than be used for fertilizers from a viewpoint of poor resorces in Japan. The worst didn't come during the war, but we recall we ate rationed rice mingled with soybean cakes after the war. After all Director Ando and Dr. Shioiri must have been a man of foresight.

Even today quite a few farmers use organic fertilizers although they cost several times higher than inorganic fertilizers. Not all of them do this out of habit. Certainly it has some merits, e.g. free from overfertilization and safe through slow effect. The idea of slow acting nitrogen fertilizers is to secure these merits by manufactured fertilizers. Future research may lead to the development of new products. We should increase our efforts even though it is a future problem.

* 1 kan = 1,000 momme = 3.75 kgr.

(E) Research on nitrification, deluviation, denitrification, etc. and the development of nitrification restrainer

The results of research on nitrification is now coming out. What directed our attention to nitrification restrainer was N-serve, i.e. 2-chloro-6-trichloromethly pyridine which the Dow Chemical discovered through screening of about 3,000. It was published in Soil Science. Its effect against nitrification is about 10 times as greater as Dicyandiamide, but it was no good, for it volatilizes when mixed with fertilizers. In Japan, too, it failed although a group of researchers studied and experimented for a year or so.

At that time AM, 2-amino-4-chloromethyl pyridine, thiourea, 2-5 dichloropheny succinamide, etc. had been developed or being developed in Japan. It has long been known Dicyandiamide produces in the dissolution process of lime nitrogen and has the restraining effect. I do not believe research on improved restrainer should have stopped so far.

The problem of cheking or controlling nitrification freely does not only concern fertilizers domestically used but covers those exported to overseas. It is a big problem. If Japan is to complete with European league, Nitrex for the same product, e.g. urea, the factors involved are price and other terms of sale. But if Japan developes a product which restrains nitrification in sub-tropical and tropical zones, e.g. South East Asia and sell the restrainer containing urea, the baiss for trade becomes different. The price may no longer the crucial factor. At present development research covers only fertilizers for domestic market. We cannot afford to consider Japan's fertilizer problem only within the home market, for if overseas market should be lost for one reason or other, then the loss would shift to the domestic market and price would go up. It may be said that the price has become lower because of larger scale of production. I am not sure but no countries eccept Japan export as much as 60 percent of fertilizers manufactured (in case of nitrogen fertilizers). In a sense Japan's fertilizer industry does not stand on a firm ground, but that is partly why fertilizer is cheap. Therefore research on the nitrification restrainer taking account of foreign markets as well as domestic has sufficient value.

Such research is just the same as the development of new agricultural chemicals. Japan and overseas the development of new insecticides, fungicides and herbicides flourishes. These come out of screening one after another what have been synthesized or extracted from various organic compounds. Something new will come out of many trials. Therefore I do not believe at all that the development of the restrainers has stopped. So far no new development equals Dow Chemical's N-serve in effects. I think such development is more assured to bear fruit if they go hand inhand with research on agricultural chemicals.

(F) Combination of nutrient absorption promotors and chemical fertilizers

Mr. Murayama told you about plant control in general. Plant control can be divided into chemical control - control by chemical substances - and environmental control - control by environmental conditions. Fertilizer indeed ranks first among means for chemical control, but its history is so long that no body considers that way.

There is one thing I would like to appeal to you and ask criticism at this occasion of the 40th Anniversary of the Society. It may be called my dream regarding future fertilizers. Since 1948 when I joined the teaching stuff in the University of Tokyo I have carried out research primarily on biochemical problems. Main subject is the absorption of nutrients. During my research I have found out there is a big difference between the absorption of nutrient which I used to consider as soil scientist and that which I studied going into problems of nutrients after they entered the roots or the body of plants in the biological or physiochemical process.

When we studied Akiochi we considered this way: plants could not absorb nutrients because their roots were damaged or decayed. Thus there would be disorder of nutrition. But such a simple way of thinking won't do. Fertilizer nutrients do not change until they pass through the surface of roots. But once they passed they enter various metabolism channels as a part of living thing. The first stage at which nutrients enter metabolism channels is the most important in nutrient absorption; this is nothing but biology. And in this aspect respiration energy and various metabolism of substances are concerned If I may be allowed a little exaggeration all the metabolism of living thing is involved there. The mechanism is so complicated that it was not easy to elucidate. So far we have grasped the outline of mechanism for three elements of fertilizers, i.e. N.P.K. and such trace elements as Fe and Mn.

