

## UPLAND CROPS

Sorghum, wheat, barley, triticale, buckwheat, cassava, sweet potato are the main crops under study at this station. Improvement of varieties and cultural methods for these crops are being carried out.

To cope with the governmental policy to turn part of the rice field into upland crop land, efforts are being made to develop new and high yielding hybrid sorghum varieties. As the results, Taichung Nos. 1, 2, 3 and 5 were released successively in recent years. Taichung 5 is now regarded as the most important variety in Taiwan because of its high yield, aphid resistance and good grain quality. It occupies 90% of the sorghum field in Taiwan at the present time. The improvements of male sterile lines and fertility restoration lines are being carried out and the new promising lines are continuously selected.

Wheat is one of the main winter crops in central Taiwan. This station has released several varieties including Taichung Nos. 29, 31 and 33. New wheat varieties Taichung (sel) Nos. 1 and 2 which are characterized by short stature, stiff straw, high fertilizer response and high yield, were released to the farmers in 1982.

Barley breeding is directed to develop varieties of low protein content (below 11%) to suit brewing. As for buckwheat, varietal improvement and experiments related to planting date, harvesting method, as well as utilization are all subjects of study at the present time.

Efforts are also being contributed to job's tear in the field of varietal improvement, mechanized methods of culture and utilization of grains (noodle, powder, tea, bread, etc.). Because of its high economic value and easy-planting nature, the acreage has been increased rapidly in recent years.

### A. Grain Sorghum

#### 1. Yield Trial of Grain Sorghum Hybrid

Four new grain sorghum hybrids-Taichung bred 69-22, 69-24, 69-27 and Taichung Yu No. 7 were tested with Taichung No. 5 as the check variety in the spring and fall crops of 1983 at 5 localities.

Results showed that Taichung bred 69-27 and Taichung Yu 7 have many good agronomic characters and high yield as compared to Taichung 5. The yield averaged over five locations were 5,753 kg/ha and 5,597 kg/ha, respectively, for Taichung bred 69-27 and Taichung Yu No. 7, namely, 10.9% and 7.9% higher than the check variety. Due to its high starch content and better germination rate, the hybrid Taichung Yu 7 is qualified to replace Taichung 5 which often germinates poor.

## 2. Regional Trial of New Hybrid Grain Sorghum

Hybrid sorghum tested under irrigated and non-irrigated plots showed different results. In the irrigated plot, the crop grew extremely well, yield was high and stable, in non-irrigated plot yield was poor.

In irrigated plots, Shiyuechia and Putzu, grain yield was 7—9 tons per hectare, but at Peikang plot, grain yield was affected by rains during maturity. Although, plant height did not differ between irrigated and non-irrigated plots. The grain yield, 1,000-seeds weight, and panicle length were significantly different. Peikang plot had longer growth period than the other.

Among the hybrids tested lines 69-2 and 69-6 had high yield potential, but the plants were too tall respectively 162cm and 178cm. The most promising hybrid in this trial was 69-24, it was dwarf, early maturity, slender stalk, loose panicle, good germination and intermediate resistance to aphids. Hybrid 70-1 has large panicle, dwarf plant, and high yielding potential. They are subjected to further test.

## 3. Cultural Practice for New Grain Sorghum Varieties

The results showed that new grain sorghum variety Taichung 5 has the best germination and grain yield under the seeding rate of 20 kg/ha and planting depth of 6 cm.

Although row spaces have less influence on agronomic characters but significantly affected the grain yield. Large space between plants obtained higher head weight. However, narrow space got more number of panicles per unit area. The highest grain yield was found in the planting space of 50x10cm.

Sorghum intercropped with bean at Peikang showed that 2-row sorghum with 2-row bean obtained the highest income (102,833 NT\$/ha) but at Tacheng, the best was 3-row sorghum with 3-row peanut (106,833 NT\$/ha). Either intercropping system gets higher income than the check of single sorghum plot.

## 4. Yield Trial of Newly Introduced Grain Sorghum

This yield trial was conducted at Chingsui and Tatsun in the spring crop of 1983 for the selection of suitable varieties in Taichung area. The growth period of C-10R was 86 days, R 17 was 98 days, R 49 and Taichung Yu No. 7 were 99 days. However, the rest of the lines were 1-9 days longer than that of the check variety, Taichung Yu No. 7. The new grain sorghum lines have plant height of 72.3 to

111.7 cm which were shorter than that of Taichung Yu 7 (134.1 cm) and Taichung 5 (124.4 cm). None of the newly introduced varieties showed higher yield than the two checks, Taichung Yu 7 and Taichung 5. Most of the newly introduced grain sorghum were short statured, early matured, insect and disease resistant as compared to the check. They were good for making hybrid sorghum.

