Studies on the Yield and Yield Components of Rice under Different Environmental Conditions

II. On the Relation among Leaf Age Index, Number of Tillers and the Stages of Young Panicle Development in Rice[1]

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ABSTRACTS

Four varieties of rice, Taichung 65, Chianung 242, Taichung (N) 1 and Tsaiyuan-chung were planted at Taipei and Chiayi to study the relations among young panicle length, young panicle developmental stage, leaf age index and tiller numbers so that to identify the reliable indicators for determining the time of fertilizer application. Three different methods of fertilizer application and three planting densities were used.

It was observed that in first crop at Taipei, leaf age index at the panicle neck differentiation stage was 77, that of the branch differentiation stage was 78-87, that of the spkielet differentiation stage was 84-91, and that of the end of panicle pregnancy period was 98-100. The leaf age index was considered to be a good indicator to determine the right time for top dressing of fertilizers.

When the young panicles reached branch differentiation stge (IV-VIII), the tillering reached its maximum, and approximately 5-7 days after the maximum tillering stage, the young panicle increased its length to 2-5 mm. This was considered to be a good time for “panicle fertilizer” application.

Correlation coefficient between number of tillers and young panicle length is r =0.837~0.880, that between number of tillers and growing date is r =0.443~0.521. Tiller number can also be served as an indicator to determine the developmental stages of young panicles. The maximum tillering stage was found to correspond to the leaf age index of 70 in the first crop at Taipei, and 70-80 in the first crop at Chiayi. Correlation coefficient between leaf age index and tiller number was r =0.98.

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The distance between the auricles of the flag leaf and that of the immediate lower leaf was also a good measurement to identify the different developmental stages of meiosis and young panicles, though it may vary according to varieties, planting densities and locations. The effectiveness of the splitted way of fertilization to bring about the high yield of rice was discussed.

INTRODUCTION

Increasing the rice yield has been the focus of attention by the rice growers for many years. Yield measurement is composed of number of panicles per unit area, number of grains per panicles, percentage of ripened grains, and 1000 grain weight. Among them, number of panicles per unit area or hill, and the number of grains per panicle are considered the most important to the grain yields of rice. Proper way of fertilization is known to be the most important practice to promote the four yield components.

The proper ways of fertilization involves the amount of fertilizers to be applied each time, and also the timing of fertilizer application, so that to provide the best condition for rice plant to grow. In order to attain this goal, the follwing problems should be cleared: (1) When the number of panicles is determined. (2) How to predict the number of panicles. (3) How to increase the number of panicles. (4) When and how the panicles is determined (5) How to increase the number of grains per panicle.

It is known that the panicle number is determined at the early stage of plant growth[7,10,11]. However, the grain number is determined at the young panicle formation stage which is about 20-25 days before heading[7,8,12]. Sufficient fertilizer supply before the maximum tilling stage will help to increase the number of grains per panicle [3,9,18,19]. How to facilitate identifying the stages of young panicle formation so that to determine the proper time of fertilizer application is therefore very important in the practical culture of rice.

In the previous paper, the writer[7] inentified 21 developmental stages of young panicles under different conditions of Taiwan by the method of microscopical studies. The writer[7] also found that there is a significant difference in young panicle length at each developmental stage and the length of young panicle is influenced by the interaction among spacing, varieties and fertilizer application.

It was inferred that the identifiction of the correct stages of panicle development should be based on an individual case. This is the continued research to correlate leaf age index and number of tillers to different stages of young panicle development so that to develop an easy method for determining the proper timing of fertilization.

Materials and Method

1.Varieties:

Four varieties of rice, including two of the *japonica* type, and two of the *indica* type, were used.The name characteristics of the varieties are given in Table 1.

Table 1. Varieties used in the experiment

	Name of varieties	Panicle type	Classi-fication	Growthduration (days)	
				1st crop	2nd crop
V1	Taichung 65	Panicle number	*japonica*	119	100
V2	Chianung 242	panicle weight	*japonica*	124	105
V3	Taichung (N) 1	Panicle number	*indica*	123	97
V4	Tsai-yuan-chung	Panicle weight	*indica*	116	99

2.Planting densities:

Three planting densities were used: viz.

S1 22.5× 22.5 cm 64plants/2 m^2

S2 27.0× 13.5 cm 86plants/2 m^2

S3 18.0× 18.0 cm 100plants/2 m^2

3.Methods of fertilizer application:

The fertilizer rates were respectively 100, 80, and 80 kg/ha N,P and K. Theamount of fertilizer was appliedin three ways: (1) fertilizer was applied twice, once asa basal, and another as a top dressing (F_1) at tilling stage. (2) One additional top dressing at the panicle formation stage was applied (F_2). (3) In addition to "panicle fertilizer" applied at the panicle formation stage, the fourth fertilization was made at the heading stage as "grain fertilizer" (F_3). The rate of fertilizer application is given in the following:

	Basal	Top dressing		
		Tillering stage	Panicle formation stage	Heading stage
F_1	¼N+K	¾N		
F_2	¼N+½N+½K	½N+½K	¼N	
F_3	¼N+½K	⅖N+¼K	¼N+¼K	N

4. Experimental design:

The four varieties and three spacings were respectively designed as sub-sub-plot and sub-plot, and fertilizer as the main plot. They were aranged in three replications resulting in a total of 4×3×3×3=108 plots in the whole experiwents. The size of sub-sub-plot was 1.3×2.7 m, sub-plot 2.7×5.2 m, and the main plot 5.2×1.8 m.

5. Locations: Taipei and Chiayi

Before transplanting, the main strm of each seeding was marked with ink so as to identify the plants from which the young panicle would be collected for microscopic study. Leaf age index, plant height, etc.

were examined in the field, while counting of the grain number, panicle length, panicle weight, as well as the observation of young panicle differentiation were made in the laboratory.

RESULTS

1.Relation between young panicle length and leaf age

Generally, the number of leaves increases as the plant grows, and the same is true with regards to young panicle growth[1,16]. Therefore, if there were some kinds of relation existing between the two, it would provide a convenient method for the identification of developmental stage, which in turn, would help farmers to determine the right time for the application of "panicle fertilizer".

