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# Genetice Variation of Soybean Hybrid Populations by Natural Selection in Spring Crop Season at Four Locations[1]

## II. Variation of Heritabilities and Correlations for Certain Agronomic Characters in $F_2$ Generation

Kou-lein Chan, Ruey-shing Lee and Fu-sheng Thseng[2]

**Abstract**: In spring crop season 1983, two $F_2$ soybean (*Glycine max*) hybrid populations, KS8×TN15 (Population A) and TN15×T175 (Population B) were planted in four locations of Taiwan to estimate the heritabilities and correlations for eleven agronomic characters in $F_2$ populations. In general, the heritability values for vegetative characters were higher than that of the yield component ones. The magnitude of heritability varied with locations, and the heritabilities of vegetative characters tended to be increased from south to north. Significant differences of correlations among characters were found. The characters in Taichung and Tainan of Population A and those in Taichung and Hsinchu of Population B were closely associated than those in other locations. These results suggested that some differentiation had taken place in the $F_2$ populations of this study.

## Introduction

A hybrid population of self-pollinated crop advanced for several generations under varied environments would be a very useful way in the studying of evolution, adaptation, breeding parameters, and genetic variation of the crop. Several workers [1,6,7,16] reported that the characters of the crop were easy to present and the practical breeding work can be easily operated and genotypes with adaptation could be selected when hybrid populations are advanced under favorable environments. The genetic parameters as correlation, heritability and inheritance mode may be significantly changed [2,5,6,8,13,17,18,19,20,21] and variant biotypes created [7,8,9] when hybrid populations of crops are subjected

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2. Respectively, Assistant Breeder, TARI; Graduate Student and Professor of Research Institute of Food Crops, National Chung-hsing University, Taichung, Taiwan, Republic of China.

to different environments.

Three crops of soybeans, namely spring, summer and fall (in southern-most that only) crop seasons can be adapted in Taiwan[10,11,12]. Significant association between crop season and variety consistently existed[13,18]. Invirtually, soybean breeding in Taiwan has totally done in two successive seasons each year---which is called the disruptive seasonal selection[14,20], but it has rarely done on direction seasonal selection. Significance on these two soybean breeding schemes under different planting seasons and locations is an urgent matter that must be solved soon as possible.

Soybean is rather sensitive to environmental factors. It grows island-wide in Taiwan. Though Taiwan is a tiny island, its weather differs greatly from north down south resulting from its long and narrow leaf-shaped geographic nature. Consequently, the planting time of soybeans varied with locations and the varieties adapted to particular areas are required. Therfore, to study the relationship between environment and soybean breeding in Taiwan is of great important event.

The main purpose of this experiment was to study the genetic variation and breeding parameters by growing two soybean hybrid populations from $F_2$ to $F_5$ generations at four locations and in two crop seasons (spring and fall) each year. We are in great hope that the result might suggest the most suitable soybean breeding locality and selection method in Taiwan.

In part one of this experiment, the authors[4] pointed out that significant differences occurred among the distribution patterns of agronomic characters due to different location/environmental effects. However, relationship between effect of environment and agronomic characters, and degrees of variation for each genotype, and interactions among characters remains obscure. This paper reports the variation of heritabilities and correlations for eleven characters of two $F_2$ soybean populations grown in spring crop season 1983 at four locations.

## Materials and Methods

Two $F_2$ soybean populations, KS8×TN15 (population A) and TN15×T175 (population B) were grown during the spring season 1983. A total of 1,000 to 2,000 $F_2$ and 100 parental seeds were sown (1 seed per hill) respectively on March 1 at Kaohsiung District Agricultural Improvement Station (Kaohsiung DAIS), located in Pingtung, southern -most of Taiwan, on February 4 at Shanhua, south-west of Taiwan, on March 1 at Taiwan Agricultural Research Institute (TARI), Taichung, Middle-west of Taiwan, and on March 13 at Hsinchu (Taoyuan DAIS), northern part of Taiwan. Local cultural practice was adopted for the management of the experimental field work. Meaurements were randomly made from 500 $F_2$ and 50 parental plants for plant height, number of branches, nodes on main stem, pods of branches, pods on main stem, number of seeds, days to flowering, days to maturity, seed weight, total pods, and 100-seed weight.