### 5. Cause of Low Germinability in Hybrid Sorghum, Taichung No. 5

The germination rate of hybrid sorghum cultivar, Taichung No. 5 is usually low in the seed production in Taiwan. The cause of low germinability were regarded to be related with the anatomy, physiology and pathology of the seeds. However, all efforts failed to improve its germinability to pass germination test. This study, therefore, emphasized on the measures during seed harvesting, seed processing, seed drying, seed storage etc. The results were summarized as follows:

1. The low germinability of Taichung No. 5 was not correlated with its seed vigor, dormancy, post-ripeness and panicle storing heat.

2. The tannic acid content in the grain of Taichung No. 5 increased to 0.275% at middough stage and down to 0.134% at full-ripened stage, while the pathogenic infection rate of seed increased to 39.4% at harvest.

3. Taichung No. 5 can be divided into four groups by its seed size. The largest seed percent was 24.9% in individual panicle. This seeds obtained high tannic acid (0.191%), low pathogenic infection rate (29.8%), and best germinability (86.5%). Unfortunately, this part decreased to 7.9% during seed processing so that the germinability was down to 54.5% in average.

4. The seed breakage including damage of testa, endosperm and embryo changed from 9.4% to 49.0%. This breakage was due to mechanical damage by using tractor and combined harvester during de-seeding process.

5. Contribution percentage computed by path analysis was evaluated for the cause of low germinability in Taichung No. 5. It indicated that seed breakage resulted from mechanical damage was the major factor to cause pathogenic infection to induce the low germinability in Taichung No. 5.

## B. Sweet Sorghum

### 1. Biomass Yield, Juice Quality and Alcohol Production of Sweet Sorghum

Cultivation of energy crops under the normal conditions to produce biomass energy is thought to be one of the important ways to develop substitute energy.

The present experiment was conducted to detect the biomass yielding capacity, juice physicochemical properties and the alcohol productivity of the selected sweet sorghum line AM-4, and to evaluate its possible value as an energy crop.

The results showed that AM-4 had the advantages of high biomass yield (44.4–46.1 t/ha), high brix value (18.2–23.2) and sucrose content (11–12%), short growth period (four months) and wide adaptability. Results from the fermentation test indicated that higher than 9% of alcohol production rate can be obtained through the juice fermentation with either *S. cerevisiac* or *Sf* yeast strain at 30°C within two days. The needed temperature can be easily achieved by the use of the abundant solar radiation in Taiwan. Therefore the input cost can be reduced considerably.

### 2. Studies on the Stalk and Grain of Sweet Sorghum for Alcohol Fermentation and Animal feed

The results showed that the sooner to squeeze the juice from the stalks of sweet sorghum after harvesting, the higher the rate of its sugar content, and the quantities of alcohol production through fermentation.

The residues of the squeezed stalks of sweet sorghum still had 3.62-7.36% crude protein and 1.77-3.01% crude fat contents. Variety Keller, for example, had 7.36% crude protein and 1.83% crude fat in the stalk residues that was still suitable to feed the cattle.

In general, the crude protein content of sweet sorghum grain was as high as 9.88%, and crude fat was above 3.33%, that were also good for animal feed.

The juice of sweet sorghum could be directly used for alcohol fermentation without adding any nutrients by *Zymomonas mobilis* B-906 and *Saccharmyces formosensis*.

### 3. Population Densities in Sweet Sorghum Cultivation

Data collected from two locations indicated that the highest stalk yield 44-46 tons/ha were obtained at the row-plant spaces of 50x10cm.

Wide space tended to have large stalk. However, narrow space gave more number of millable stalk per unit area.

### 4. Planting Date of Sweet Sorghum

This experiment was conducted to find out the optimum planting date for the spring and fall crops in central Taiwan.

The results showed that for the fall sweet sorghum, the crop should be planted before the late August, to obtain high fresh stalk yield (34,667–57,666 kg/ha), high stalk juice production (14,2000–24,249 kg/ha) and high alcohol production via fermentation. Sweet sorghum was unsuitable to grow in the spring crop season in central Taiwan.