In order to get this information, the leaf number was counted at a 7-day interval, from one week after transplanting. The coleoptile, which appears like a white film and encloses the plumule is excluded, and the leaf number is counted by taking the leaf immediately succeeding the coleptiole as the first foliage leaf, the next one as the second, and the one after the second as the third and so on,successively. The age of the plant is measured as follows: When the first foliage leaf is fully developed, the plant is recorded as age two, and so on. The time of completion or full development of a leaf is recognized by the appearance of the tip of the succeeding leaf, and when the leaf is not fully developed, the following method of counting is adopted. For instance, when the sixth leaf on the main stem of a plant is not fully developed, but has reached 30% of its full length, the plant's age is recorded as 5.3, and when it raches 70% of its full length the plant's age will be 5.7. To obtain the physiological growth stage of certain varieties for comparisons, the leaf age index is estimated. The number of leaves existing on the main stem at a particular time is divided by the total number of leaves of the main stem of the variety multiplied by 100. Accirding to this criterion, the relation between developmental stages and leaf age index is estimated and given in table2.

As indicated in Table 2. the leaf number increased rapidly during the early stage of growth, and slowed down at the later stage. Leaf age index at the panicle neck differentiation stage was 77 (1st crop, Taipei), that of the branch differentiation stage was 78-87, that of the spikelet differentiation stage was 84-91, and that of end of panicle pregnancy period (stage XX-XXI) was 98-100.

Matsushima[11,12] reported that the best time to apply the "panicle fertilizer" is the stage when the young panicle has reached the length of 2 mm young-panicle-length corresponded to the leaf age index of 88-91 in the first crop,and 88-89 in the second crop at both Taipei and Chiayi. Using the leaf age index is a good way to determine the right time for top-dressing the fertilizers.

In figures 1-4, the mean young panicle length is scattered according to the leaf age index . As seen in figures 1-4, no marked difference in young panicle length,up to leaf age index of 80 was observed.

However, at the later stage, the variations increased as the leaf age index increased. Variations differed from different crop seasons. Application of "panicle fertilizer" (F_2) at the young panicle differentiation stage tended to promote the growth of young panicles.

Table 2. Identification of developmental stages and length of young panicles by leaf age index number

	Developmental stage	1st crop		2nd crop	
		Taipei	Chiayi	Taipei	Chiayi
		L.A.I. P.L.(mm)	L.A.I. P.L.(mm)	L.A.I. P.L.(mm)	L.A.I. P.L.(mm)
Young panicle formation period(II-X11)	1. Differentiating stage of panicle neck (II-III)	77 0.16-0.17		75-77 0.13-0.20	77-79 0.15-0.22
	2. Branch differentiation stage (IV-VIII)	78-87 0.20-0.62	80-83 0.67-0.70	82-88 0.26-0.88	79-82 0.29-0.85
	a.Primary branch differentiation stage (IV-VI)	78 0.20-0.35	79 0.41-0.67	82-85 0.26-0.49	79-80 0.29-0.42
	b.Secondary branch differentiation stage (VII-VIII)	77-87 0.36-0.62	80-83 0.44-0.70	86-88 0.44-0.55	81-82 0.53-0.42
	3.Spikelet differentiation stage (IX-XII)	84-91 1.00-4.82	84-88 0.93-5.62	89-96 1.01-6.96	82-89 1.01-4.46
	a.Early stage (IX-(X))	84-87 1.00-1.33	89-91 0.93-1.18	89-91 1.01-1.35	83-84 1.01-1.44
	b.Middle stage (X-XI)	87-89 1.33-1.88	85-86 1.18-1.83	91-95 1.35-1.99	84-88 1.44-2.07
	c.Late stage (XII)	90-91 0.96-4.82	87-88 3.28-5.62	95-96 3.53-6.49	88-89 2.07-4.26
Panicle pregnancy period (XIII-XXI)	4.Pollen mother cell differen-Tiation stage (XIII)	93 4.91-5.27	89 5.26-8.50	96-98 5.97-6.96	89-90 7.53
	5.Reduction division stage of P.M.C. (XIV-XVII)	94-97	89	98-99	91-92
	6.Extine formation stage (XVII-XIX)	97-98	90-93	100	92-94
	7.Ripe pllen stage. (XX-XXI)	98-100 7.12-19.07	94-100 18.96-22.0	100 16.40-17.95	94-95 18.90-20.30

Note:L.A.I….Leaf age Index(%)

P.L……Panicle length(mm)

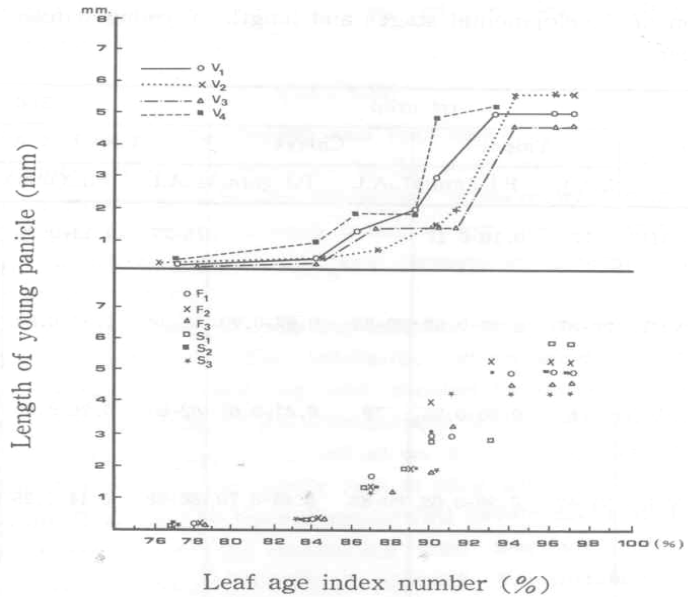

Fig. 1. Mean length of young panicles, scattered according to the leaf age index numbers (1st crop,Taipei)

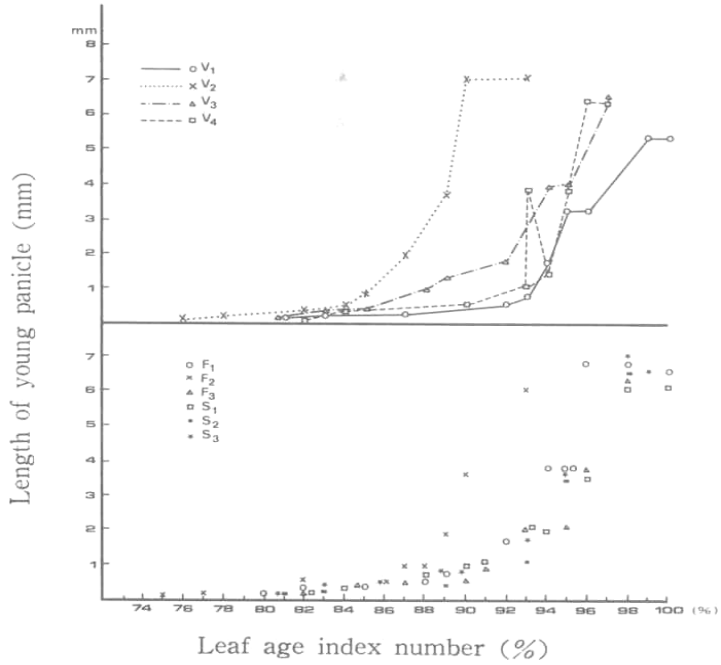

Fig. 2. Mean length of young panicles, scattered accoridng to the leaf age index numbers (2nd crop, Taipei)