What has been the problem of fertlizers to date? Roughly speaking since Justus von Liebig (1840) it is to supply plant nutrients lacking in soil - their number is increasing - around the root in necessary and sufficient quantity in a form the plant can absorb. The theory of fertilizers ended there, at least, as far as the knowledge of fertilizer manufacturing was concerned. But I believe fertilizer manufacturing must cover further - to make clear what happens after the fertilizer passed through the surface of the root.

Although they are not directly connected with the development of nitrification restrainers which I have been dealing, various plant activation substances, which control the growth of higher plants in a wide sense - the control of activities of microorganisms- have been developed. For example giberellin have been used to produce seedless grapes. Another examples are those which bloom flowers earlier or make stems longer. But what I am thinking is the control in a little narrower sense, that is, the control to take up rapidly the nutrients that have entered the root by promoting metabolism, i.e. the control to promote absorption and assimilation, and the development of such substances. I call it 'promotor' provisionally. A certain amount of promotor is put into fertilizers. The stage up to the surface of root is the same as usual. The promotor is considered to be an inorganic compound whose molecular weight is generally not very large, but large enough to enter the root as glucose and organic acid do. It enters at the same time and promotes absorption and assimilation. Promotor reduces ion density so that further entry is made easy.

What I mean is that the development of fertilizers containing promotor deriving from biological viewpoint ought to be considered. As far as I know such idea has not yet been conceived anywhere in the world.

It is probably a most difficult road. But anyone going a new road must prepare for a rough road.

About 15 years ago when I went to Germany with Mr. Okuda we called on Prof. Flaig at Versuchanstalt of Volkenrode. He was a biochemistry specialist but, at that time, was studying the formation of soil humus, especially coloring substances, in various ways, from a standpoint of soil microorganism. His project involved thymohydroquinone belonging to the quinone group as starting substances in coloring substances of soil humus. This thymohydroquinone was said to be able to lengthen the root of plant. We saw Neubauer's test on young plant conducted in a glasshouse. Roots in hydroponic liquid were, to be sure, growing longer. Later we were taken to a field where thymohydroquinone had been applied to some potatoes.

But Dr. Flaig conducted these projects with conception different from mine. What he was looking for was something which helped humus or a stimulative substance in a sense.

Dr. Ueda, who worked for my laboratory, studied on his doctor's thesis whether the thymohydroquinone could be a promotor in my sense. He found that it would promote the absorption of nutrients to some extent but the effect varied according to the place of a node at which the root emerged when studied in time series of growing period. We fully recognized difficulty involved in screening of such researches.

According to tan American Professor high yielding varieties of corn contain a larger amount of nitric acid reducing enzyme and the study of its activation may lead to plant breeding. Possible substances which promote the function of the enzyme sould turn out to be one of promotors of nitrogen fertilizers.

Because of the organization of manufacturing companies it would be desirable that the development of promotors should be carried out in a study closely connected with agricultural chemicals.

It is no exaggeration to say such fertilizers, if they should come into being in future, would be a revolution to the fertilizer industry.

(G) Possibility of use on paddy rice of nitrate form fertilizers, especially compound fertilizers manufactured through nitric dissolution of phosphate ore

Here I deal with the place of nitrate as a fertilizer in Japan. Long before we were born, in the days of the Komaba Agricultural School foreign teachers had found that Chile salpeter was not effective to paddy rice and concluded that it was nothing but the non-nitrogenous in case of paddy rice.

I remember a project carried out by Dr. Okuda and Dr. Iwata who are with us today. It was probably motivated by the utilization of equipment for manufacturing explosive compounds from ammonium nitrate in when the war should end. The project was to investigate if ammonium sulphate mixed with a certain amount of ammonium nitrate could be applied to paddy crop. The experiment was conducted in a precision block. The amount added was only about 10 percent of ammonium sulphate nitrogen (half of it for nitric acid). This meant, I presume, the results were good.

