by mist sprayer. The latter has been influenced by aerial spray of ultra low volume pesticide. Pesticidal dust can cover plant efficiently for its weight with almost same volume as in low volume spray of liquid. In addition, dust can be distributed further and wider because it has a rather small apparent density for its particle size. This fact explains the higher efficiency in dusting. It is a peculiar character to this country where sloping area is cultivated for use and the highly intensive agriculture is prevailing, that dusting is prefered in spite of its higher cost than liquid spray. Recently, trials have been made to apply dusting to citrus orchard.

Pesticidal effect depends upon not only pesticide and apparatus, but also technique to use them. The easier the technique is, the better and more popular the method becomes. Speed sprayer is rather difficult to conduct, but easy to have right spraying, while small type apparatus is easy to handle, but difficult to spray pesticide evenly. Generally speaking, pesticide is often sprayed in less than neccessary quantity when small type apparatus used.

Pesticidal effect is always displayed through the sprayed particles of pesticide. More than one factor determine what most suitable particle is. Main character of spraying depend upon the size, density and velocity of the particles. Technique of making good particles is conditioned with both pesticide and apparatus.

In the present time, the spraying apparatus will be estimated as of no practical use, if it cannot be conducted outside of the paddy fields. As a result, handy method of dusting, such as that by the pipe duster, where the hose with small holes is drawn by the men walking along the both sides of paddy field, has become very popular. On the other hand, drastic improvement in the lay-out of farm is now required to introduce highly efficient apparatus. For example, a trial is now under way in the citrus zone in Shikoku Island, to raise up productivity, rationalizing pest control by turning 20% of cultivated land into farm roads.

Future of ground application of pesticide

Whether it is the above-mentioned ground application or aerial one, pesticidal application should be practiced with the right method in the right field. Ground application is not neccessarily satisfying method, when the present shortage of farm labor is considered. Farmers will be exhausted, if they continue applying pesticide for a long time, tightly dressed in the broiling weather. Therefore, the easier method of pesticidal application is always expected eagerly. Dipping test of plant root is repeated for the development of systemic pesticides, which can be treated on or in soil instead of being sprayed or dusted. Development of attractant is also expected.

With the progress of pesticide, it has not become neccessary to spray Bordeaux mixture on the both side of plant leaves. The easier and more efficient application of pesticide should be developed with the help of the improvement of both pesticide and applicator.

New Crop Varieties Bred by Mutation Breeding

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Background

Induced mutations of practical significance in Japan were first reported on rice by Ichijima in 1934. Mutation studies, bearing utilization of induced mutations for plant breeding in mind, were started after the

Second World War, as a part of the framework of basic studies for improving breeding methods. Survey researches on rice were commenced in 1948 at the National Institute of Agricultural Sciences. The researches revealed rather wide possibilities of inducing beneficial mutations. Influenced from the results of survey researches, some of the breeders also made the similar line of works from their own point of view, and the mutation technique was practically introduced into crop breeding program.

Use of radioactive isotopes made it practicable to treat a large quantity of seed with radiation. In 1956 a gamma room, equipped with 100 Ci of Cobalt 60, was installed in the National Institute of Agricultural Sciences at Hiratsuka. In a routine way, seeds of different crop plants were sent from every breeders to this Institute, exposed to gamma rays and sent back to breeders.

Many beneficial mutants were obtained from the irradiated materials at many breeding stations during the past twenty years. Among them, 29 promising mutant lines of rice, soybean, oil rape and wheat have been, up to the present, released as "local number lines" (candidates for national registered variety). They were mostly characterized by early maturity, short culm or high yielding capacity. Although they were superior to their respective original varieties, most of them could not compete well with new varieties or "local number lines" bred by conventional methods.

In 1966, however, two of the "local number lines" were approved as national registered varieties, one rice variety "Reimei" (daybreak) and one soybean variety "Raiden" (thunderbolt). They are the first commercial varieties bred by means of induced mutation. Their characteristics and breeding procedures are outlined here.

New rice variety, "Reimei"

The original line of this mutant variety is a "local number line" Fukei No. 47. This line was later (in 1960) approved as a national registered variety, "Fujiminori" (Norin No. 125), which is now a leading variety of the Tōhoku District (the northern part of the Japan Honshu Island) and ranks second in cultivation acreage in Japan in 1965. Fujiminori is an early maturing and high yielding variety, possessing resistance to cool-weather and blast-disease, and also wide adaptability to different climates. This variety is, however, relatively long-culm and liable to lodge in high fertilizer application. In order to shorten culm length of this variety, mutation breeding was started at the Fujisaka Branch Station of Aomori Prefectural Agricultural Experiment Station.