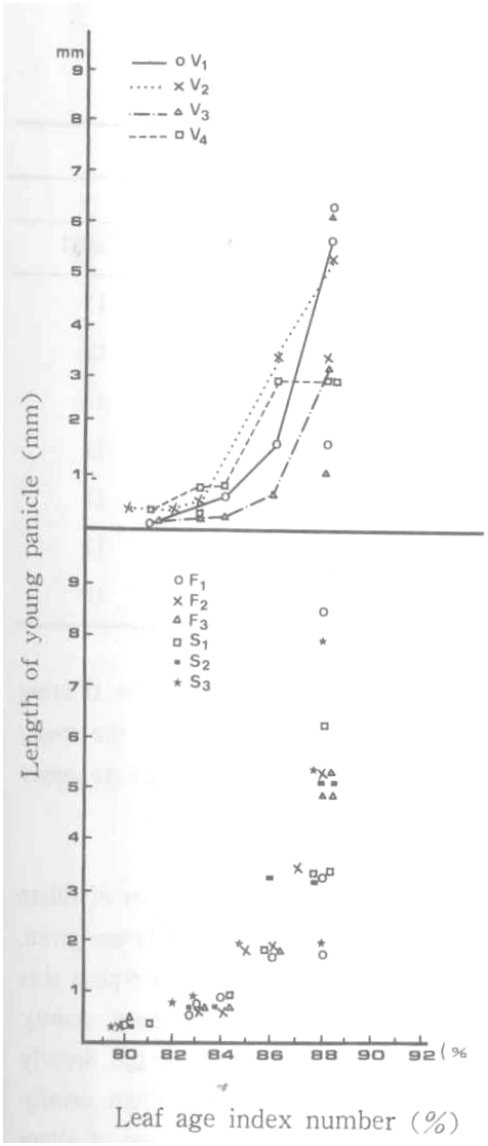

Fig. 3. Mean length of young panicles scattered according to the leaf age index numbers (1st crop,Chiayi)

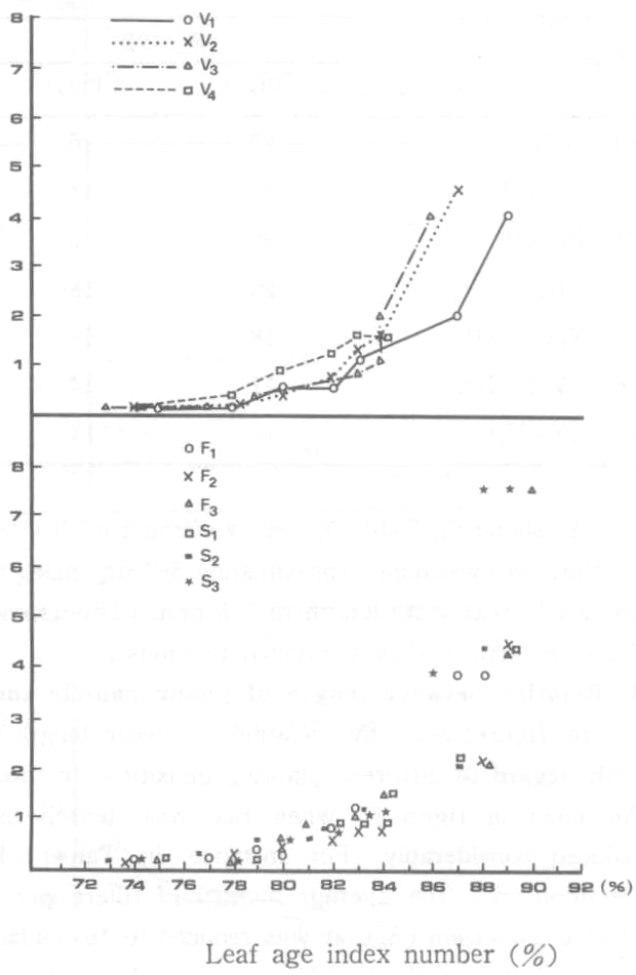

Fig. 4. Mean length of young panicles, scattered according to the leaf Age index numbers (2nd corp, Chiayi)

2. Relation between young panicle developmental stages and tiller numbers

The number of tillers is one of ther most important yield components. Generally. The tiller number increase as the plant growth proceeds, unitl it reaches the maximun tillering stage. Thereafter, the development of new tillers are rare, and the tiller number may slightly decrease due to the dying of the

underdeveloped tillers. Since the increase in the number of tillers is corredlated with the growth of young panicles, it may serve as an index of young panicle developmental stages. In order to clarify this point, the developmental stages of young panicles are coupled with the number of tillers and are shown in Table 3. The data in Table 3 are the average number of four varieties

Table 3. The tiller numbers counted at various panicle developmental stages

Developmental stages	Number of tillers			
	1st crop		2nd crop	
	Taipei	Chiayi	Taiper	Chiayi
(1) II-III	20	16	17	11
(2) IV-VIII	23	17	19	12
(3) IX-XII	22	16	19	11
(4) XIII	20	15	17	11
(5) XIV-VXII	18	14	17	11
(6) XVIII-XIX	17	14	17	11
(7) XX-XXI	17	14	17	11

As shown in Table 3, when young panicles reached the IV-VIII stages ,the tillering reached its maximum.Aproximately 5-7 day after the maximum tillering stage, the young panicle increaed its length to 2-5 mm. This is considered to be a good time to apply “Panicle ferilizers”as mentioned previously.

3.Relation between length of young panicle and number of tiller

In figures 5-7, the relations between length of young panicle and number of tillers with regard to different planting densities, fertillization methods and varieties are given As shown in figure 5, when rice vas densely planted, the tiller number per plant was reduced condiderably. For instance, in Taiper (1st crop), under the ordinary densely condition (S_1), the average number of tillers per plant was 20, While under the densely planted condition (S_3), it was reduced to 16. That produced under the medium density condition (S_2). falls in between S_1 and S_3 (18 tillers). Although the number of tillers per plant was smaller in the densely planted field, however, due to the increased hill numbers, the total number of tillers in an unit area became much larger, as it will be discusssed in the next paper.