## Experimental Results

### Heritability

The broad sense heritabilities for eleven characters measured were shown in Table 1. They varied greatly not only between populations, but also among characters and locations. They were high (over 70%) for plant height, branch number, nodes on main stem, days to flowering and maturity, but low for yield component characters: seed number, seed weight and total poes. In general, the more north were the experimental locations, the higher heritabilities were for plant height and nodes on main stem. In other words, they tended to be decreased from Hsinchu downward Taichung, Tainan and Pingtung. Similarity, with the exception of population A, heritability for number of branches also tended to be high in northern locations and low in southern ones. In addition, higher heritabilities for branch number and pods on main stem were obtained in Hsinchu, moderate in Taichung, and lower in Tainan and Pingtung locations. Heritabilities for seed number, total pods, and seed weignt were consistently low in four locations, and they had no significant differences among locations. As for 100-seed weight, its heritability was also high in Hsinchu, moderate in Taichung and Tainan, and low in Pingtung.

**Table 1.** Heritability values (%) for eleven characters of $F_2$ populations in four locations

| Character | Pingtung | | Tainan | | Taichung | | Hsinchu | |
|---|---|---|---|---|---|---|---|---|
| | Population A | Population B | Population A | Population B | Population A | Population B | Population A | Population B |
| Plant height | 76 | 86 | 79 | 81 | 80 | 91 | 84 | 92 |
| Branch number | 69 | 72 | 75 | 76 | 62 | 83 | 91 | 89 |
| Nodes on man stem | 70 | 78 | 73 | 81 | 76 | 88 | 89 | 87 |
| Pods of branches | 54 | 69 | 67 | 72 | 50 | 71 | 72 | 74 |
| Pods on main stiem | 56 | 55 | 64 | 66 | 51 | 54 | 69 | 68 |
| Seed number | 65 | 63 | 68 | 67 | 50 | 66 | 63 | 68 |
| Days to flowering | 87 | 88 | 89 | 82 | 84 | 85 | 84 | 86 |
| Days to maturity | 87 | 79 | 80 | 81 | 86 | 72 | 87 | 84 |
| Seed weight | 60 | 60 | 62 | 63 | 67 | 64 | 60 | 66 |
| Total pods | 56 | 62 | 61 | 64 | 58 | 63 | 68 | 65 |
| 100-seed weight | 69 | 54 | 69 | 74 | 76 | 73 | 80 | 72 |

Remarks: Population A: KS8×TN15. Population B: TN15×T175.

### Correlations among Characters

Phenotypic correlations among characters of the two populations at four locations were shown in Figs. 1 and 2. Generally, correlations differed not only between populations but also among locations. The detailed explanation by locations were as follows:

