16. KIDNEY BEAN AND AZUKI BEAN IN JAPAN WITH REFERENCE TO BREEDING IN HOKKAIDO

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Introduction

Kidney bean and azuki bean were brought into Japan from China many centuries ago and now these are important crops in upland farming. The cultivated acreage and total production of kidney bean (dry seeds) in Japan in 1970 are 73,600 ha and 123,700 tons, respectively, and of these 67,500 ha and 117,800 tons are occupied by Hokkaido located at the northern part of Japan. These amount to 91.7% and 95.2% of the total acreage and production.

On the other hand, as shown in Fig. 1, the cultivated acreage of azuki bean in Japan in the same year is 90,000 ha, in Hokkaido 43,800 ha (48.7%), in Kumamoto prefecture 4,540 ha (5.0%), in Aomori 4,020 ha (4.5%), and so on. The production in Japan is 109,000 tons, in Hokkaido 67,700 tons (62.1%), in Kumamoto 4,220 tons (3.9%), in Aomori 4,340 tons (4.0%), and so on.

The reasons why acreage of beans has been spreaded largely in Hokkaido are (a) extremely larger fields compared with in the other districts of Japan, (b) cool summer which prevented rice cultivation, and (c) the climatic conditions suitable for bean cultivation. In these situations studies on kidney and azuki beans had been adopted at many stations in Hokkaido and breeding of beans has been developed by many researchers.

In Tokachi Agricultural Experiment Station studies on kidney and azuki beans were adopted about seventy years ago, since then about twenty varieties of kidney bean and several of azuki bean have been bred in this station. Now, I will mention in later chapters cultivation of kidney and azuki beans in Hokkaido and the problems in breeding at Tokachi Agricultural Experiment Station.

Kidney Bean in Hokkaido

Kidney bean is *Phaseolus vulgaris*, L. in scientific name and by the usage this crop is classified in two kinds, one is dry bean or field bean and the other string bean or garden bean but this classification is for convenience.

CORBETT (1907) classified kidney bean as follows:

- field
  - bush
    - pea (white or colored)
    - medium (〃)
    - marrow (〃)
    - kidney (〃)
  - pole
    - medium (〃)
    - kidney (〃)
- garden
  - bush-kidney
    - wax
    - green-pod
  - pole-kidney
    - wax
    - green-pod

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In the field bean bush- and pole-types were classified by plant type or growth habit, bush-type is short and pole is tall. In Hokkaido, however, field bean is classified in four types, namely dwarf (shortest, erect stem), bush (a little taller than dwarf, slightly viny stem), short viny or semi-pole (medium plant height between bush and viny type, bending but cultivated without poles), and viny or pole type (tallest and cultivated with poles). Pea, medium, marrow, and kidney are with classification by seed size and seed shape.

"Brand" ('Meigara' in in Japanese) is a principal problem in breeding and marketing of kidney bean, which is distinguished by seed size and seed coat color. Usually product of new variety of kidney bean is brought into market as a new brand but if the quantity was not so much the new brand could not been adopted. Some brands with similar characteristics are gathered up to a "Kind". For instance ,we have a kind named "Kintoki", which has large seeds and purplish red or dark red seed coat color, and to which "Kintoki", "Taisho-kintoki", "Beni-kintoki", "Showa-kintoki", etc. belong. "Tebo" and "Uzura" are another kinds of bean.

Now cultivated acreage of each kind in Hokkaido (1970) is as follows:

Kintoki	32,800 ha	48.6%
Tebo	26,100 ha	38.7%
Uzura	4,310 ha	6.4%

The sum acreage of Kintoki and Tebo is 58,900 ha and 87.3% of total acreage of kidney bean in Hokkaido.

Kidney beans in Hokkaido were introduced from Honshu and the United States of America in 1870's to 1880's, since then cultivation had spread out over the upland fields in Hokkaido and it is said that many local varieties were selected by farmers who picked up new mutants in their fields. At the stations in Hokkaido many local varieties were gathered up, tested, selected again, and registered. Here some important brands will be explained.

"Taisho-kintoki" originated as a plant selected from Kintoki by a farmer and was registered in 1956. Prior to register, Taisho-kintoki was examined in the performance tests at Tokachi Agricultural Experiment Station through several years. Distinguishing characteristics of this variety are pink flowers, dwarf stem, dark purplish red seed coat, and white hila. The seed weight of Taisho-kintoki is 65 g/100 seeds which means larger seed size in kidney beans. It is early maturing and can be sown as succeeding crop after harvesting winter wheat in Tokachi district. Taisho-kintoki is adapted to the eastern and northern parts of Hokkaido.