After the maximum tillering stage, the number of tillers began to decrease rather than maintaining its maximum number conber constant due to the dying of the underdeveloped tillers. This is the case found in both crops at two locations as seen in figures 5-7. Similar phenomena was reported by Lin ([8]). The fixed tiller number stages correspond with the stages of young panicle length of 4-5 mm (1st crop, Taipei), 3-4 mm (1st crop,Chigyi); and 3-4 mm (2nd crop,Taipei)and 2-3 mm (2nd crop, Chiayi) respectively. They differed silghtly from planting densities. Corrrelation coefficient between number of tillres And young panicle length is r=0.837~0.880. That between number of tillers and growing date is r=0.443~0.521.

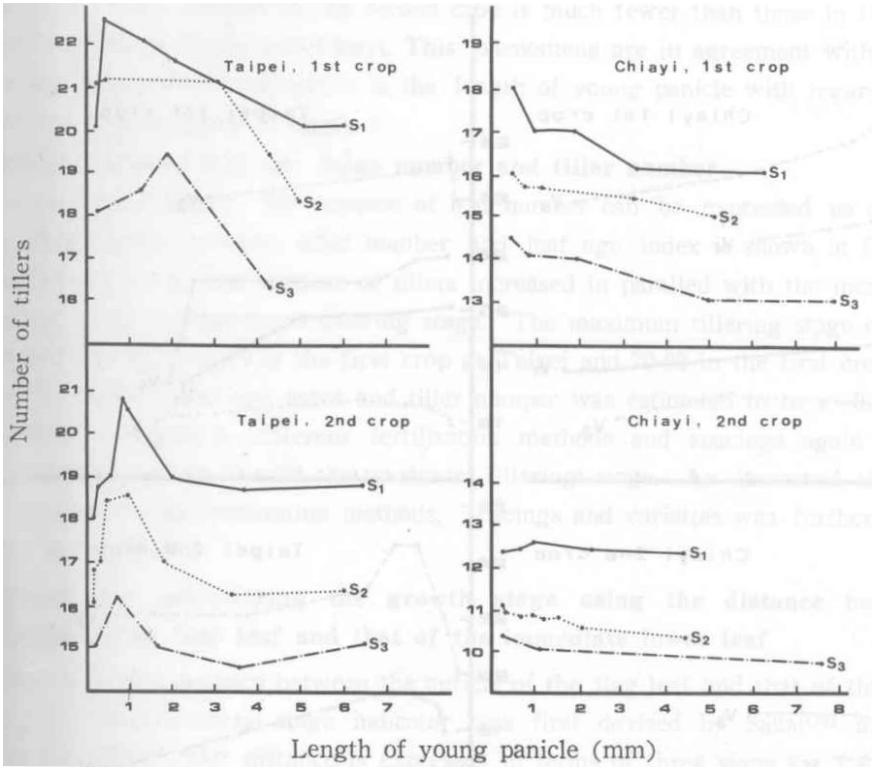

Fig . 5. Relation between length of young panicle and number of tillers, as affected by spacings.

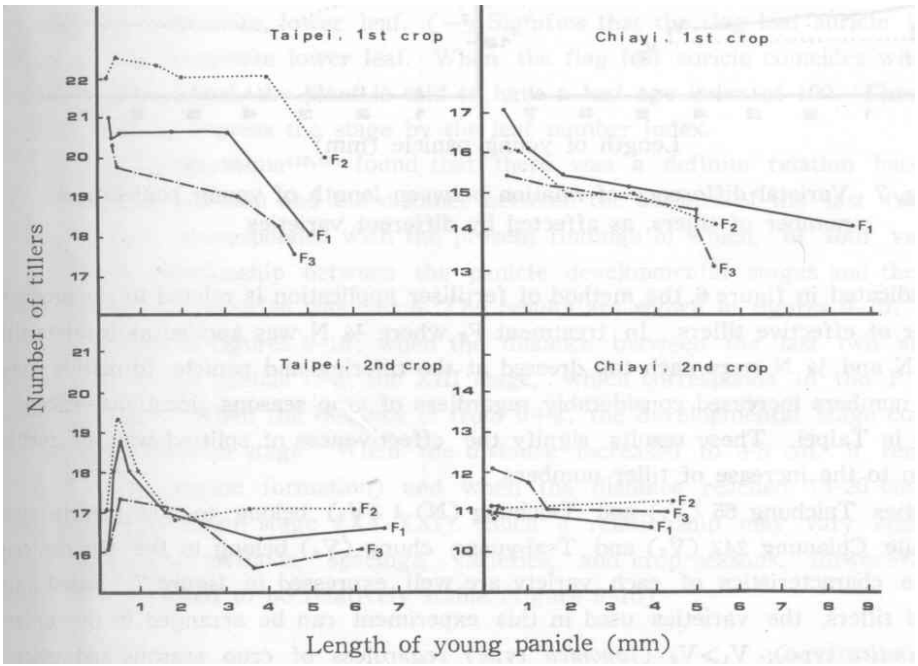

Fig. 6. Relation between length of panicles and number of tillers, as affected by the methods of fertilization.

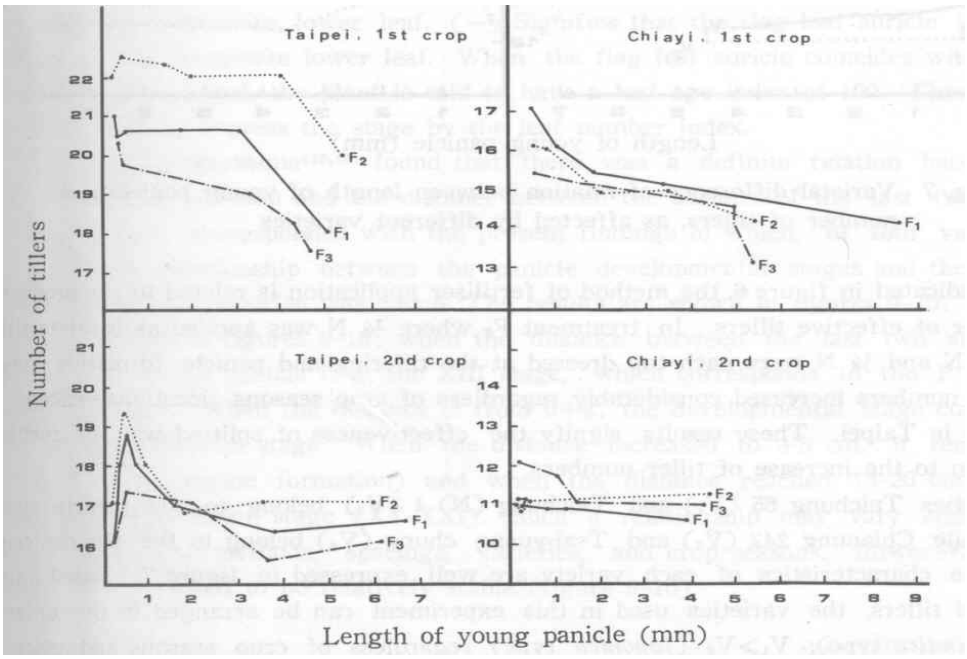

Fig. 7. Varietal difference of relation between length of young panicle and number of tillers, as affected by different varieties.