After the war Japan suffered from a severe shortage of food. But food import was difficult because of world-wide shortage. GHQ suggested that ammonium nitrate could be made available to Japan as plants manufacturing this products in Canada and the United States could produce for Japan because the cease of hostilities lift them with spare capacity. We thanked them but asserted that ammonium nitrate was no good for paddy crop and that high humidity from the rainy season through summer would make it unsuitable in Japan. But they assured us that granular materials with coating (about 3 percent-in terms of weight-mixture of resine, paraffin and kaolinite) had solved the problem of hygroscopic nature and that it had passed a test conducted at the Beltsville Experiment Station of the U.S. Department of Agriculture. Thus this ammonium nitrate was imported. But as you know we had hard time with it as it absorbed moisture in summer. In some place a warehouse was flooded with melted fertilizer so that you could not go in without high boots. Fertilizers shipped on rail to Hokkaido was reduced to half, because of leakage, when arrived. Probably newly manufactured product was used in the hygroscopic test at Beltsville but coating was cracked or worn off by rolling and pitching while crossing the Pacific. However it was successfully used for winter wheat. Later the Ministry of Agriculture conducted experiment on ammonium nitrate for a short period of time, but I do not know why they carried out such experiment.

In more recent years Mr. Yamazaki, who is now at Tottori University, paid his attention to the problem of ammonium nitrate applied to paddy crop from a different point of view. He analyzed the techniques of Japan's No. 1 rice farmers and found that all of them were very strict with water control. It was further discovered that rice plants supplied with nitric acid from showed good growth, especially root development was good and healthy. Upland nursery seemed to contribute to high yield.

In the fertilizer industry attention has recently been given to sulphuric acid from a different angle, consideration was given to nitric dissolution of phosphate rock. Mr. Munakata of Asahi Kasei vigorously developed this type of fertilizer, which has been successfully used for upland crops or second crops in paddy fields. But increased production is not possible until its use for paddy crop has been developed.

The problem of nitric acid and ammonia has a long history. Even today study is carried out from plant nutritional viewpoint. From this angle no one considers nitric acid is always bad. Not only that some sonsider it is probably useful. However, the problem of deluviation and denitrification of nitrate form nitrogen in paddy soil chemistry discovered by Dr. Shioiri cannot be ignored. It is a serious mistake to deny this and say that nitric acid form is good. As evidence it is still true that nitrate form fertilizers used as basic fertilizer have practically no effect, although when used as additional fertilizer they seem good in some cases.

This problem is now studied by a study group a number of manufacturers for nitrate compound organized cooperatively by. I take part in it as I am interested. I think we should examine all the knowledge known up to now from every angle.. Action is inevitably followed by reaction. The same can be applied to non-sulphate radical fertilizers or nitrate fertilizers. It is no good to proceed one-sidedly. A certain balance is required. Anyway attention should be given to the problem of nitrate compound fertilizers for paddy rice.

Other problems include labour saving by high analysis compound fertilizers and liquid fertilizers, increased utilization by coating and polyphosphate, the combination of existing agricultural chemicals and fetrliizers, and the development of soil improving agents which takes palce of the function of compost. But I will not go into detail because of time limit.

3. The Role of Soil, Fertilizer and Plant Nutrition Scientists of Japan in Asian Food Production and the Development of Fertilizers.

As mentioned earlier Japan exports more than 60 percent of nitrogenous fertilizers and much smaller shares of ammonium phosphate and compound fertilizers. Foreign market is limited by transportation cost and other factors, as evidenced by the fact that mainland China is the largest market. Although domestic market is very important Japan must provide southeast Asian countries with her accumulated knowledge and techniques in rice culture.

Last January I went to Bangkok and met Dr. Jisaku Takahashi, who used to work at Nishigahara. He has been sent there by FAO. He enjoys fullest confidence of the Thai Government. His fertilizer experiment in rice culture using local varieties and, mainly, ammonium phosphates resulted in raising yields to near Japanese level in various places. This has encouraged the Government to launch an extensive program for increased production.

Rice is the most important export of Thailand accounting for about 40 percent of the total merchandize exports in value. But the domestic consumption is increasing owing to growing population. Rice exports would decrease if no measures were taken. The government now provides a certain kind of subsidy for imported fertilizers used for rice culture, reducing fertilizer price paid by farmers to c.i.f. price.