"Otebo" was registered in 1927 after the performance tests at Tokachi Agricultural Experiment Station but the origin is not clear. It has white flowers, short viny stem, and white seed coat. The seed weight is 30 g/100 seeds which is the smallest of the the kidney beans in Hokkaido. Otebo usually ripen at the middle of September at Tokachi but in a cooler summer the maturity is apt to delay so that the variety is not adapted to the cooler areas of Hokkaido.

"Kairyo-chunaga" (the brand name is "Chunaga-uzura") originated as a plant selected from Chunaga-uzura by a farmer and was registered in 1960. The performance tests was carried out several years at Tokachi Station. Characteristics of the variety are similar to that of Chunaga-uzura, crimson flowers, short viny stem, and colored seeds (pale buff mottled with reddish purple). The seed weight is 52 g/100 seeds. The maturity is earlier than Otebo.

Cultivated acreage and production of garedn beans are 11,900 ha and 83,300 tons respectively in Japan but there is no famous variety. It is, however, thought that the consumption of green pods of kidney beans will increase as a good vegetable. In the

future studies on garden beans will be adopted at our Station.

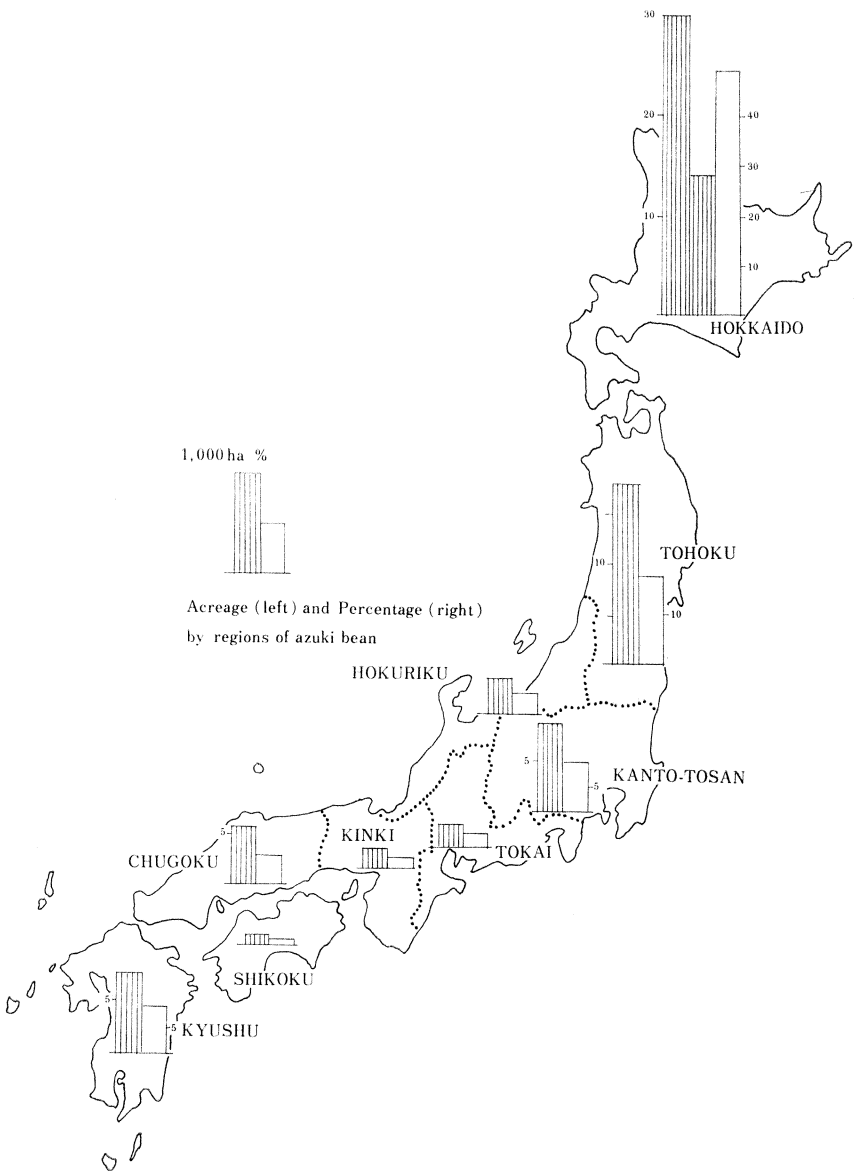


Fig. 1.

