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GENETIC STUDIES ON QUANTITATIVE CHARACTERS IN SOYBEAN

III. Inheritance modes of F_2 generations in the crosses between indeterminate and determinate varieties

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Although the indeterminate and the determinate types of soybean have been known to differ in physiological and ecological characteristics (NAGATA 1960 a, b, c; THSENG and HOSOKAWA 1971), the genetic behavior of such habit has not been clarified completely. But the introduction of the indeterminate habit into determinate varieties to make the "*half-indeterminate type*", seems to be a promising method to create a new subject of soybean breeding in Japan. Consequently, in order to raise such variety effectively, it is indispensable to obtain the information of the inheritance mode of these characters.

This study is devoted to the analysis of the inheritance mode of the several agronomic characters in the early segregating generations from the some crosses between indeterminate and determinate varieties.

Materials and Methods

Four F_2 populations *i. e.*, Harosoy \times Tokachi-nagaha, Harosoy \times Kitami-shiro, Kogane-jiro \times Shinsei and Isuzu \times Toiku No. 122, and seven parental varieties were used for experiments. Harosoy and Kogane-jiro are known as a indeterminate variety, and Tokachi-nagaha, Kitami-shiro, Shinsei and Toiku No. 122 are determinate variety.

In 1969, the P_1 , P_2 , F_2 plants were grown in the farm of Tokachi Agriculture Experimental Station, Hokkaido.

The experimental designs were as follows :

- 1) Two crosses, Harosoy \times Tokachi-nagaha and Harosoy \times Kitami-shiro, were designed following a completely randomized block with six replications. Each replication contained two plots of P_1 , P_2 , and ten

TABLE 1. Total F_2 variance, error variance, and heritability in four F_2 populations

Character	F_2 , Harosoy \times Tokachi-nagaha			F_2 , Harosoy \times Kitami-shiro			F_2 Kogane-jiro \times Shinsei			F_2 , Isuzu \times Toiku No. 122		
	$\sigma_{F_2}^2$	σ_e^2	h^2	$\sigma_{F_2}^2$	σ_e^2	h^2	$\sigma_{F_2}^2$	σ_e^2	h^2	$\sigma_{F_2}^2$	σ_e^2	h^2
Days to first flowering	64.817	1.426	97.8	130.367	2.347	98.2	—	—	—	—	—	—
Plant height	734.572	26.445	96.4	1074.492	47.000	95.6	694.652	20.029	97.1	43.733	40.912	6.5
Node no. in main stem	13.714	0.741	94.6	18.442	0.852	95.4	9.714	0.564	94.2	0.567	0.448	13.7
Branch number	5.940	0.791	86.8	5.296	0.678	87.2	3.541	0.925	73.9	0.949	0.658	30.7
Pod number	3045.235	228.493	92.5	2761.325	234.712	91.5	608.392	150.541	75.3	132.604	77.678	41.4
Seed number	—	—	—	—	—	—	2053.165	571.095	72.2	733.544	440.581	39.9
Seed weight	—	—	—	—	—	—	89.749	27.748	70.0	42.921	27.103	36.8
Ratio of node no.*	164.685	13.011	92.1	204.012	24.278	88.1	—	—	—	—	—	—

* Increment of node number after first flowering in percent of the total node number.

plots of F_2 . Each plot consisted of 12 plants, 10 of them being used for taking records. All the plants were planted in 60×60 cm spacing.

- 2) Other two crosses, Kogane-jiro \times Shinsei and Isuzu \times Toiku No 122, were also designed following a completely randomized block with four replications. Each replication contained one plot of P_1 and P_2 , and four plots of F_2 . Each plot consisted of 20 plants, 15 of them being used for taking records. All the plants were space-planted at 60×20 cm.

Results

1. Genetic parameter in F_2 population (Table 1)

In spite of the difference in the planting density, experimental error in all characters seemed to be small enough to inference that the phenotypic values of F_2 plants were made up almost only of the genotypic effects.

The heritability values in broad sense were estimated by the following formula :

$$\text{Genetic variance } (V_G) = V_{F_2} - \frac{1}{2}(V_{P_1} + V_{P_2})$$

$$\text{Heritability } (h_2) = V_G/V_{F_2}$$

Where V_{F_2} is phenotypic variance in F_2 population, V_{P_1} and V_{P_2} are phenotypic variance in P_1 and P_2 populations, respectively.

The heritability values estimated from the F_2 population of indeterminate \times determinate crosses were rather high in all characters, especially most of them from wide spaced experiment exceeded over 90%. On the other hand, the heritability values estimated from the F_2 population crossing from the determinate \times determinate were very low.