As indicated in figure 6, the method of fertilizer application is related to the production of number of effective tillers. In treatment F_2 where 1/4 N was applied as basal fertilizer

While 1/2 N and 1/4 N were each top dressed at the tillering and panicle formation stages, the tiller numbers increased considerably regardless of crop seasons, locations, except the first crop in Taipei. These results signify the effectiveness of splitted way of fertilizer application to the increase of tiller numbers.

Varieties Taichung 65 (V_1) and Taichung (N) 1 (v_3) belong to the panicle-number type, while Chianung 242 (V_2) and Tsai-yuang chung (V_4) belong to the panicle-weight type, while chianung 242 (V2) and Tsai-yuang chung (V_4) beloong to the panicle-weight type. The characteristics of each variety are well experssed in figure 7. Based on the number of tillers, the varieties used in theis experiment can be arranged in the order of V_3>V_4 (*indica* type); V_1>V_2 (*japonic*a type) regardless of crop seasons and place of growth. The mean tiller number in Taipei is greater than that in Chiayi at both first and second crops. Tiller number in the second crop is much fewer than those in the first crop at both locations in Taipei and Chiayi. This phenomena are in agreement with the reports by various authors[6,21], Difference in the length of young panicle with regard to number of tillers is also indicated in figure 7.

4. Relation between leaf age index number and tiller number

As mentioned before, the increase of leaf number can be expressed as the leaf age index . Relationship between tiller number and leaf age index is shown in figure 8. As indicated in figure 8, the number of tillers increased in paralled with the increase of leaf age index, up to the maximum tillering stage. The Maximum tillering stage corresponed to the leaf age index of 70 in the first crop at Taipei and 70-80 in the first crop at Chiayi, Correlation between leaf age index and tiller numper was estimated to be r=0.98. Further as indicated in figure 8, different fertilization methods and spacings again exert their effects on tiller numbers untile the maximum tillering stage. An increased difference in tiller numbers due to fertilization methods, spacings and varieties was further noticed at the leaf age of 80-90.

5. Methods for indentifying the growth stage using the distance between the auricles of the flag leaf and that of the immediate lower leaf

The use of the distance between the auricle of the flag leaf and that of the immediate lower leaf as developmental stage indicator was first devised by Sakai[15] and later by Matsushima[10,11,12]. The distance is experssed in terms of three signs vis. (+), (0) and (-), (+) Signifies the stage in which the flag leaf auricle has already emerged from the sheath of the immediate lower leaf. (0) signifies that the auricle of flag leaf coincides with that of the immediate lower leaf. (-) Signifies that the flag leaf auricle is still in the sheath of the immediate lower leaf. When the flag leaf auricle coincides with that of the immediate lower leaf, the plant is said to have a leaf age index of 100. Thereafter, it becomes difficult to experss the stage by the leaf number index.

Sakai[15] and Matsushima[10,12] found that there was a definite relation between the period of reduction division and the distance between the auricles of the last two leaves. Their results were corresponed with the present findings in which , of four varietes of rice, a definite relationship between the panicle developmental stages and the distance between the last two auricles was found. The results are shown in figures 9-10.

As it is showed in figures 9-10, when the distance between the last two auricles is from 0-5, the young panicle is at the XIII stage, which corresponds to the P.M.C. differentiation stage. When the distance is from 0+2, the developmental stage corresponds to the reduction division stage. When the distance increased to +5 cm, it reached the XVIII-XIX stage (extine formation)and when the distance reached 13-20 cm, it was already at the ripe pollen stage (XX-XXI). Such a relatonship may vary according to different fertilization methods, spacings, varieties, and crop seasons. However, it may generally be considered to be relatively stable(figure 9-10).

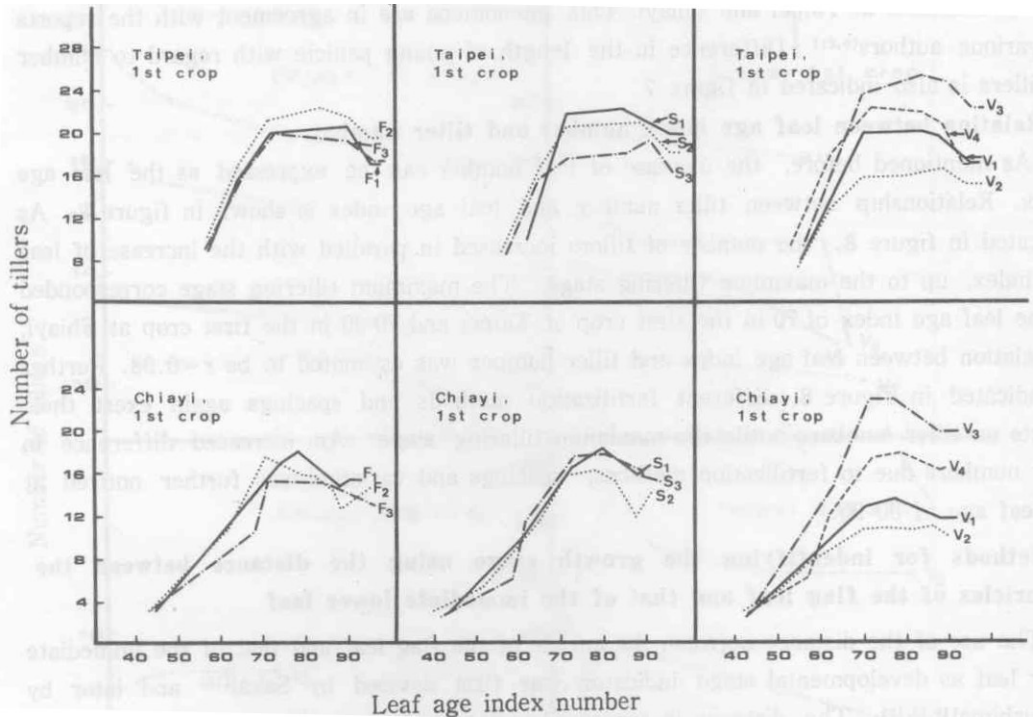

Fig. 8. Relation between leaf age index number and number of tillers.