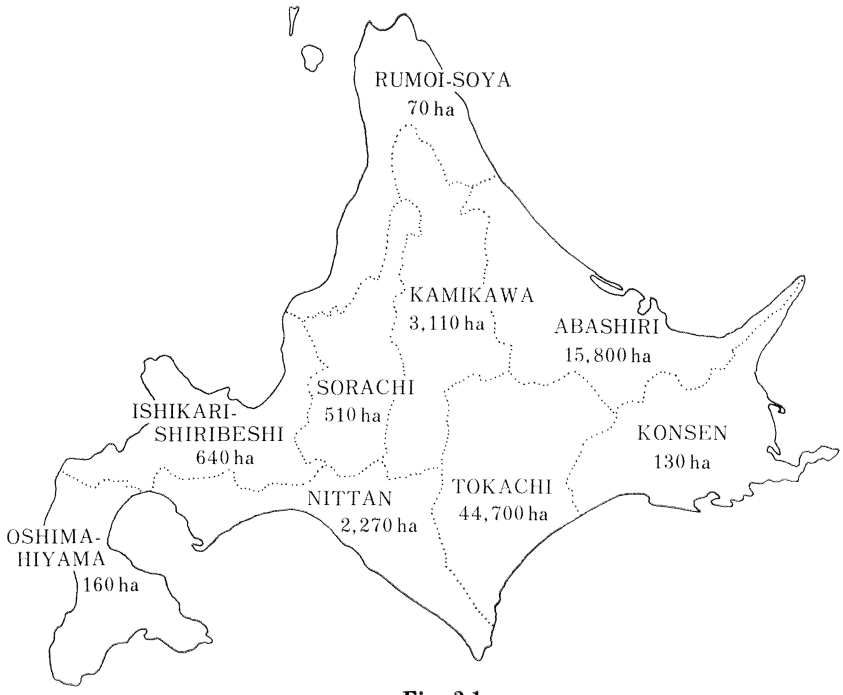

RUMOI-SOYA
70 ha
KAMIKAWA
3,110 ha
ABASHIRI
15,800 ha
SORACHI
510 ha
ISHIKARI-
SHIRIBESHI
640 ha
KONSEN
130 ha
NITTAN
2,270 ha
TOKACHI
44,700 ha
OSHIMA-
HIYAMA
160 ha

Fig. 2-1.

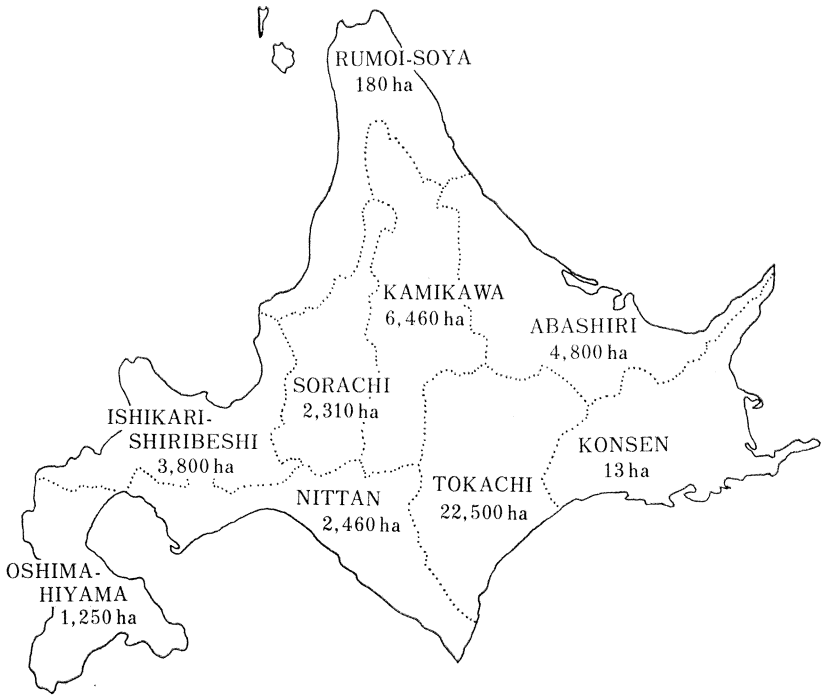

RUMOI-SOYA
180 ha
KAMIKAWA
6,460 ha
ABASHIRI
4,800 ha
SORACHI
2,310 ha
ISHIKARI-
SHIRIBESHI
3,800 ha
KONSEN
13 ha
TOKACHI
22,500 ha
NITTAN
2,460 ha
OSHIMA-
HIYAMA
1,250 ha

Fig. 2-2.