### 5. Harvest and Squeeze Dates on Sugar Content of Sweet Sorghum

The result suggested that the optimum harvesting dates for sweet sorghum hybrid AM-4 were from milky to maturing stages. Harvested during these stages obtained a maximum brix of 12.3% and 14.7%, respectively. It also showed that the sooner to have the sweet sorghum squeezed, the more juice to be obtained. For example, 3kg of stalk could get 1.09 kg juice if squeezed in one day after harvest. However, it showed 0.48 kg reduction in juice if squeezed 12 days later.

## C. Barley

### 1. District Yield Trial of New Barley Lines

Four barley lines CB-3, CB-10, CB-15 and JB-3 were grown with two check varieties, Chung-hsin No. 1 and 2 in Shiusui, Tacheng, Longching and Taya in Taichung district. In general, Two-rowed barley (JB-3 and Chung-hsin No. 2) showed lower grain yield than the six rowed barley (CB-10, CB-15, and Chung-hsin No. 1). The former barley had less number of grains per spike. Since CB-15 had good agronomic characters with a growth period of 122 days from planting to harvest and 82cm in plant height, its yield (4,302 kg/ha) was the highest among the tested lines.

### 2. Cultural Methods for New Barley Lines

Two cultural methods combined with three seeding rate were conducted with two fold split plot design. Four new barley lines were planted at Taya, Shiusui and Erhlin. Among them, CB-15 obtained the highest grain yield. However, with 12% of protein content, it was no good for brewing. Broadcasting obtained significantly higher grain yield than the row planting. The grain yield from the plot

seeded at the rate of 90kg/ha was similar to that of 120kg/ha, but the barley from the former plots seemed to have low protein content. Therefore, for brewing purpose it should be broadcasted at the rate of 90kg/ha.

### 3. Different Genotypes and Cultural Methods on the Grain Yield and Protein Content of Barley

This experiment was designed to study the effect of 4 spring genotypes (six-rowed lines CB-15 and CB-3, two-rowed lines JB-3 and Chung Hsin No. 2), 2 sowing methods (broadcasting and row seeding) and 3 seeding densities (60kg/ha, 90kg/ha and 120kg/ha) on the grain yield and protein content of barley. A two-fold split plot design was used in the three experiment sites at Taya, Shiusui and Erhlin. The results are summarized as follows:

- 1) The results showed that the line CB-15 had the highest grain yield among the 4 genotypes, especially at Erhlin where grain yield was 4,968 kg/ha. However CB-15 was unsuitable for brewing due to its higher protein content.
- 2) As to sowing methods, broadcasting obtained significantly higher yield than rowseeding.
- 3) The grain yield was not significantly different between the two seeding densities of 90kg/ha and 120kg/ha. But broadcasting at the rate of 90kg/ha resulted in low protein content, and was good for brewing beer.

### 4. Correlation and Path Analysis of Important Characters in Spring Barley

The main purpose of this study was to find out the correlation between yield and yield components of spring barley varieties grown during the winter season in Taichung, Taiwan. These experimental materials included 31 two-rowed barley varieties and 32 six-rowed barley varieties collected from Japan, USA, Mexico and Taiwan. Seeds of barley were sown on November 14, 1979.

The coefficient of variation and simple correlation among agronomic characters of two- and six-rowed spring barley were studied separately. The grain yield and its components of spring barley were also investigated by multiple regression and path analysis.

Results of the studies indicated that the genetic behavior of cultivated barley differs in different spike types (two-row or six-row).

Tests of simple correlations showed significant negative association between heading days and grain yield in two-rowed barley. Highly significant positive

correlations were found between grain yield and fertile spikes, spike weight, number of rachis node per spike, kernels per spike and volumetric weight. Therefore, all of these characters can be used as major characters for selecting high-yielding varieties in two-rowed barley. Similarly, kernels per spike, seed fertility, volumetric weight, fertile spikes, spike weight and number of rachis node per spike were the most effective characters in the selection of high yielding varieties in six-rowed barley.

The results of multiple regression and path analysis indicated that fertile spikes, spike weight and kernels per spike are the three major factors which caused high yield in two-rowed barley, and kernels per spike, fertile spikes and volumetric weight in six-rowed barley. It seems that these characters can be used as a selection criterion in barley breeding programs.