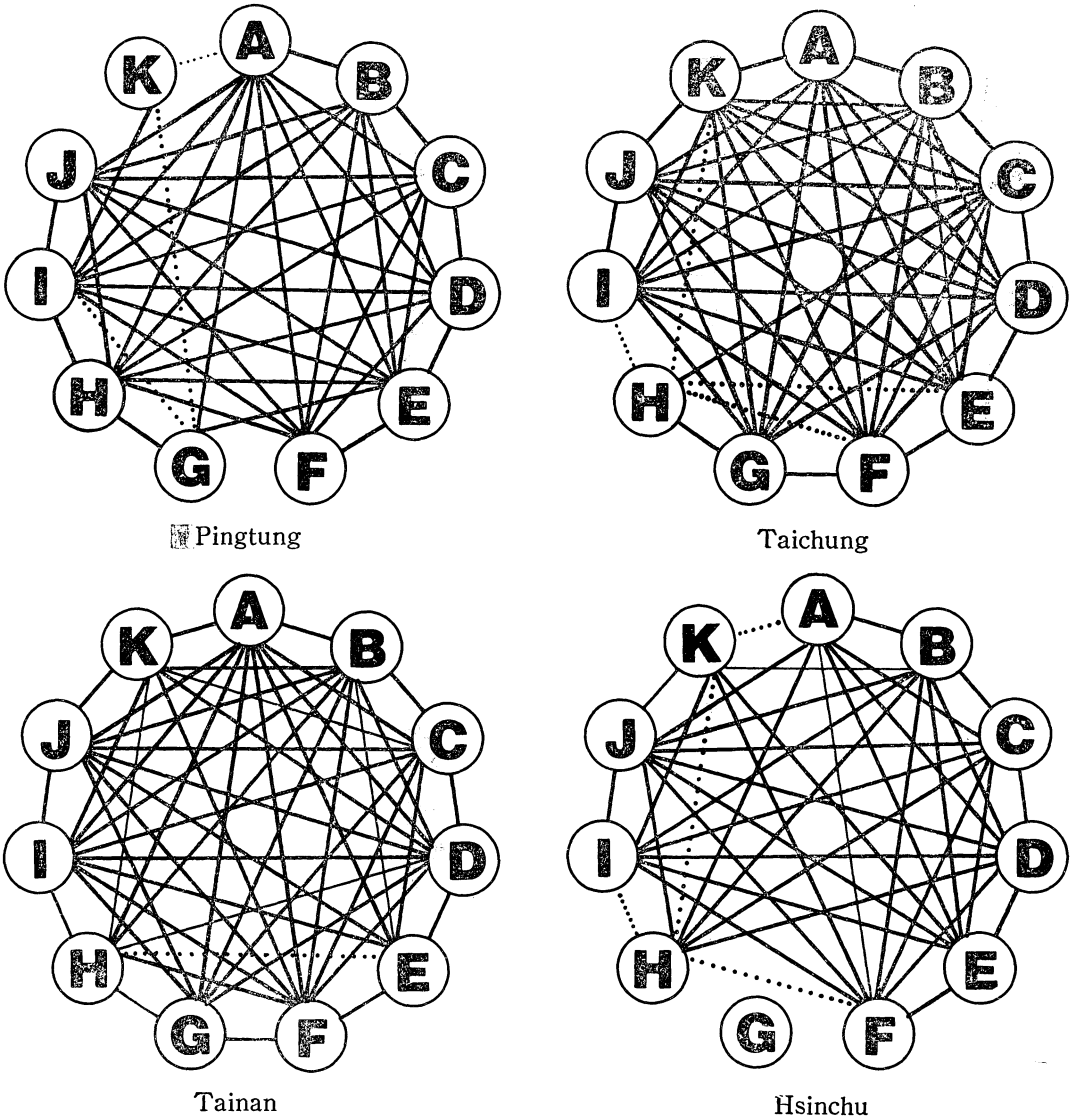



**Fig. 1.** Schematic diagrams showing the phenotypic correlations between all pairs of 11 agronomic characters for $F_2$ population of Population A (KS3×TN15) in four locations.

(A) plant height
(B) no. of branches
(C) node number of stem
(D) pod number of branches
(E) pod number of stem
(F) seed number/plant
(G) days (from sowing) to flowering
(H) days (from sowing) to maturity
(I) seed weight/plant
(J) pod number/plant
(K) 100-seed weight

———High positive correlation (significant at 1% level)
———Moderate positive correlation (sig. at 5% level)
·····High negative correlation (sig. at 1% level)
·····Moderate negative correlation (sig. at 5% level)
others with no mark are nonsignificant, either positive or negative.