The International Rice Research Institute (IRRI) - Dr. Ishizuka of Hokkaido University is one of the Directors of IRRI and Dr. Tanaka also worked for the Institute for a long time - made public new IRRI-8 (more recently IRRI 5 has been added), which has been developed by correcting many defects of Indica type rice. It is a high yielding variety which can stand heavy fertilization. Its breeding was not done by Japanese but by Americans, I'm sorry to say. However, I hear, physiological study of rice by Dr. Ishizuka and Dr. Tanaka contributed greatly to it. Plant breeding has of course a great value, but I was told in Thailand these varieties were not suitable for export because of their poor quality. The quickest way to increased production was to apply fertilizers to a local variety with potential of higher yield.

In 1952 and 1954 I went to India at the invitation of FAO International Training Centre. I gave lecture at its international training course for 20 dyas each time. My subject centered on the results of study on soil, fertilizer and nutrition of paddy rice in Japan. My lectute was made into an English book titled "Inorganic Nutrition, Fertilization and Soil Amelioration for Lowland Rice".

Also, I went to Ceylon with Dr. Morinaga in 1955. We stayed there for a month, making an inspection tour of rice growing areas. Ceylon's rice production covers only half of domestic consumption.

In 1957 I went to Mainland China as a member of the Japan Agricultural Chemistry Professors' Team headed by Dr. Sumiki and organized by Japanese Academy of Science. Mainland China is the largest market for fertilizers exported from Japan. Here I would like to introduce some data which estimated China's fertilizer requirements from results of fertilizer experiments on rice. It was a report by an Englishman Richardson at the Fertilizer Working Party of FAO Rice Commission held in Bandung, Indonesia in 1954. He had been an advisor to the Nanking Government. According to his report the Imperial Chemical Industry of the United Kingdom conducted fertilizer experiment in Mainland China as early as in 1935. Richardson also carried out experiments in paddy fields of 300 different places all over the country employing many Chinese technicians. The experiment consisted of the three element-and proper quantity tests. The data were processed using modern statistics. Experiment places represented regions divided by soil and climate. The fina ressults were obtained by multiplying with the area. a.

According to his estimate rice culture alone requires 12 million tons of chemical fertilizers, varieties and growing techniques being unchanged. The breakdown is 7 million tons of ammonium sulphate, 4.5 million tons of calcium superphosphate and 0.5 million tons of potash fertilizers. Requirement of potash fertilizers is very small but the report adds that in southern China there are many places where it is very effective.

The 12 million tons of fertilizers would increase a total of 24,873,000 tons of rice (17,882,000 tons by ammonium sulphates, 6,137,000 tons by calcium superphosphate and 854,000 tons by potash fertilizers). The total would support a population of about 70 million. This is, so to speak, a natural phenomenon. Therefore, the change of governments will not affect it basically. Of course improved growing techniques, more adequate irrigation and dranage and other improvements in production system would make these figures larger. If applied to Japan the difference in technical levels between Meiji and present days would make the figures for fertilizers increase several times. The above figures were limited to rice. Data for other crops are not available. But as the northern half of Mainland China divided by River Fun is not rice growing area, the total fertilizef requirement for rice and other crops might be no less than twice as much as for rice alone. Such a big requirement exists in the very near neighborhood of Japan.

What I wish to say is, we must attach the same importance to foreign market as domestic whether you like it or not. It would be impossible to consume domestically all the fertilizers produced in Japan unless they were to be scattered over forests, will fields and lakes by airplane. Decreased production owuld increase the price. According to Mr. Tomizo Imai's lecture at Tokyo University before the war fertilizers accounted for about 30 percent of all the cahs expenditure of farm households in Japan but in recent years it has accounted for only 10 percent. The days are gone when the fertilizers were the largest item of cash expenditure. Thus fertilizer use could be increased. Even so without foreign market fertilizer price would go up. In this sense I would like to suggest that a specialized character be given to fertilizers, adopting new ideas developed in Japan, and taking account of exports. I have shown a few examples. For this purpose, I may venture to say, more investment in research is required both by manufacturers and by the government.