A highly significant negative correlation was also found between grain yield and grain protein content and husk percentage in two- and six-rowed spring barley.

#### 5. Influence of Planting Dates and Planting Methods on the Yield and Quality of Brewing Barley

Two-row barley (Chung-hsing No. 2) and six-row barley (CB-15) were used to study the effects of planting dates (Oct. 25, Nov. 5 and 15) and planting methods (broadcasting, single-row drilling and double-row drilling) on the agronomic, yield and quality characters. Experiments were conducted at Fushing and Taan areas. The results of variance analysis showed that, in general, planting date had more effect on the performances of barley than planting methods. No interaction was found for the two treatments. The yield difference was not significant among the three planting methods tested. However, there was a tendency that broadcasting might increase the grain yield of barley. Planting methods did not affect the quality (e. g., protein content and 1,000-grain weight) of the grain. Neither did broadcasting show any positive effect on quality characters. The influence of planting date on yield and brewing quality varied according to variety and location. Correlations between characters showed that yield and quality of both varieties were markedly influenced by environmental factors. Lodging was suggested as a significant factor in decreasing the brewing quality of barley.

#### D. Wheat

##### 1. District Yield Trial of New Wheat Lines

Sixteen new wheat lines were evaluated in yield trial conducted at 3 locations,

Taya, Shiusui and Kuoshing in Taichung district. The results showed that grain yield of CI13-224, CI17-006, CI12-037, CI13-279 and CI13-452 were 20-48% higher than that of the check variety (Taichung wheat Sel. No. 1). Among these 16 lines, CI12-038 had outstanding agronomic characters of 82 cm in plant height, 41.3 gm of 1,000-kernel weight and a growth period of 128 days from planting to harvest.

Five wheat lines, CI11-259, CI12-206, CI12-443, VI13-434 and Taichung wheat Sel. No. 1 were selected for advanced district yield trial. CI12-443 has the good characters of 83cm in plant height, 38gm of 1,000-kernel weight, 57 days from planting to heading stage, 127 days from planting to harvest and 4,688 kg/ha of grain yield.

Although CI12-443 was highly resistant to rust and powdery mildew, it was lightly susceptible to BYDV-like disease. Since CI12-443 has good potential, it was registered as Taichung wheat Sel. No. 2 in March, 1983.

##### 2. Yield Trials of Newly Bred Wheat Varieties and Correlation Analysis of Their Agronomic Characters

This experiment showed that varied field managements resulted differently, especially the irrigation after heading. Trial at Tatsun was conducted under early planting and irrigation on time.

The result showed that correlation coefficients between yield and heading days, plant height, fertile spikes and test weight were positive and highly significant.

Trial at Shiusui was conducted under regular planting date and no-irrigation after heading. The result showed that the correlation coefficients between yield and heading days, maturing days and plant height were negative and significant. However, the correlation coefficient between yield and test weight was the same as the trial at Tatsun.

##### 3. Estimates on Heritability of $F_2$ Progeny and Selection Criterion on Reproductive Characters of Early Generation of Wheat

In order to estimate selection index for breeding, a study on the broad sense heritability of agronomic and yield component characters of 7  $F_2$  progenies crossed from 7 parents were conducted. This experiment was carried out in Taichung. The results were summarized as follows:

1). The modes of gene action on heading days and plant height appeared in near normal distribution showing polygenic-additive effect. Estimated mean of

heritabilities for both traits were highly significant with a range from 70% to 94%. Moderately high heritability for harvest index was estimated with a range from 57.9% to 64.4%.

2). The experimental results in two crosses of C111-17xW.T.S. No.1 and C111-68xW.T. No. 33 showed that the genetic effect were negative with highly significant between heading days and grain yield but positive with highly significant between flag leaf width and grain yield, 1000 kernels weight and grain yield, harvest index and grain yield. Using reproductive characters as dependent variables and other agronomic characters as independent variables, a multivariate analysis was conducted by multiple regression equation. The results indicated that the improvements of selection in kernel numbers per spike, kernel numbers per spikelet and grain yield of these two crosses were on genetic effect in  $F_2$  early generation. But the selection criterion for grain yield improvement on harvest index of these two  $F_2$  crosses, showed highly significant effect. Since high correlation existed between grain yield and harvest index, grain yield may be improved indirectly by improving harvest index.