Azuki Bean in Hokkaido

The scientific name of azuki bean is Phaseolus radiatus, L., var. aurea, Prain and synonym is *Phaseolus angularis* (Willd.), W. F. Wight but in Japan the latter is familiar.

Seed of azuki bean is used mostly for Japanese cakes, in the other words, azuki bean is used always with sugar. Therefore, when we had few sugar in our country, consumption of azuki bean was few and now we have much sugar so that we need a large amount of abuki bean.

The brands of azuki bean are very simple compared with that of kidney bean and they are "common azuki bean" and "large seeded azuki bean" ('Dainagon' in Japanese). The seed weight of common bean is about 13–15 g/100 seeds and Dainagon 18–20 g/100 seeds. Dainagon is always more expensive than common bean but in Hokkaido acreage of Dainagon is only 4,300 ha (9.8%) and in the other hand common azuki bean 39,500 ha (90.2%). The reason of this situations is that varieties of Dainagon cultivated now are low yielding and the income from unit area of Dainagon is lower than that of common azuki bean.

19 ecotypes of azuki bean in Japan were classified with flowering and ripening dates by KAWAHARA (1956). In Hokkaido, however, only maturity is thought as an important characteristics on cultivation and varieties are classified into three maturity groups. Now some varieties will be explained here.

"Chagara-wase" was registered in 1914 but the origin is not clear. Distinguishing characteristics are very short stem, yellow flowers ,light brown pods at maturity, and smaller seeds. This variety is very early but rather low yielding. The seeds of Chagara-wase belongs to the brand of common bean.

"Takara-shozu" was in the old collection of azuki beans at Tokachi Agricultuarl Experiment Station and attention was paid at the test for characteristics of the collection. After the performance tests in some years, Takara-shozu was registered in 1959 and it is now most leading variety in Hokkaido. It has medium plant height (50–60 cm), light brown pods at maturity, and yellow flowers. The seed weight is 13 g/100 seeds which is included in common bean.

"Hikari-shozu" originated as a selection from the cross "Chagara-wase×Wase-tairyu 1" in breeding programs of Tokachi Agricultural Experiment Station. Prior to register in 1964, Hikari-shozu was identified by the number Toiku 7. It is classified in maturity group medium. Its characteristics are slightly taller stem than that of Takara-shozu, yellow flowers, and light buff pods at maturity.

"Wase-tairyu 1" which is one of the parents of Hikari-shozu, was registered in 1930 and originated as a selection from an old variety Wase-tairyu with a pure line selection. Its characteristics are a slightly shorter stem than Takara-shozu, a few number of seeds per pod, cartridge buff pods, and large seeds (18 g/100 seeds). Wase-tairyu 1 is, however, low yielding.

A new variety of Dainagon "Akatsuki-dainagon" registered in 1970 is high yielding and very promising. It originated from the cross "Noto-shozu × Wase-tairyu 1". Distinguishing characteristics are vigorous growth, cartridge buff pods at maturity, and larger seeds than Wase-tairyu 1 (20 g/100 seeds).

The other brand of azuki bean is "Shiro-shozu" which means white azuki bean and which is material for white 'an' of high quality. The varieties of Shiro-shozu cultivated nowadays are very low yielding and consumption is not so much that problems on Shiro-shozu are not adopted in the Stations in Hokkaido.

Problems of Bean Culture in Hokkaido

1. Climatic conditions

In Hokkaido it is very cold in winter and cool in summer compared with the other regions of Japan so that climatic conditions are extremely important on agriculture.