Procedure of breeding: In 1959, dry seeds of Fukei No. 47 were exposed to 20 kR and 30 kR of gamma rays. Progenies from 1467 panicles of 766 R_1 plants were grown as R_2 lines (about 50,000 R_2 plants). Short-culm plants were observed segregating in 112 R_2 lines, and 46 short-culm plants from the 33 segregating lines were selected. In R_3 genelation, 46 lines from these selected R_2 plants were tested for their short-culmness and for yield. The test for yield as early as in R_3 generation was conducted expecting that induced recessive mutations would breed true in R_3 generation and the test would give preliminary informations on practical values of the induced mutants. Thirty R_3 short-culm mutant lines among the 46 tested lines were practically true breeding. After the tests in two years in R_3 and R_4 generations, two promising lines were selected and designated as "local number lines". One of them (obtained following 20 kR irradiation), Fukei No. 70, was a short-culm lines and the other one (obtained following 30 kR irradiation) was a very short- and stiff-culm mutant line which seemed to be valuable as a cross parent. Fukei No. 70. was further tested for their agronomic characteristics in R_5, R_6 and R_7 generations at 10, 40 and 26 localities respectively. Tests in Aomori Prefecture and in mountainous regions of Hiroshima Prefecture (the southern part of the Japan Honshu Island) proved superiority of this line in these districts. In 1966 (R_8 generation), Fukei No. 70 was registered as a national registered variety (Norin No. 177),

Table 1. Characteristics of a new rice variety, "Reimei", bred by mutation breeding.

Mutant and original variety	Heading date	Maturity date	Culm length	Panicle length	No. of panicles per plant	1000 grain weight	Grain yield per 10 ares (dehulled)
Reimei	8, Aug.	26, Sept.	73 cm	18.0 cm	13	22.1 g	544 kg
Fujiminori	7, Aug.	25, Sept.	86	18.2	13	22.1	517

(Results of tests for three years in Fujisaka Branch Station of Aomori Prefectural Agricultural Experiment Station. By Futsuhara, Toriyama and Tsunoda, 1967).

named "Reimei" and released to farmers.

Characteristics: Characteristics of "Reimei" are shown in Table 1. "Reimei" is about 15 cm shorter in culm length (Fig. 1) and more resistant to lodging than Fujiminori. The growth pattern of this new variety at early growth stage is similar to Fujiminori, but internode elongation after ear primodia formation is markedly less than Fujiminori and lengths of basal internodes at maturity are reduced. "Reimei" produces grain yield equivalent to or higher than Fujiminori, and its yield variation in different years and localities is less than that of Fujiminori. Germination and seedling growth are better in "Reimei" than Fujimori. "Reimei" is fairly well protected from cool damage because of lower position of ear primordia, which enable to cover primordia with deep irrigation water and protect them from low atmospheric temperature. Other characteristics of Fujiminori are, almost unchanged, inherited to "Reimei". One defect of this new variety is that lower leaves at maturity tend to dry up earlier than Fujiminori. (Details of the breeding procedure and the characteristics were recently reported by Futsuhara, Toriyama and Tsunoda, 1967).

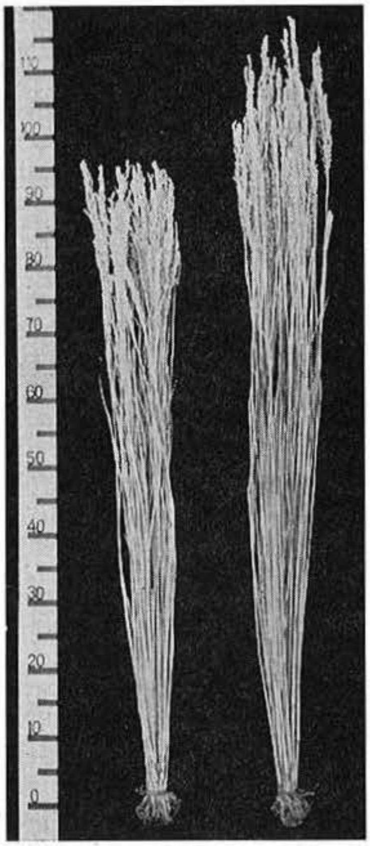

Fig. 1 New rice variety "Reimei" by mutation breeding (left) and its original variety "Fujiminori" (right)

New soybean variety, "Raiden"

The original line of this variety is Tōhoku No. 6. This line was later registered as a national registered variety (Norin No. 25), and named Nemashirazu. Nemashirazu is prominent for its high resistance to nematode pest and excellent grain quality. However, this variety is too late in maturity in the Tōhoku District and rather liable to lodge. No nematode-resistant early maturing variety was available in the district. Mutation breeding was adopted to get "Nemashirazu" modulated as an early maturing variety. The breeding was done in the Kariwano Branch Station of the National

Tōhoku Agricultural Experiment Station.

Procedure of breeding: Since distinctly earlier maturing mutants as compared with the original variety were wanted and such mutants can be easily detected by observation on plant basis, the so-called one grain-one plant method (Yoshida 1962) was adopted as a breeding method.