#### 4. Grain Yield and Quality of Spring Wheat Grown in Different Years

This studies dealt with the grain yield and quality of 100 spring wheats grown over three years (1978-80) in Taichung. The results were summarized as follows:

1. Stepwise multiple regression analysis was made taking grain yield as dependent variable and other agronomic character as independent variables. The results showed that earlier heading date, higher plant height, higher grain fertility, greater kernel weight and volume weight contributed significantly to the grain yield.
2. The high positive correlations between protein and dry gluten contents as well as between dry gluten content and baking volume were observed. The baking volume is mainly determined by glutenin content in flour. Although high protein content can't fully express the high baking quality, it is still a useful selecting index in wheat breeding program.

#### E. Triticale

##### 1. District Yield Trial of Triticale Lines

A total of 11 triticales lines was involved in this experiment conducted at Taya and Hsinyi. The results were summarized as follows.

1. Taya plot was in paddy field area and Hsinyi plot in upland area. Due to

different environmental factors the characters of triticales became very different. The average heading days of triticale in Hsinyi was 20 days longer than that of Taya, and the average yield in Hsinyi (2,138 kg/ha) was 870 kg/ha higher than that of Taya. The results showed that Hsinyi was suitable for triticale.

2. T-11-196 performed the best among the 11 tested lines in both areas. Its grain yield was 2,262 kg/ha, namely 40% outyielded the check variety Taichung Yu 1. The T-11-196 was 133 days from planting to maturity and 106 cm tall. The lines may fit the winter catch crop season.

#### 2. Yield Trials of Newly Bred Triticale Varieties

This experiment showed that all the variances of agronomic characters of the crop were significant. The correlation coefficients between yield and maturing days, plant height and fertile spikes were all highly and positively significant. The average test weight and fertile rate of triticale were still low and resulted in low yield. The maturing dates of triticale were too late to fit it as a winter catch crop. So early maturity, highly fertile rate and high yield were the important characters to be improved in our triticale breeding program.

#### F. Job's Tears

##### 1. Planting Density on the Growth of Job's Tears

Low planting density in paddy field resulted in increased fertile tillers, spikelet number, grain number and unit grain yield. The plant height and total yield were not proportion to the increase of yield components. From the results of polynomial equation analysis, the optimum plant population was 125,000 plants per hectare in paddy field with respect to the highest grain yield. Under dryland conditions, it was difficult to obtain high yield by high plant density. Higher planting density resulted in poor yield, poor seed fertility and less fertile tillers per plant owing to more competitive effects. The good planting density was 50 x 20 cm or 60 x 15 cm. As far as two cultivated conditions were concerned, the job's tears was more adaptable for high planting density in paddy field than in dryland field.

##### 2. Cultural Method of Job's Tears

Job's tears grew well in paddy field. The proper time for transplanting of

seedling is 25 days after sowing for the first crop and 15 days for the second crop. Direct seeding yielded 2.24-2.87 tons/ha of grain, which was 75-87% less than that of the transplanting. This is because that the germination and seedlings of job's tears are easily damaged by the flooding during seedling stage.

## G. Buckwheat

### 1. Newly Introduced Buckwheat Varieties

Twelve exotic buckwheat varieties were introduced to Taichung DAIS. This observation trial was conducted for the investigation of their agronomic characters and yield potential. The result showed that all exotic varieties were shorter than 72.9 cm and matured 16-31 days earlier than the control, Kao-sha. The grain yields of Shi-nung 1 and Hokaido were 34.8% and 18% higher than the check variety, Kao-sha (2,055kg/ha), respectively, however, others were 15.4% to 59.2% lower than control.

### 2. Planting Dates and Furrowing Practice in Buckwheat

Experiments were conducted on Oct. 1, 1983 with a sequence of 15-day interval. The result showed that early planting induced higher grain yield for having long vegetative growth; while early flowering resulted in low grain yield when the planting date was later than Nov. 11, 1983. Kao-sha is more suitable for early planting than Feng-ten 1.

Four furrowing methods, namely: normal-tillage (NT), semitillage (ST), non-tillage with rice straw coverage (NTRS), and non-tillage with rice straw ash coverage (NTRA) were designed to identify the best cultural practice in production.

The result showed that owing to have better germination rate and more unit plants, ST practice gave higher grain yield than other practices.