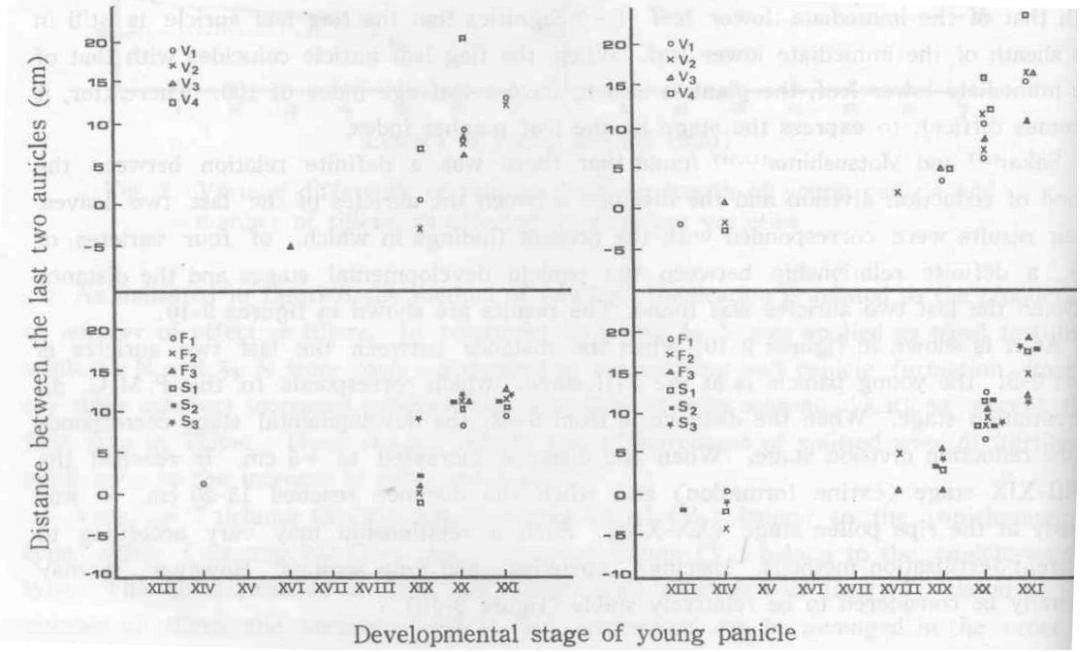

Fig. 9. Relation between distance between the last two auricles and the developmental stage of young panicle (1st and 2nd crops at Taipei).

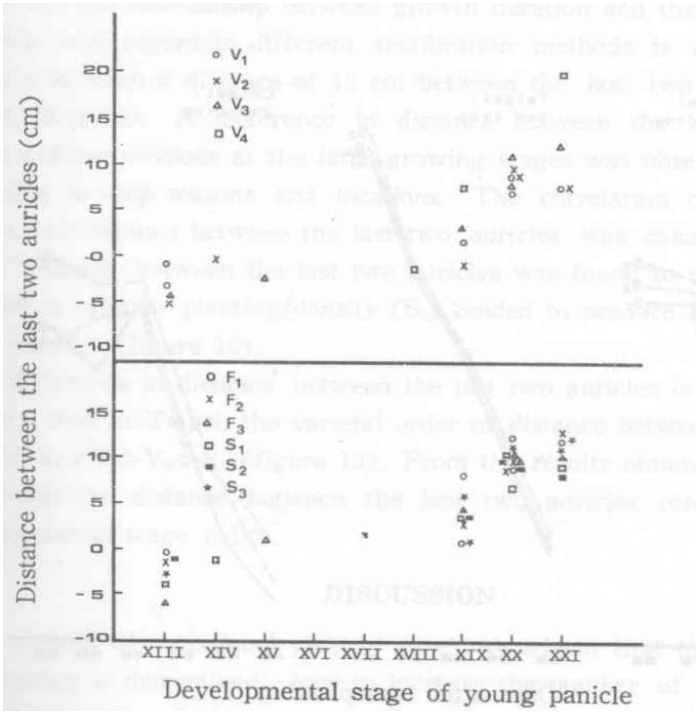

Fig. 10. Relation between distance between the last two auricles and the developmental stage of young panicle (2nd crop at Chiayi).

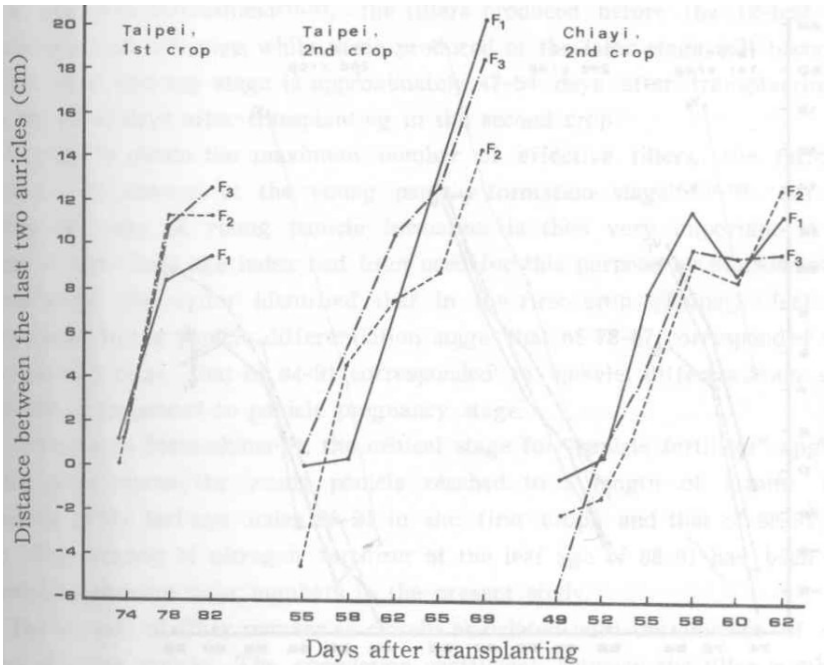

Fig. 11. Difference in relation between distance between the last two auricles and the gowth duration due to different methods of fertilizer application.