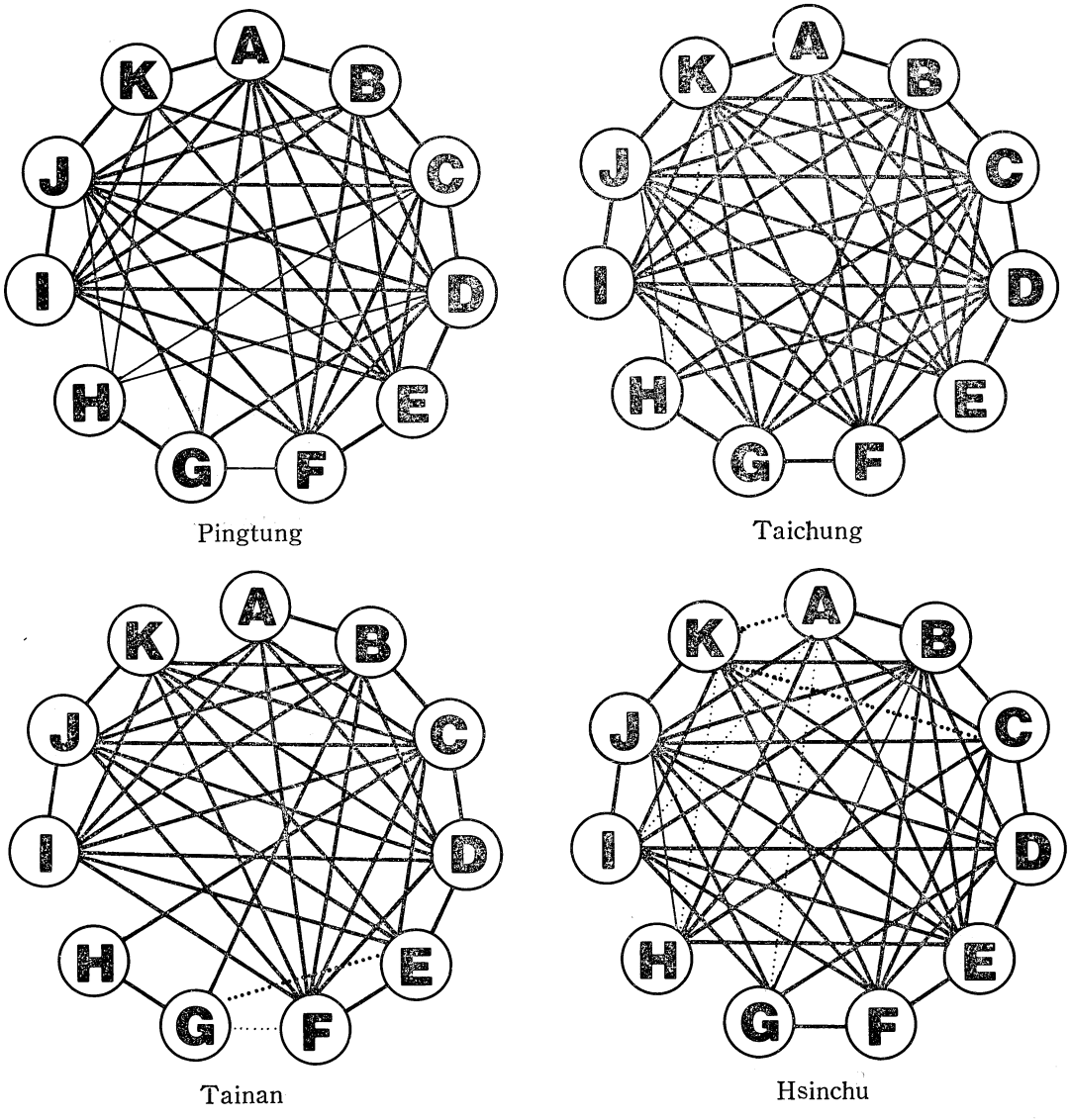



**Fig. 2.** Schematic diagrams showing the phenotypic correlations between all pairs of 11 agronomic characters for $F_2$ population of Population B (TN15×T175) in four locations.

(A) plant height
(B) no. of branches
(C) node number of stem
(D) pod number of branches
(E) pod number of stem
(F) seed number/plant
(G) days (from sowing) to flowering
(H) days (from sowing) to maturity
(I) seed weight/plant
(J) pod number/plant
(K) 100-seed weight

———High positive correlation (significant at 1% level)
_____Moderate positive correlation (sig. at 5% level)
.....High negative correlation (sig. at 1% level)
.....Moderate negative correlation (sig. at 5% level)
others with no mark are nonsignificant, either positive or negative.