## H. Edible Canna

### 1. Yield Trial of Edible Canna Varieties

Yield trial of two edible canna varieties, green leaf and red leaf were planted in two locations in Taichung area. The result showed that tuber yield seemed significantly affected by soil fertility and soil texture. In general, more canna tubers were produced from fertile soil. It caused early maturing and low tuber production

as it was grown in sandy soil. Red leaf variety produced more tuber with rich starch content as compared to green leaf variety.

Edible canna was significantly influenced by soil texture and organic matter content (OM). In general, edible canna produced 12.09%-50.47% more tuber in sandy loam with higher OM. However, as compared with green canna, red canna possessed higher yield potential under water stress condition. Besides, red canna also produced 2.3%-3.4% more starch than green canna (16.3%-17.8%).

### 2. Planting and Harvesting Dates on Tuber Yield of Edible Canna

Green and red edible canna cultivars were planted in four growth periods at one-month interval from Dec. 16, 1981. High canna tuber yield was obtained by Dec. 15, 1982. Most canna plants died before Jan. 1, 1983. It can not survive to overwinter. Besides, the new shoots produced as it was harvested on Mar. 15, 1983. The starch content of canna was affected by growth period. Higher starch content was obtained by the shorter growth period and the lowest starch content of canna was obtained on Mar. 15, 1983.

Four planting dates in combination with four harvest dates in a 15-day interval were designed to evaluate the effect of planting and harvesting dates on the tuber production of edible canna. The result showed that early planting (Dec. 16, 1983) did not help tuber yield as compared to the late planting on March 16, 1982. However, late harvest (March 15, 1983) obtained higher yield in tubers but got lower starch content than that of early harvest one. It is suggested that canna is unnecessary to be planted in winter, but harvest before the spring season is necessary.

### 3. Planting Density on Growth and Tuber Yield of Edible Canna

A yield trial consisting of six individual spaces (30, 40, 50, 60, 75, and 90cm) combined with a row distance of 60 cm was conducted at two locations. Among the six treatments, 60 x 30 resulted in higher plant height and more tillers and higher tuber yield. However, starch content was inversely correlated to tuber yield. Although dense planting treatment (60x30) produced 24.15% more tuber than that of thin planting (60x90), it reduced 2.31% starch as compared with the latter.

Soil fertility influenced the tuber production and starch content of edible canna. In general, more tubers were obtained from fertile soils and the proper planting density for canna is 60x50 or 60x60 cm. Higher planting density often caused 1-2% reduction in canna starch percentage.

#### 4. Tuber Size and Planting Depth on the Growth and Yield of Edible Canna

An experiment consisting of four tuber sizes (200, 100, 50 and 20 gm) combined with three different planting depths (10, 5 and 0 cm) was conducted at 2 locations. The results showed that the larger the tuber was planted, the higher the tuber yield was obtained. Since soil moisture was quite different in the 2 locations, it indicated that deep planting treatment (10cm) induced more tuber to germinate under water stress condition. However, there was no significant difference in starch content among the planting depths.

Big seed-tubers resulted in tall plant and higher tuber yield. Deep planting delayed the emergency of canna bud so as to decrease the tuber yield. However, tuber size and planting depth did not have significant effects on the starch content of edible canna. The better cultural method for edible canna is to select big seed-tuber and shallow planting.

#### 5. Studies on the Agronomical Characteristics of Edible Canna Tuber

Two local edible canna cultivars, i. e. green leaf variety and purple leaf variety were involved in this experiment to evaluate their differences in tuber characteristics. The results showed that purple leaf variety yielded 1205.4 gm/plant of tuber in fresh weight which was 133.0% better than that in green leaf variety. The agronomical characteristics of tuber number, tuber fresh weight, tuber moisture content and crude starch extraction rate found in purple leaf variety were 20.9/plant, 55.6 gm/tuber, 66.4% and 22.9%, respectively and those in green leaf variety were 10.0/plant, 49.9 gm/tuber, 55.7% and 13.5%. However, the better tuber germination rate (61.8%) and seedling growth rate (0.96 cm/day) found in green leaf variety seemed to be the reason why the farmers accepted it as a popular cultivar.