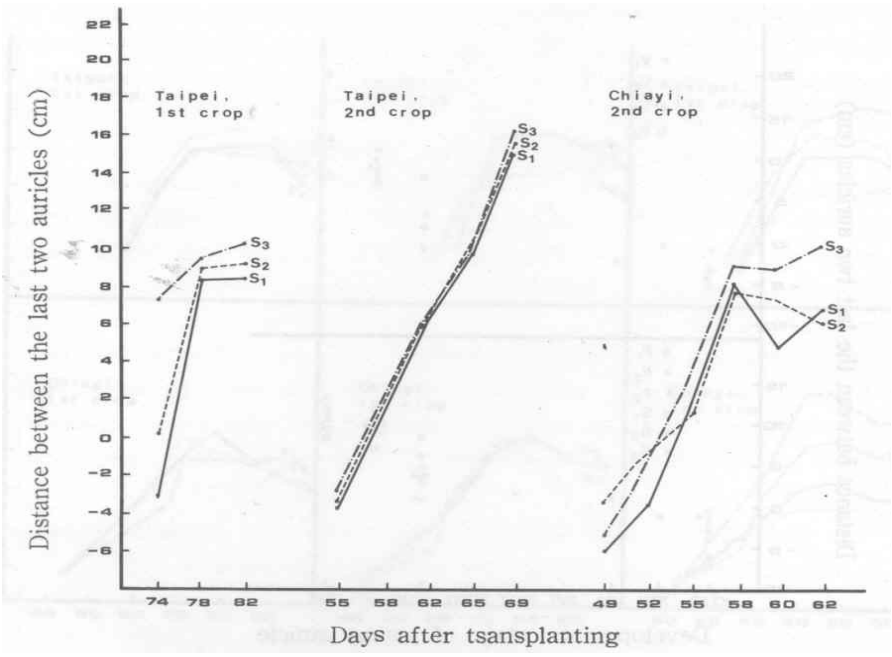

Fig. 12. Relation between distance between the last two auricles and the growth duration due to different spacing.

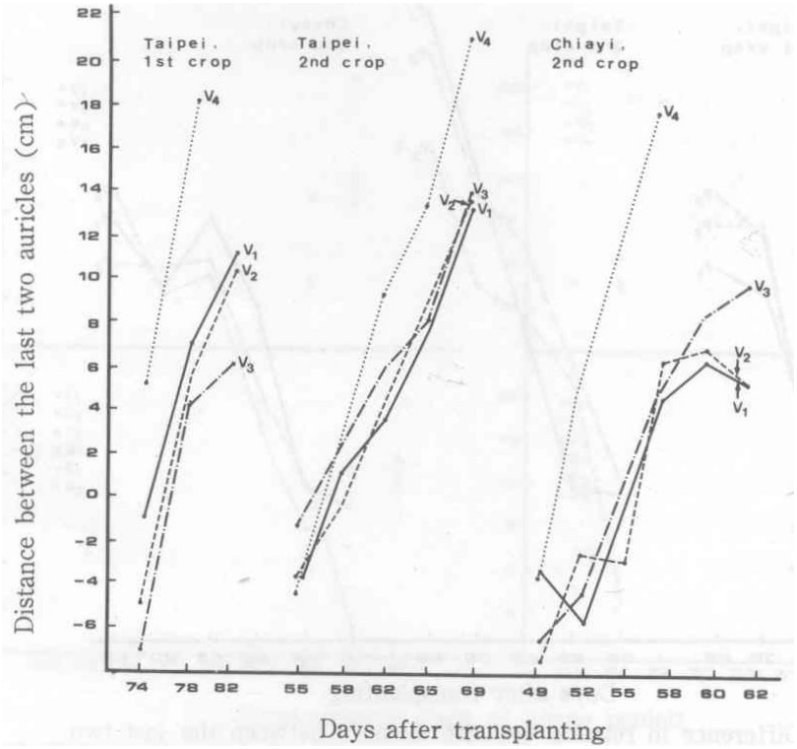

Fig. 13. Varietal difference of relation between distance between the last two auricles and growth duration.

In figure 15, the relatonship between growth duration and the distance between the last two auricle with regard to different fertilization methods is indicated. Generally. it takes 6-7 days to reach a distance of 12 cm between the last two aurcles and about 10 days to reach 18-20 cm. A difference in distance between the last two auricles due to different fertilization methods the later growing stages was obsered , but this difference varied according to crop seasons and locations. The correlation coefficient between the growing days and distance between the last two auricles was calculated to be r=0.28~0.869. The distance between the last two aurcles was found to correlate with different planting desities. Higher planting densities. Higher planting density (S_3) tended to produce longer distance between the last two auricles (figure 12).

Varietal differentce in distance between the last two auricles is guite obvious. Except in the the first crop at Taipei, the varietal order of distance between the last two auricles is arranged as $V_4>V_3>V_2>V_1$ (figure 13). From the results obtained in this study, it can be concluded that the distance between the last two auricles can be used as a definite panicle development stage index.

DISCUSSION

In order to gain the maximum yield of rice, we should first to know when and how the panicle number is determined, how to increase the number of panicles, and how to increase the number of panicles, and how to increase the number of grains. These problems were throughly investigated in this study.

According to matsushima[11,12], the tillers produced befroe the 12-leaf stage of the main tiller are all effective, while those produced at the later stage will become ineffective. The maximum tillering stage is approximately 47-54 days after trancplanting in the first crop and 33-40 days after transplanting in the second crop.

In order to obtain the maximum number of effective tillers, the nitrogen fertilizer should be top dressed at the young panicle formation stage[6,8,12,16]. An easy way to identify the stage of young panicle formation is then very improtant in the practical cultrue of rice. Leaf age index had been used for this purpose by Matsushima[12,13]. In the present study, the writer identified that in the first crop (Taipei), leaf age index 77 corresponded to the panicle differentiation stage, that of 78-87 corresponded to the branch differentiation stage, the of 84-91 corresponded to spikelet differentation stage and that of 98-100 corresponded to panicle pregnancy stage.

Acccording to Mastushima[12], the critical stage for “panicle fertilizer” application should be the stage where the young panicle reached to a length of 2 mm. This stage is equivalent to the leaf-age index 88-91

in the first crop, and that of 88-91in the second crop. Top dressing of nitrogen fertilizer at the leaf age of 88-91 has been proven to be effective to promote tiller numbers in the present study.

The increase of tiller number is closely associated with the advance of developmental stages of young panicle. The correletion coefficient between the tiller number and young panicle length is r=0.837~0.88. Approximetely 5-7 days after the maximum tillering stage, the young panicle reached its length of 2-5 mm.

Another method can be used to identify the gorwoing stages of rice plant is to measure the distance between the auricle of the flag leaf and that of the immediate lower leaf. This measurement was first used by Sakai[15] to identify the meiotic division stage of rice. Later it was applied by Matsushima[12] as an indicator for length of young panicle. This has also proven to be a good method to predict the meiotic tage and length of young panicle in this study.