**In Pingtung location**

With the exception of days to flowering and 100-seed weight, the other nine characters such as plant height, branch number, nodes on main stem, pods of branches, pods on main stem, seed number, days to maturity, seed weight, and total pods were significantly positive correlated one another in both populations. In population A, characters between days to flowering and pods on main stem, plant height, and days to maturity were significantly positive correlated, but characters between days to flowering and branch number, nodes on main stem, pods of branches, seed number, and total pods were not associated at all. Further, days to flowering and seed weight, and 100-seed weight were siginificantly negative correlated. In respect to 100-seed weight, it was negatively correlated with plant height, days to flowering, and positively correlated with seed weight, but it was not correlated with other eight characters studied.

In population B, positive correlations were obtained between days to flowering and plant height, pods of branches, seed number, days to maturity, and total pods, but no correlations were found between days to flowering and number of branches, nodes on main stem, pods on main stem, seed weight, and 100-seed weight. Apart from being no correlations between 100-seed weight and number of branches, pods of branches, number of seeds, and days to flowering, positive correlations were found between 100-seed weight with other six characters. As for days to maturity, it had no correlations with plant height, number of branches, pods on main stem, number of seeds, and seed weight, but it had significantly positive correlations with other five characters.

**In Tainan location**

With the exception of no correlations were found between days to flowering and pods on main stem, 100-seed weight, and between days to maturity and total pods, nodes on main stem, and significant negative correlations found between days to maturity and pods on main stem, the remainder pairs of all characters were positively correlated in population A.

In population B, no correlations were found between pods on main stem and number of branches, plant height, days to maturity, and between dasy to maturity and plant height, number of branches, pods of branches, pods on main stem, number of seeds, seed weight, total pods, and 100-seed weight. As for days to flowering, it was significantly positive correlated with branch number, and days to maturity, and negatively correlated with pods on main stem and seed number, but it was not correlated with other six characters. Except that no correlations were found between 100-seed weight and plant height, days to flowering, and days to maturity, it was significantly positive correlated with other seven characters.

**In Taichung location**

The following nine characters: plant height, branch number, nodes on main stem,

pods of branches, pods on main stem, number of seeds, days to flowering, seed weight, and total pods were variously positive correlated, and so nine positive correlation groups showed in both populations. However, pairs of characters between days to maturity and pods on main stem, number of seeds, seed weight, and 100-seed weight were negatively correlated, and this character was not correlated with plant height, number of branches, and total pods in population A.

In population B, no correlations were found between days to maturity and plant height, number of branches, pods on main stem, number of seeds, and seed weight; and between days to floweirng and pods on main stem, and plant height. Moreover, significant negative correlation was found between days to maturity and 100-seed weight.

**In Hsinchu location**

The correlation patterns in Hsinchu location differed greatly from those of other three locations in both populations. In population A, character of days to flowering was independent of other characters. Character pairs between plant height and 100-seed weight, between days to maturity and number of seeds, seed weight, and 100-seed weight were negatively correlated, but the remainants were variously positive correlated.

More negative correlations were found in population B than those in other three locations. They were plant height and days to flowering, seed weight, and 100-seed weight, and 100-seed weight and nodes on main stem, and days to maturity. Character pairs not correlated were plant height and number of seeds, pods of branches; days to flowering and nodes on main stem, pods on main stem, days to maturity, 100-seed weight; days to maturity and pods of branches, number of seeds, seed weight; and seed weight and nodes on main stem. Other pairs of characters, however, were positively correlated, and six of them such as number of branches, nodes on main stem, pods of branches, pods on main stem, number of seeds and total pods were the very correlated groups in population B.