##### I. Soybean

##### 1. Root Activity and Photosynthetic Rate on Grain Yield of Soybean

We evaluated the relationship among root activity, photosynthetic rate and yield of soybeans. Excluding a-NA oxidizing act., P-32 absorption rate, root respiration rate and succinate dehydrogenase act. were concurrently related with the photosynthetic act. of soybean plants. Moreover, soybean cultivars with high grain yield obtained high shoot growth, while the plants passed the pod-filling stage, the growth of plant height stopped earlier before this stage. In poor yield cultivars, plant

height continuously grew, but the shoot weight stopped growing 5-10 days before pod-filling. This suggested that higher root activity in pod-filling stage of soybean plants could be a sensitive indicator for selecting a high yield variety.

##### 2. Selection Index of Effective Rhizobium Japonicum Nitrogen Metabolism of Denitrifying Rhizobia

TGP-042 is an indigenous effective rhizobia. As compared to ineffective strains, TGP-042 maintained 70% (1.17  $\mu\text{mole C}_2\text{H}_2/\text{plant/hr}$ ) of N fixing ability in 50 ppm N soil. Specific activities of nitrate reductase and nitrite reductase in TGP-042 were very active and it produced  $\text{N}_2\text{O}$  or  $\text{N}_2$  gas in anaerobic Durham tube. The available N found in the rhizosphere of nodulated soybean was reduced to 10.5-14.7 ppm. The evidence suggested that TGP-042 is a denitrifier and its effectiveness is correlated to its tryptophane/IAA conversion rate in vitro. Hereby, the antagonism between TGP-042 and combined nitrogen is deleted.

##### 3. Alkali Production and Denitrification Properties of Rhizobium Japonicum

Due to crop rotation system, soybean cultivation in Taiwan is always followed by paddy rice. Based on a five-year study, only 32.6% (8.08/24.80) of effective nodules/plant was measured in 616 localities. Since soil was immersed for about 6-7 months before soybean planting, the failed revealed low nodulation and resulted in less rhizobia population by 6,309-63,095/gm soil around the  $\text{V}_3\text{-R}_2$  developmental stage of soybean rhizosphere. Besides, acidic soil condition (pH5.6) and high residual nitrogen content (44.9ppm) were statistically significant to inhibit the nodulation.

However, a few indigenous isolates kept alkali producing ability in acidic nutrient broth (pH4.0). These rhizobia can produce more crude polysaccharide so as to shorten their lag phase when they were in acidic condition. This was the reason why pH variation in rhizosphere were usually 0.4 unit higher than that of surface soil. Moreover some isolates (30/616) with denitrification ability could still maintain certain  $\text{N}_2$  fixing ability ( $\text{C}_2\text{H}_2$  reduction ability) in 50 ppm  $\text{NO}_3\text{-N}$  soil.

##### 4. Denitrifying Rhizobium Japonicum on Soybean-Maize Cropping System and Soil Fertility

TGP-042 is an indigenous nodule bacteria (*Rhizobium japonicum*), which was isolated from Kao-Ping area of the southern Taiwan. The objectives of this study is aimed to evaluate the influences of soybean inoculation and ammonia fertilization on soybean-maize cropping system. Results are summarized as follows:

More nitrogenase activity (2.64  $\mu\text{mole C}_2\text{H}_2$  / plant / hr) was detected in Taichung 4 soybean nodules. On the basis of seedling growth and chlorophyll content, the difference was insignificant between nodulation treatment and 20 kg/ha basal N application one. According to the previous report, TGP-042 was a denitrifying bacteria, therefore, it maintained 82.2% of nitrogenase activity when 20 kg/ha basal N was applied.

TGP-042 supplied 13.8 mg per plant of biological fixed nitrogen (BFN). However, this unit plant BFN reduced to 2-2.0 mg in proportion to the increase of 20-60 kg/ha ammonia fertilizer; and 22.3-35.0 mg N per plant due to ammonia fertilization (AF) was also in parallel to the increase of ammonia application rate. This suggested that more AF stayed in shoot to induce higher vegetative growth; otherwise, more BFN in nodulated plant might be translocated to the pods.

Soil factors varied at soybean harvest, i.e. soil pH was 0.45 unit higher, organic matter was 0.52% lower,  $\text{P}_2\text{O}_5$  was 24.5 kg/ha lower and  $\text{K}_2\text{O}$  was 5.9 kg/ha higher. Soil total nitrogen in nodulated plots significantly increased for 0.02-0.05% which was consistent with 2.03-4.12 ppm of soil available nitrogen increase. The growth effect of residual nitrogen due to previous soybean crop was the same as supplying with 20 kg basal N to 20-day maize seedlings.