2. Days to first flowering (Fig. 1)

In both populations, the ranges of F_2 variation exceeded the parental difference by more than twelve times. The F_2 mean exceeded the parental mean about ten days. There were two peaks of distributions; one of them located at the class of 100-120 days was bigger, and another one located at the class of 60-70 days was small.

3. Plant height (Fig. 2)

The distributions of plant height observed in each of the three F_2 populations derived from the crosses between indeterminate and determinate varieties were continuous showing the deviation from the normal distributions. On the other hand, F_2 populations derived from the crosses among deter-

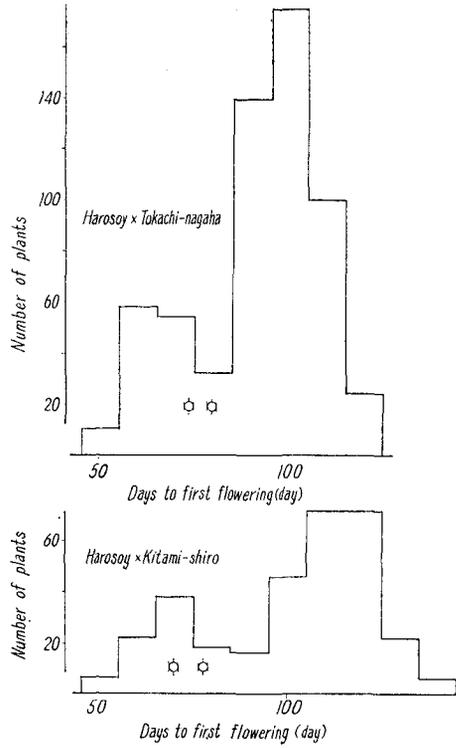


Fig. 1. F_2 distribution of days to first flowering (cross figures indicate the parental mean with σ_e).

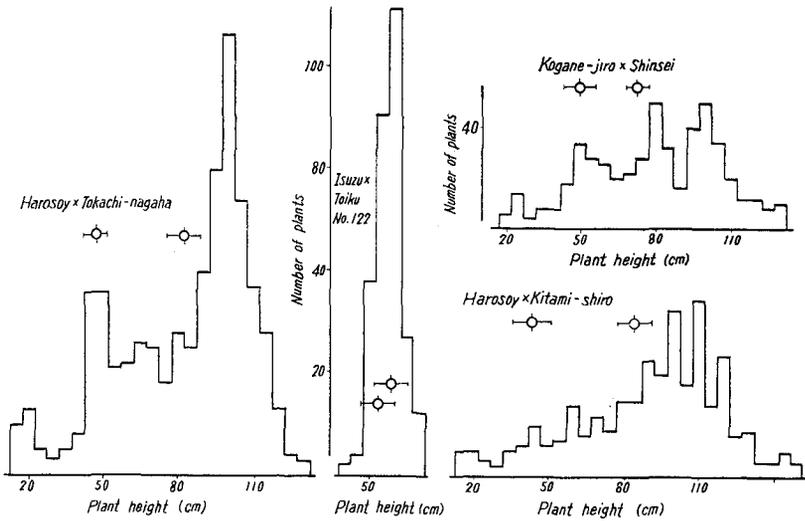


Fig. 2. F_2 distribution of plant height (cross figures indicate the parental mean with σ_e).

minate varieties showed the normal distribution. The ranges of variation in F_2 populations were greatly wider in the crosses between indeterminate and determinate varieties, and the mean of F_2 populations overwhelmingly exceeded the parental means. In the F_2 population from the crosses between the determinate varieties, mean value was equal to the parental mean and noticed that amount of F_2 population plants lower than both the low and high parents is very few.

4. Node number in main stem (Fig. 3)

In three crosses, Harosoy \times Tokachi-nagaha, Harosoy \times kitami-shiro and Kogane-jiro \times Shinsei, the variation in the F_2 populations were so big that the node number of plants in the largest classes were more than four times as much as another extreme value. Seeing the distributions of the F_2 populations, the former two populations were somewhat deviated from normal distributions, while the distribution of the later population is normal. The ranges of F_2 variations in all crosses were much wider than the parental differences, and these mean values exceeded the parental means.