At Tokachi district we have the last frost on May 20 and the first one on October 1 in an average year, in the other words we have only 134 days of no frost. Seeding times of kidney and azuki beans are the last ten days of May and we are not worried by the last front but anxious about the first frost when medium and late varieties are going to ripen. (Fig. 3)

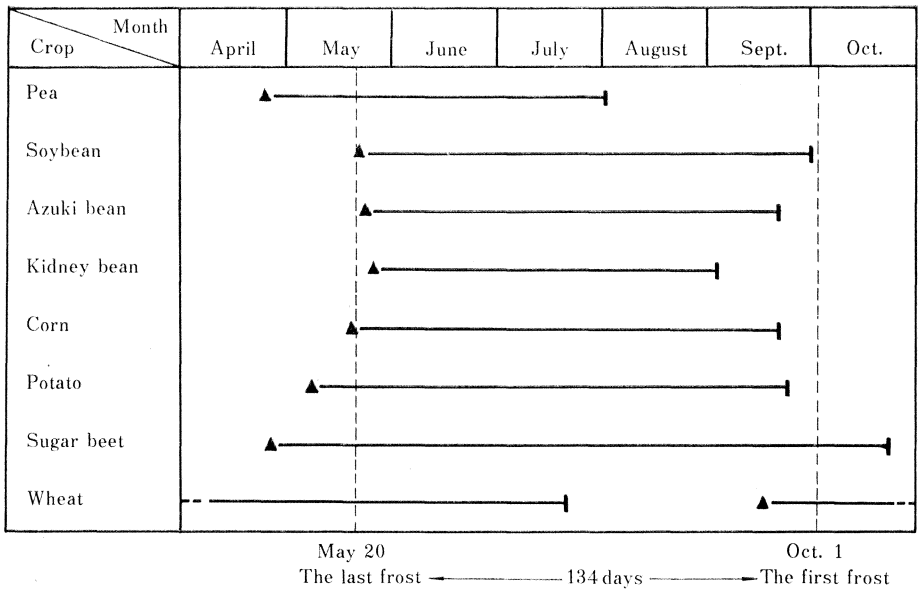


Fig. 3.

The other problem on frost is that we have frost in June once a few years when seeds under ground are just emerging. Primary leaf or the first trifoliate exposed frost turns to yellow and die if severe.

Temperature is one of the most important factors which affects on the growth and yield of kidney and azuki beans. A cooler summer than average causes the delay of growth and maturity of bean plants, than number of pods, number of seeds per pod, and seed yield are decreased (Table 1).

2. Diseases and insects of bean plants

Diseases and insects of bean plants are mainly common in food legumes in Hokkaido. So some representative troubles will be mentioned here.

'Halo blight' of kidney bean (*Pseudomonas phaseolicola*, (BURK), DOWSON) spread in 1962 and damaged Taisho-kintoki and other dwarf types. This bacteria on injured plants infects the other healthy plants with wind and rain. Control of the disease is with a bactericide 'Kasugamicine' which is covered bean seeds and the other control is spraying basic copper sulfate at the vegetative stage on plants. But now non-infested seeds are produced at original and propagation seed farms so that this disease is becoming very few.

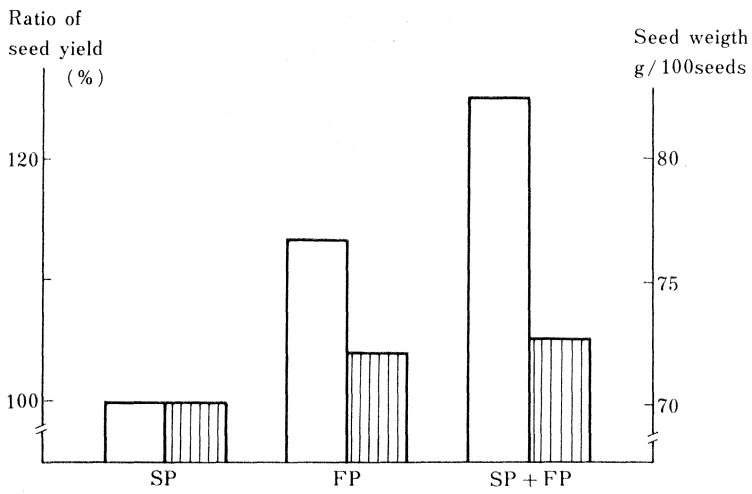
Table 1. Effects of cool summer on the growth and seed yield of beans.

	Flowering tme*			No. of pods per hill			Seed yield (kg/ha)		
	Mean**	1964	Ratio (%)	Mean	1964	Ratio (%)	Mean	1964	Ratio (%)
Wase-tairyu 1	49	57	116	26	15	58	1,580	610	39
Maruha 1	57	64	112	29	11	38	1,760	380	22
Takara-shozu	49	57	116	33	19	58	1,840	770	42
Otebe	38	50	132	18	16	89	1,470	1,280	87
Taisho-kintoki	31	39	126	13	10	77	1,720	1,290	75
Tsunetomi-nagauzura	31	38	123	13	12	92	1,730	1,390	80
Kairyo-chunaga	34	44	129	13	12	92	1,560	1,340	86

Notice: * means no. of days from germination to flowering time.
** Average from 1959 to 1963.