The effectiveness of the splittded way of fertilization to bring about the high yield of rice had been demonstrated by many workers[2,3,4,5,16,20]. The best results were obtained when nitrogen fertilizer was top dressed at the young panicle formation stage[11, 18,19,20]. Cheng[5] also obtained the positive results in his experiment of splittted application of nitorgen fertilizr at the panicle formation stage of rice grown in both sandy loam and clay loam soils. The results of present study alll agreed with the reports by the above mentioned workers.

LITERATURE CITED

1. Akimoto S., and Y. Togari. 1939. Varietal difference in panicle formation due to different transplanting times in rice. (in Japanese) Japanese Crop Science (Nibon Sakumotsugakkai Kiji) 11:1.
2. Chiu S. M. 1968. Effect of splitted fertilizer application on the grain yield of rice (in Chinese) Jour. Taiwan Agr. Res. 17(3)L:1-6.
3. Chang W. L, and S. C. Yang. 1966. The effectiveness of splitted fetilizer applicaition, Planting densties on the yield, yield components and major agromic characters in rice III. Jour. Taiwan Agr. Res. 15(1):1-7.
4. Chang W. L. 1968. the effectiveness of splitted fertilizer application and planting densities on the yield, yield components and major agronomic characters ini rice V. (in Chinese)Jour . Taiwan Agr. Res 17(1):1-6.
5. Cheng L. H. 1969. Studies on the effect of panicle fertilizer on yield of rice. (In Chinese)Taiwan Agriculture 5(4)131-136.
6. Hsieh S. C. 1979. Differences in preformance of yield components and other characters between the first and second crop rices in Taiwan. Proceed.of symposium on the causes of low yield of the second crop rice in Taiwan and the measures for improvement . (in Chinese), pp 49-60 NSC Symposium Series No.2. Natl. Sci. Council, Taiwan, R.O.C.
7. Hsieh S. C. 1985. Studies on yield and yield components of rice under different

environmental conditions I. On the duration of flower-bud formation and young panicle development under different conditions in rice. Bull. Taichung Dis. Agr. Imp. Sta. No. 10:1-22.

8. Lin M. H. 1974. Studies on the relation among leaf age index, the stages of panicle development and number of tillers in rice. (in Chinese). Jour. Taiwan Agr. Res. 23(3). 176-187.
9. Matushima S. and Manaka T. 1953: An experiment on the method of top dressing of fertilizers based on the procedure of yield formation in rice. Agr. And hort. 34:1189-1194.
10. Matushima, S., and Manaka T.1956. The Developmental Procedure and its Diagnosis on the young Panicle of Rice. (in Japanese), pp57, published by Agriculture Technological Association, Japan.
11. Matsushime, S., and Manaka T. 1959. Analysis of developmental factors determining yield and yield prediction in lowland rice. Bull. Nat. Inst. Agr. Sci. Japan Ser. A 51-271.
12. Matushima , S., 1966, Crop Science in Rice.(In Japanese), Fuji Publishing Co., Ltd, Tokyo.
13. Matsushima, S. 1976. The Improvement of Rice Culture and Technology.(in Japanese), pp. 214-219, Yokendo. Tokyo.
14. Matsubayashi, M., T. Nomoto, R. Ito, T. Takase, and N. Yamada. 1967. Theory and Practice of Growing Rice. P. 77-89. Fuji Publishing Co. Ltd. Tokyo.
15. Sakai, K. I. 1949. on the panicel and flower development in rice with special emphasis on the cold damage susceptible stage in rice. (In Japanese), Cold region Agr. 2:4.
16. Shih, C. Y., H. Chang, and S. C. Yang. 1979. Effects of foliar application of fertilizers and growth regulators on the yield of the second crop rice. (in Chinese), Symp. Of the Causes of Low yield of the Second Crop Rice in Taiwan and the Measures for Improvement. pp155-165. NSC Symposium Series No.2 Natl. Sci. Council, Taiwan, R.O.C.
17. Terao, H., Y.Ohtani, Y. Tsuchiyi, and S. Izum. 1942. physiological studies on cold damage in rice VIII. Effect of low temperature on the young panical differentiaton, heading stages (In Japanese),Japanese Crop Science 13:3-4.
18. Tsai. W. F. 1964, Relation Between yield components and time of nitrogen fertiliazation in rice. (in Chinese), Scietific Agriculture 12:233-241.
19. Tsai, W.F.,and C.S. Chen. 1966. The young panicle formation stage and effect of nitrogen fertilizer applied at the uniform tillering stage on the grain yield and yied components in rice. Scientific Agriculture 14:53-54.
20. Tsai. W.F. 1967. Studies on the amount of potossium fertilizers needed at the young panicle formation stage in rice. (in chinese), Jour. Agr. Assoc. of China, New Series 57:72-78
21. Wu. H. P. 1974. Influence of climate and locality on rice yield difference between two crop seasons. Proceedings of Symposium on the Causes of Low Yield of the Second Crop Rice in Taiwan and the Measures for Improvement. (in Chinese), NSC Symposium Series No. 2. Natl. Science Council R.O.C. pp39-46.

不同環境下之稻產量構成要素之研究
第二報 葉齡指數及分蘗數與幼穗發育期之關係[1]

謝順景[2]

摘 要

利用臺中65號、嘉南242號、臺中在1號及菜園種四個水稻品種，分別種植於臺北及嘉義二地，並研究各品種幼穗發育期、幼穗長度、葉齡指數及分蘗數間之關係及找出決定適量施用追肥期之指標。本試驗在三種施肥法及三種栽植密度之設計下進行。

在臺北一期作稻之穗頸分化期之葉齡指數爲77、枝梗分化期爲78~87、小穗花分化期爲84~91、孕穗本期則爲98~100。本試驗結果爲葉齡指數爲決定施追肥適期之良好指標。當幼穗生長到枝梗分化期(IV-VIII期)時，即爲最高蘗期，而幼穗生長到2~5 mm最高分蘗期後5~7天時爲施用“穗肥”的良好時期。

分蘗數與幼穗長度間相關係數爲r=0.837~0.880，分蘗數與生育日數間之相關係數爲r=0.443~0.521因此分蘗數亦可做爲決定施用追肥的指標。在臺北第一期作葉齡指數70時爲最高分蘗期，在嘉義第一期作則在葉齡指數70~80時爲最高分蘗期。葉齡指數與分蘗數間之相關係數爲r=0.98。劍葉與其下葉間之葉耳長度亦認爲可做爲判定減數分發時期及幼穗發育期之指標。葉耳長度因品種栽植密度及地點不同而略受影響。最適當的時間分施肥料，可以提高稻之最高產量。

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