In the population of Isuzu \times Toiku No. 122, the parental mean was about equal to the F_2 mean and the range of F_2 variation was equal to the parental

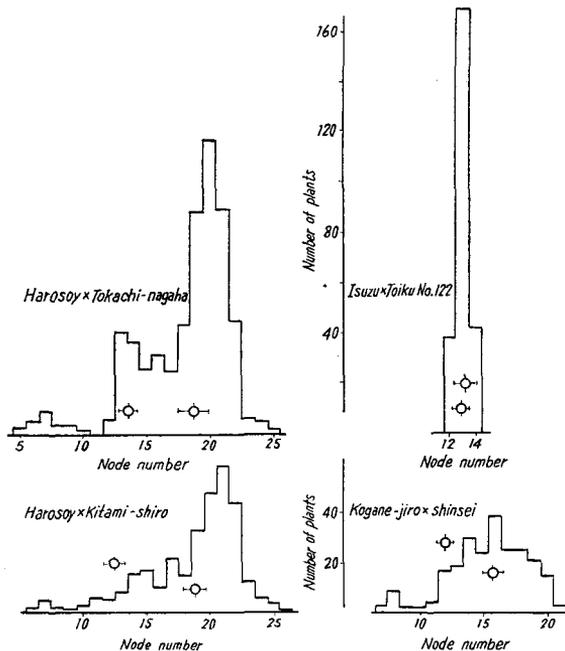


Fig. 3. F_2 distribution of node number in main stem (cross figures indicate the parental mean with σ_e).

difference.

5. Branch number (Fig. 4)

In all of the three crosses between indeterminate and determinate varieties, F_2 distributions were typically normal and the ranges of F_2 variation were apparently wider than the parental differences. The parental means, F_2 means showed the almost same value.

In the population of Isuzu \times Toiku No. 122, more than half of the plants exceeded the values of lower parents and none of the plants in F_2 than the highest value in the parental varieties.

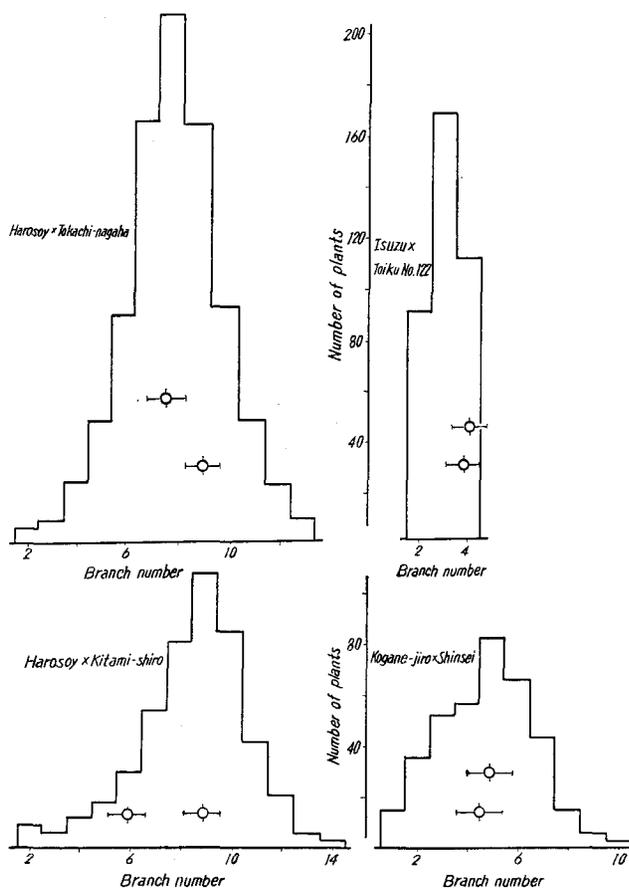


Fig. 4. F_2 distribution of branch number (cross figures indicate the parental mean with σ_e).

6. Pod number (Fig. 5)

About four populations, F_2 distributions were normal, especially the F_2

population of Isuzu × Toiku No. 122 showed the typical normal distribution, and none of these plants had a lower value than the lowest value in parental varieties. The ranges of F₂ variation of the crosses between indeterminate and determinate varieties were extremely wider than the parental difference, especially in the population of Harosoy × Tokachi-nagaha, where the range exceeded the parental difference by more than four times.