## Relationship among Characters

In order to find out the relationship of the eleven characters over four locations, the principal components for each of the phenotypic correlation matrixes were analysed. Their scatter diagrams were shown in Figs. 3 and 4. The figures showed that significant differences of the first and second principal components, mostly existed among locations.

In population A, the scatter diagrams of the three vegetative characters, plant height, branch number, and nodes on main stem resembled with moderate positive component scores either in first or second principal component planes both in Taichung and Hsinchu locations. However, they scattered differently in Tainan and Pingtung locations. Their component scores were moderately positive in first principal component plane, but smaller negative in second principal component plane in Tainan. In Pingtung location, their first principal component scores were moderately positive, but number of branches was positive whereas plant height and nodes on main stem were negative in second principal component plane.

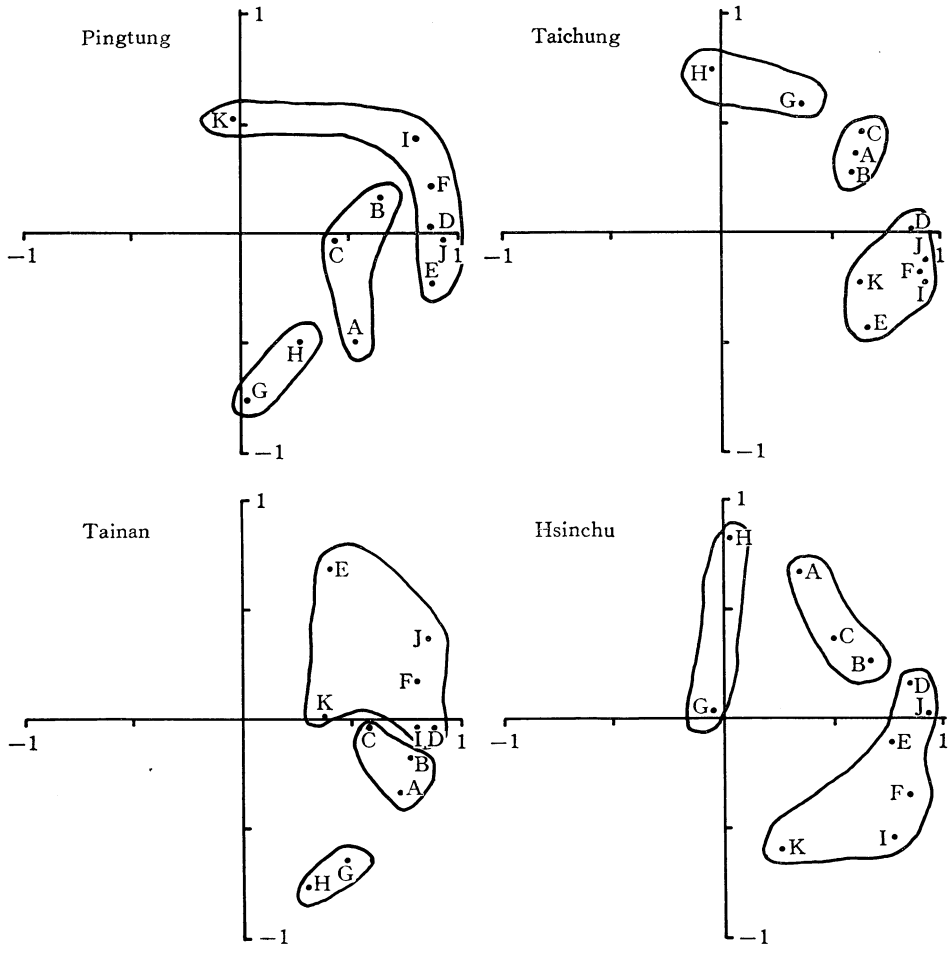



**Fig. 3.** Eleven characters of population A (KS8×TN15) scattered in the plane defined by the first two components for four locations. Symbols of characters are the same as indicated in Fig. 1.