Based on the soil available nitrogen variation during soybean-maize cropping system, maize may absorb 13.2-33.4 kg/ha of residual nitrogen. Treatment of inoculation with TGP-042 and 20 kg/ha basal N was rather out-standing which remained 33.4 kg/ha N and yielded 3.23 ton/ha of maize grain.

Hence, the cropping system in central Taiwan may be suggested as rice-soybean-maize. Besides, inoculation with denitrifying effective rhizobia and supplying 20 kg/ha basal N for soybean planting is necessary.

### 5. Root Activity and Photosynthesis on Grain Yield of Soybeans

This experiment was conducted to evaluate the relationships among root activity, photosynthetic activity and yield of soybeans. Except a-NA oxidizing activity, P-32 absorption rate, root respiration rate and succinate dehydrogenase activity were concurrently related with the photosynthetic activity of soybean plants. Moreover, soybean cultivars with high grain yield gave high shoot-growth while plants were pod-filling and the growth of plant height stopped before this

stage. In the low grain yield cultivars, plant height continuously increased, while shoot weight stopped 5-10 days before pod-filling. It is suggested that the high root activity of soybean in pod-filling could be a reliable index for grain yield selection.

### J. Others

#### 1. Labor-saving Cultivation in Sorghum, Soybean and Corn Production

The objectives of this experiment were to find out a good cultivation practice for saving labor in sorghum, soybean and corn.

The results showed that yield and net profit of both sorghum and corn could be increased significantly by means of irrigation and fertilization during growth stages. However, as far as the net profit and labor cost were concerned, the cultural practices including non-tillage, irrigation and fertilization in sorghum; non-tillage, irrigation, fertilization and pest control in corn were the best. The studies on soybean cultivation during summer crop showed that non-tillage with fertilization but without weed and pest control may save the labor cost.

#### 2. Flooding Resistance of Tainung 351 Corn

A new high yield corn variety, Tainung 351 was released recently to provide as a substitute crop for paddy rice. Evaluation was made to study the flooding resistant ability of this variety. As compared to local varieties, Tainan 5, Tainan 11 and Tainan 16, Tainung 351 germinated well in a wide soil moisture range between 45.2% to 86.2% of maximum holding capacity (MHC) and those local varieties only showed good germination at 72.7% MHC. Tainung 351 also got 45.0% higher germination rate than others after a 2-day flooding treatment. It was found that  $\text{CaO}_2$  seed-coating could not improve the low germination caused by flooding.

However,  $\text{CaO}_2$  coated seeds reduced microorganism infection by 41.3%. While different ages of seedlings were under a 5-day flooding treatment; 10-days-old seedlings were more sensitive to water logging than the others. Flooding treatment caused the wilting of lower leaves and yellowing. In conclusion, Tainung 351 has been proved to be more resistant to water logging and was suitable as a substitute crop in paddy field than local varieties.

#### 3. Cropping Pattern Improvement for Rice Substitution Crops in Paddy Field

In order to find out an optimum rotation system for growing upland crops in paddy field, some experiments were designed to study the efficiency of six substitution crops for the 1st rice crop season and eight crops for the 2nd season on their yield and net profit.

The results indicated that job's tears was the best substitution crop for the 1st crop in paddy field due to its highest net profit, then followed by corn and sorghum. For the 2nd crop, the better substitution crops were soybean, corn and peanut. All of them gave higher net profit than rice. Therefore, in order to achieve the objective of reducing rice production and to obtain high net profit, the suggested crop rotation systems are: rice-soybean-wheat, rice-green manure-corn, rice-peanut-fallowing, and rice-sorghum-wheat.

#### **4. Studies on the Cropping Pattern Changes in Low-Yield Paddy for Dryland Food Crops**

To evaluate the possibility for changing the cropping system in lower yield area of rice, experiments were conducted in Tachia and Sensi, during the 1984 crop seasons.

The result showed that sorghum and corn are the ideal crops as a substitute for the first crop of rice in Tachia. The pattern of sorghum-sorghum (ratoon)-corn may be the best cropping system to replace rice production in this area. However, the crops used in this experiment can not replace rice crop in Sensi.