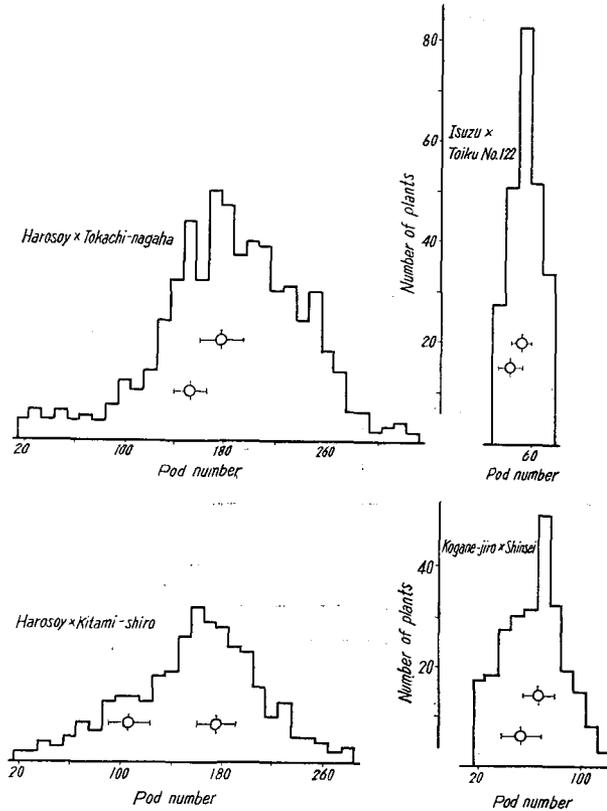


Fig. 5. F₂ distribution of pod number per plant (cross figures indicate the parental mean with σ_e).

7. Seed number (Fig. 6)

In F₂ populations derived from crosses Kogane-jiro × Shinsei and Isuzu × Toiku No. 122, the ranges of variation were much wider than the parental differences, only five plants in population of Isuzu × Toiku No. 122 showed the lower seed number than values of lower parents, and the distribution of the population of Isuzu × Toiku No. 122 was deviated from the normal, but the variation was continuous.

In the population of Isuzu \times Toiku No. 122, the mode of F_2 distribution was a extremely skewed one, and the mean value was smaller than the parental mean. On the other hand, the mean of F_2 in Kogane-jiro \times Shinsei was equal to the parental mean.

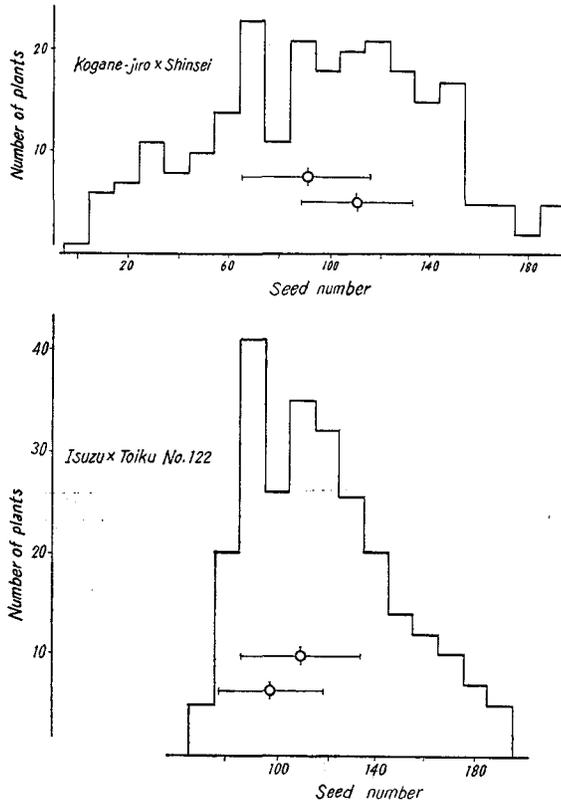


Fig. 6 F_2 distribution of seed number per plant (cross figures indicate the parental mean with σ_e).

8. Seed weight (Fig. 7)

In both populations, the ranges of F_2 variation were greatly wider than the parental differences, while F_2 distribution of Kogane-jiro \times Shinsei was a typically normal.

The F_2 mean of Isuzu \times Toiku No. 122 exceeded the parental mean, but in the population of Kogane-jiro \times Shinsei, the F_2 mean and each parental means were not so much different, as the value was 24.17, 24.91 and 25.01, respectively.