In population B, the diagrams of the three vegetative characters scattered similarty with positive values both in first and second principal component planes, and they showed close relationship one another in Pingtung and Tainan locations. Close relationship among the three vegetative characters also found in Taichung, but only number of branches and nodes on main stem showed positive scores, while plant height showed negative in second principal component plane. Though the diagrams of the three characters showed positive scores in both principal component planes, they were not closely related one another in Hsinchu location.

As to the characters of days to flowering and maturity, they scattered similarity with positive component scores in first and negative in second principal component plane in population A in Pingtung and Tainan locations. The two characters mentioned had relatively large positive scores in second principal component plane, but days

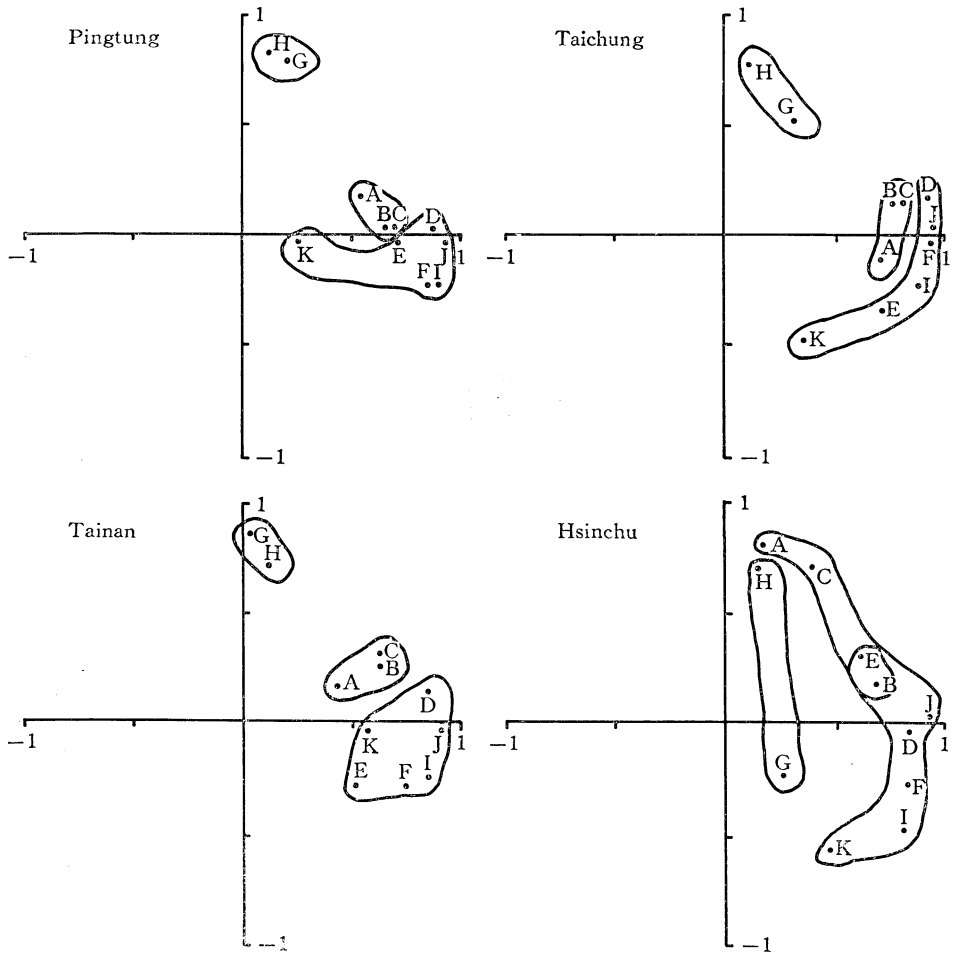



**Fig. 4.** Eleven characters of population B (TN15×T175) scattered in the plane defined by the first two components for four locations. Symbols of characters are the same as indicated in Fig. 1.

to flowering had large positive score and days to maturity had almost nil in first principal component plane in Taichung. The diagram scores for days to flowering and maturity were almost nil in first and positive large scores in second principal component planes in Hsinchu location. In population B, the scatter diagrams for days to flowering and maturity showed mostly similar in Pingtung, Tainan and Taichung locations. They had small positive scores in first and large positive scores in second principal component planes. However, the scatter diagram scores for the same two characters in Hsinchu differed greatly from those in other three locations. They had small positive score in the first principal component plane, but days to flowering had small negative and days to maturity had large positive score in the second principal component plane.