'Anthracnose' (*Glomerelle lindemthianum*, (SACC. et MAGNUS) SHEAR) is the most terrible disease of kidney bean in Hokkaido. Being infested by the fungi, leaves of bean plants have brown circles, seed yield is decreased, and moreover quality of seed is made bad. There are some fungicides in market but few farmers use them, so that breeding resistant varieties are urgent.

'Stem rot' (*Sclerotinia sclerotiorum*, (LIBERT) de BARY) infests many species of crops, for instance, soybean, kidney and azuki beans, tomato, egg plant, and so on. Several years ago decreasing rate of yield of kidney and azuki beans by the disease



Notice : SP and FP are super-phosphoric acid and fused phosphate respectively.
In each plot the same amount of phosphorus is applied.

Fig. 4.

was terribly large. However, a controlling method with a new fungicide 'Dichlozoline' was established in our station and now it is very common to farmers.

'Japanese butter bur borer' (*Ostrinia varialis*, BREMER) is a harmful insect which attacks bean plants especially azuki bean in Hokkaido. When many borers break into stems and petioles, azuki bean plants sometimes die. This insect, however, is controlled by spraying insecticide three or four times.

3. Problems on soil and fertilizer

About 80% of upland fields of Tokachi district are covered with volcanic ash soils which are very sterile and bean plants request much fertilizers especially phosphoric acid and magnesia. Fig. 4 shows the effect of magnesia and phosphoric acid on kidney bean. Fused phosphate contains phosphate and magnesia but the phosphate in it is slow-acting so the quick-acting super phosphate have to be given. The act of root nodule bacteria is most weak on dwarf kidney and additional nitrogen at full-bloom stage is very effective (Fig. 5).

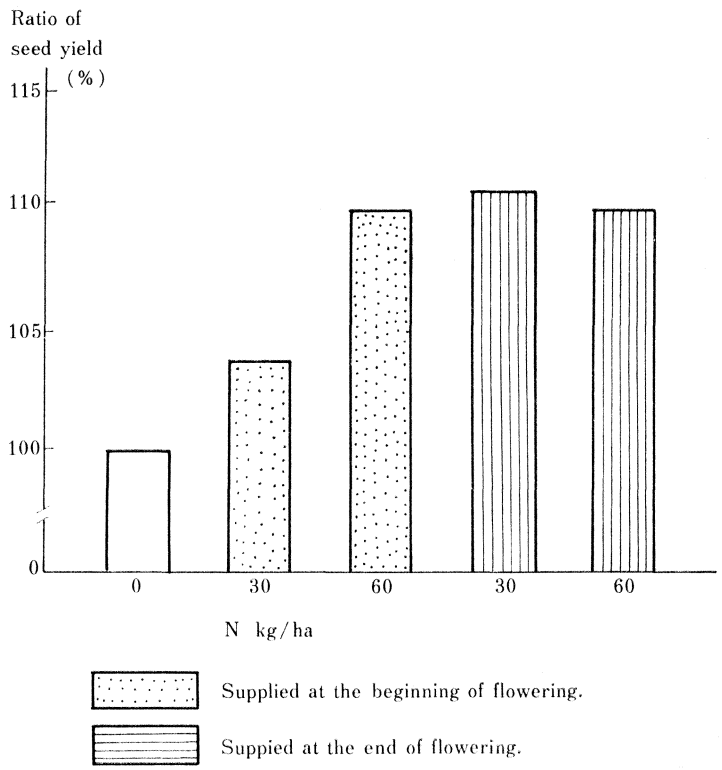


Fig. 5.