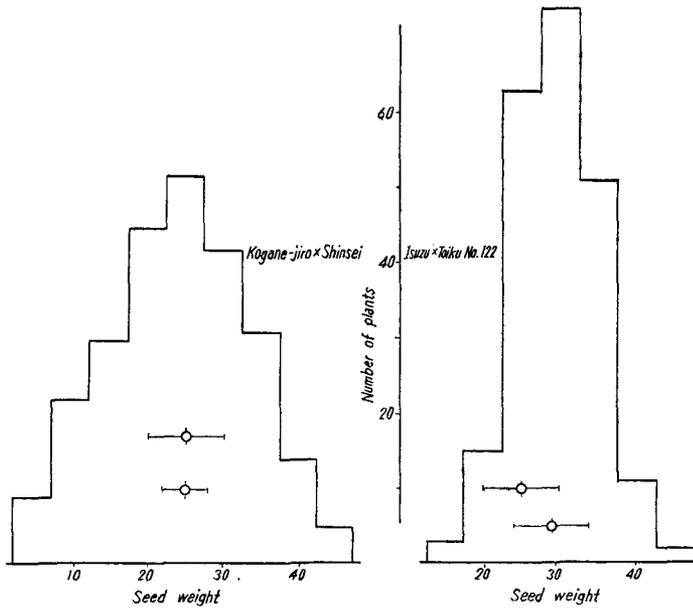


Fig. 7. F₂ distribution of seed weight per plant (cross figures indicate the parental mean with σ_e).

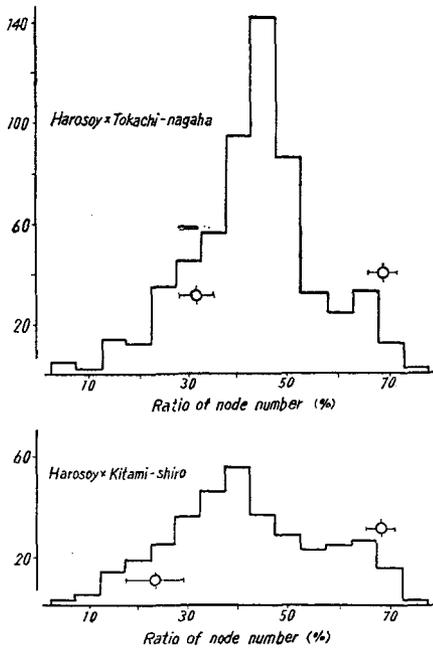


Fig. 8. F₂ distribution of ratio of node number (cross figures indicate the parental mean with σ_e).

9. Ratio of node number (Fig. 8)

To describe the growth habit, the authors took the increment of node number after first flowering in per cent of total node number (Sanbuichi 1967; Thseng and Hosokawa 1971).

In both populations, the distributions of F_2 populations were normal, the ranges of F_2 variation were not so much bigger than the parental differences and F_2 means were smaller than the parental means. There were only 1% plants located at the tail of distribution of higher parent and 10% plants at lower parent, generally about 60% plants showed the values ranging from 35% to 55% in the F_2 distributions.

Discussion

To study the variations on three F_2 populations in the crosses between indeterminate and determinate varieties revealed that many of the characters are similar in inheritance mode and transgressive segregation in F_2 distribution. Also the variations of F_2 populations apparently showed that the distributions are normal or far normal, and continuous, and no character is conditioned monogenically. These results as mentioned above, seem to support that the indeterminate and determinate varieties are controlled by a different genetic basis, and its may be roughly said that the inheritance of F_2 plants are under the control of various gene effects, and with intra and inter-allelic interaction or additive effects, and poly-genic effects in all characters. Thus, the analysis of the effective number of genes and their effects will be a very important problem for breeding for which indeterminate and determinate varieties are used as the parents of the hybridizations.

THSENG and HOSOKAWA (1971) reported that the node number in main stem at first flowering was not correlated with its increment after first flowering in the F_2 hybrids of indeterminate \times determinate variety, and the heterosis of ratio of node number was not found in F_1 plants. In this study, it is indicated that many plants located between indeterminate and determinate variety in the F_2 distribution of ratio of node number.

Selection of the "half-indeterminate" plants seems to be possible in soybean breeding. This will be discussed in the following paper.

Summary

Three F_2 populations obtained from the crosses between indeterminate and determinate varieties, and one F_2 population of determinate \times determinate variety, and their parents were used to investigate the inheritance modes of

the F_2 plants for several agronomic traits.

The environmental variance, estimated by the variation of each parental variety, was so small enough that the heritability values estimated by the formula (total F_2 variance—environmental variance/total F_2 variance), and heritability value was very higher in the populations of the crosses between indeterminate and determinate variety.

The inheritance modes of the F_2 distributions were more or less normal in all characters given, i.e., plant height, node number in main stem, branch number, pod number, seed number, seed weight and ratio of node number.

Days to first flowering was only exceptional character whose distribution was found by two peaks in the inheritance mode.

Ratio of node number, 60 percents of the F_2 plants distributed in the centre of the parents.

The F_2 mean exceeded the parental mean in days to first flowering, plant height, node number in main stem, branch number, pod number, seed weight, except the ratio of node number.

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