In respect of the scatter diagrams for yield component characters, such as pods of branches, pods on main stem, number of seeds, total pods, seed weight per plant and

100-seed weight, they differed significantly among four locations.

In population A, their scatter diagrams appeared similar in Taichung and Hsinchu locations, but, they scattered more concentrated and closer in Taichung than those in Hsinchu location. The diagrams for number of seeds, pods of branches, seed weight, and total pods in the first principal component plane resembled in Pingtung and Tainan, while those in the second principal component showed inversely between Tainan and Taichung locations. In population B, the scatter diagrams for yield component characters were closely concentrated in Pingtung, loosely in other three locations. The diagram score for 100-seed weight in the first principal component plane were largely positive in Tainan and Hsinchu locations, moderately in Taichung, and small in Pingtung. On the contrary, in the second principal component plane the component score for 100-seed weight were largely negative in Taichung and Hsinchu locations, but almost nil in Pingtung and Tainan locations. The component score for pods on main stem in the second principal component plane was positively in Hsinchu, approximately nil in Pingtung, and moderately negative in Taichung and Tainan locations.

## Discussion

Variation of plant quantitative characters caused by environments or in terms of natural selection were often influenced by the diversity of environment and genetics. In other words, the effect of natural selection depends on the extent of phenotypic and genotypic variation. Generally, heritability indicates the relationship of phenotypic and genotypic variation. Thus, natural selection effect is remarkable and the time needed is shorter on individual plant characters with higher heritability and sensitive to environments. Result in this experiment showed that vegetative characters including plant height, number of branches and days to flowering had higher heritability, and they were greater in norhtern experimental locations than those in southern ones. Hence, significant differences of natural selection effect on hybrid populations among locations may occur when generation added. On the contrary, we found lower heritability values for other yield component characters in this experiment. Since genetic variation is always masked by environmental stress force, less natural selection and less population differentiation would be expected to those with low heritabilities.

In order to survive and propagate the offsprings, the hybrid populations and each individual plants can adapt to a somewhat different range of environmental stimulus resulting from the populational and individual bufferings during the period of growth and development [3]. Researcher [15] also pointed out that the adjustability generated among characters during the course of growth. Distinct differences of the intension and direction of correlations for characters studied were found among locations in this experiment. For instance, closer relationship was found among characters in population A in Tainan and Taichung, and in population B in Taichung and Hsinchu locations. These result suggest that differentiation occured in $F_2$ populations grown in four loctions.

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# 春作單向及不同栽培地區之自然淘汰對大豆雜種集團育種行爲之影響[1]

## II. $F_2$ 世代農藝性狀遺傳率及相關之變異

詹國連　李瑞興　曾富生[2]

**摘　要**

使用 KS8×TN15 (A 集團) 及 TN15×T175 (B 集團) 兩個大豆雜種集團之 $F_2$ 種子，於1983年春作分別播種於臺灣四個地區，探討 $F_2$ 集團在四個不同栽培環境下，農藝性狀之遺傳率及相關之變異。試驗結果顯示，一般營養性狀之遺傳率較高，產量構成性狀較低。而遺傳率之大小因栽培地區之不同，有顯著差異。營養性狀之遺傳率且呈南向北增大之趨勢。性狀間相關之强弱及方向，在地區間均有明顯差異；一般 A 集團之性狀在臺中及臺南，B 集團之性狀在臺中及新竹較其他地區密切。由此等地區間性狀遺傳率及相關之變異現象，可推測本試驗之$F_2$雜種集團，已有地區間分化現象。

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1.臺灣省農業試驗所　研究報告第 1287 號。

2.本所農藝系助理研究員、國立中興大學糧食作物研究所博士班研究生及教授。