About 50,000 dry seeds of Nemashirazu were exposed to 10 kR and 20 kR gamma rays for 6 and 12 days respectively, and 49,815 R_1 plants from the irradiated seeds were grown with narrow spacing in 1960. Single seed of the lowest pod on main stem was collected from each R_1 plant, and 44,301 R_2 plants were grown as R_2 bulk populations in 1961. Observations on flowering and maturity dates on R_2 plants were made after every five days, and 135 early maturing plants were selected. The earliest maturing mutant was 41 days earlier in maturity than the original variety but was quite dwarfish. Agronomic characteristics of progenies of early maturing R_2 plants were investigated in R_3 and R_4 generations, and in R_5 generation two very promising early maturing lines following 10 kR irradiation were designated as "local number lines", Tōhoku No. 27 and 28. The former was three weeks and the latter was two weeks earlier in maturity than the original variety. After tests in R_5 and R_6 generations in 32 localities, Tōhoku No. 27 was approved as a national registred variety (Norin No. 42), named "Raiden" and released to farmers in 1966.

Table 2. Characteristics of a new soybean variety, "Raiden", bred by mutation breeding.

Mutant and original variety	Flowering date	Maturity date	Plant height	1000 seed weight	Seed yield per 10 ares	Crude protein content	Crude fat content
Raiden	30, July	1, Oct.	63 cm	231 g	216 kg	41.4 %	20.2 %
Nemashirazu	7, Aug.	26, Oct.	86	247	226	40.8	20.0

(Results of tests for two years in Kariwano Branch Station of National Tōhoku Agricultural Experiment Station. By courtesy of Mr. S. Ishikawa, breeder of this new variety).

Characteristics: Characteristics of "Raiden" are presented in Table 2. The new variety, as already mentioned, is particulary characterized by early maturity, being 40 days earlier in flowering and 25 days earlier in maturity than the original variety (Fig. 2). The new variety is also shorter in plant height and more resistant to lodging than the original variety. The nematode-resistance, good seed quality, high yielding capacity and other characters of the original variety are, almost unchanged, inherited to the new mutant variety. The new variety performs well in thin or newly developed fields.

These two mutant varieties would present beautiful examples of use of induced mutations in plant breeding. It would be worthwhile to mention that these varieties were bred in 7 or 8 years after initiation of the breeding works.

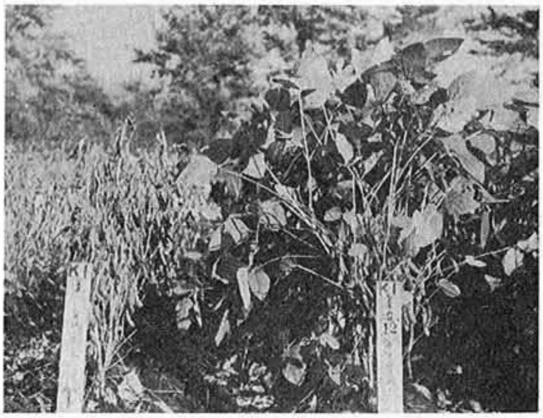

Fig. 2 New soybean variety "Raiden" by mutation breeding (left) and its original variety "Nemashirazu" (right)

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Pest Control Machinery in Japan

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General description

The pest control machinery in Japan have been mostly hand applicators which are small and light and used for a small area. As the agricultural modernization proceeds, however, hand applicators have been gradually replaced by high efficiency machines because the former are considerably lower than the latter in efficiency relating to working area per day or number of working hours per unit area. Unlike those in the Western countries, the machinery in Japan are small in size and weight, and particularly suited for lowland rice fields and sloping upland fields.

Trailer type power sprayer

The sprayer of this type consists of liquid tank, a reciprocating pump, an engine, hoses and nozzles. The hose is extended from the sprayer on a farm road and an operator with the nozzle in his hand sprays a liquid chemical, moving along the ridge in a field. The merit of this machine is that the operator staying outside a lowland field can carry out the chemical application works very easily without using much of his physical power and saves much labor. As a result of tests performed in an agricultural experiment station, when a trailer type power sprayer applied 210 galons of parathion 0.047 per acre with swath width of 66 ft to rice stem borer, the control effect was about 85 percent.

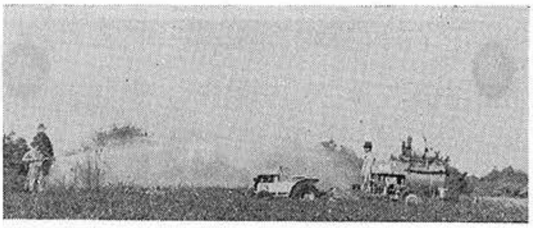

Fig. 1 Travelling type power sprayer

The sprayer requires 3—5 workers for its operation who can perform the application of chemicals for 1 acre in about 10 to 20 minutes without supplementing chemicals and moving the machine around. The unit area of lowland fields for which the sprayer can work most efficienctly is considered to be 100×330 ft. In order to make deposit of chemical uniform, the travelling speed of the nozzle should be constant as shown in the following well-known equation. If application rate per acre=Q gal; swath width =L ft; nozzle discharge=q gal/min; and V=travelling speed,

$$V = 7.26 \times 10^2 \frac{q}{LQ} \text{ ft/sec} \quad \text{or}$$

$$V = 4.95 \times 10^2 \frac{q}{LQ} \text{ MPH}$$

When a travelling type power sprayer is employed against a disease, the application rate is higher than when it is used against an insect. The rate is reported to be 100—200 gal/acre against rice blast.

Travelling type power duster

The appearance of this type of power duster is just as shown in Fig. 2 and typical