Problems on Breeding Kidney and Azuki Beans

1. Kidney bean

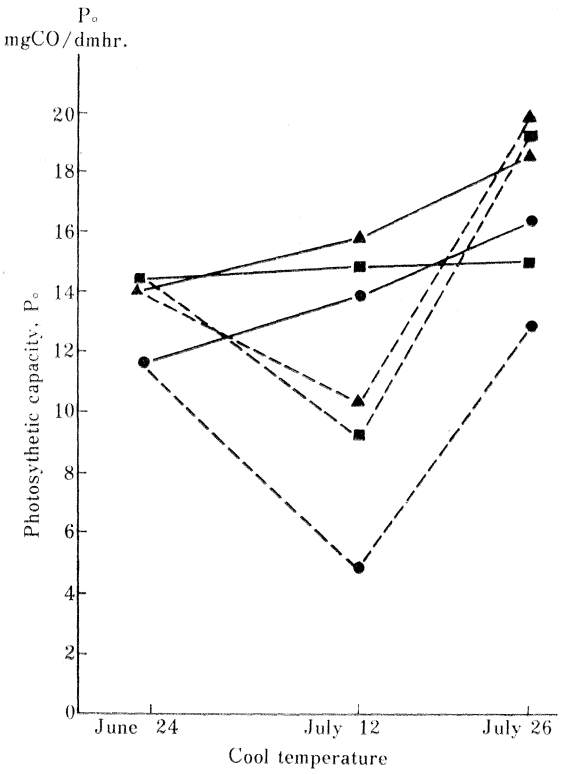
As mentioned above, Kintoki and Tebo are main kinds of kidney beans. Therefore, our efforts on breeding are directed to this two kinds mainly at Tokachi Agricultural Experiment Station.

Taisho-kintoki has seeds of good quality but susceptible to halo blight and is not so high yielding because of short plant hight and highly shattering. The variety has

only 3.5 trifoliates on the main stem in average, which might be limiting of yield. New variety of Kintoki must have more trifoliates on the stem. Six or seven trifoliates type is in our collection (Collection No. 1260) but it is a slightly viny and the leaves on upper parts are too small. The crosses between Kintoki and No. 1260 were made and selections are being continued. There is no resistant variety to halo blight now and it is emergent to introduce and to screen many varieties from another countries.

The representative variety of Tebo 'Otebo' is short viny and apt to lodging. Lodging prevents harvesting with machines and is cause of bad quality of seeds. Then the bush type of Tebo is wanted. The resistance to shattering is also an important factor for harvesting with machines. Some varieties introduced from the United States of America are resistant to shattering and some crosses have been made for breeding varieties with resistance to shattering.

The other disadvantages of Otebo are weak to anthracnose and late maturing. Many varieties have been introduced as resistant ones to anthracnose but all are susceptible in Tokachi. If it is very cool in summer, Otebo would ripen too late and have a chance to receive the first frost. There is, however, possitive correlation between maturity and



Notice : 1. —— Control
--- Cool temperature
2, ● Otebo
▲ Chileam Arrowz Bean
■ Sanilac Pea

Fig. 6.

seed yield that makes breeding difficult. Moreover, Otebo is not cool-weather tolerant. According to the studies at Tokachi Agricultural Experiment Station, 'Sanilac Pea' and 'Chilean Arrowz Bean' which are bush and short viny respectively, are more resistant to cool temperature than Otebo and they have large capacity of photosynthesis under cool temperature condition (Fig. 6). Several crosses between these and kinds of Tebo have been made and selections are being succeeded in the phytotron.

2. Azuki bean

Azuki bean plant is most weak to cool temperature in three beans (soybean, kidney bean and azuki bean) and the fluctuation of seed yield between years is very large. Therefore, the tolerant varieties to cool temperature are needed in Hokkaido especially at northern and eastern parts of Hokkaido. A few varieties (Buchi-shoryukei, Wasekei 3 etc.) are resistant to cool temperature but low yielding and the seed quality is bad. It is difficult to transfer only the germplasm of resistance to the commercial variety.

Breeding of resistant varieties to diseases and insects is not started at our station. SAWA (1971) reported that green gram (Phaseolus radiatus, L.) is resistant to soybean cyst nematode (*Heterodera glycines*, ICHINOHE) which is parasitic on bean roots and that he tried to make the inter-specific hybridization between azuki bean and green gram.

The half of consumption of azuki bean in our country is imported and azuki bean varieties are of the best quality. Dainagon is, as mentioned above, large-seeded and of good quality. New variety of Dainagon 'Akatsuki-dainagon' is high yielding but too late maturing in Tokachi district and selections of early Dainagon is urgent in our station.

The adaptability of beans to farm mechanization is one of the most important objectives in breeding. It is not a single character but a complex one which contains resistance to lodging, uniformity of maturity within plant, resistance to pod shattering, and so on. However, these points have not been resolved.