Jour. agric. Res. China (中華農業研究) 30(4) : 385~394 (1981)

Studies on seed production techniques of water convolvulus (*Ipomoea aquatica* Forsk.)

II. Effect of planting dates on the seed production potentiality of different cultivars of water convolvulus grown under paddy and upland fields[1]

Tsung-dao Liou[2]

Abstract : Two cultivars of water convolvulus, cv. Pingtung Green Stem(pointed leaf)and cv. White Stem (broad leaf) were planted in paddy and upland fields jn early July, August, September and October of 1978. The days of flowering after planting (DFAP) of these two cultivars indicated shortened period when planted late. They showed similar horticultural characters and seed production potentialities. Cultura l conditions (paddy or upland) did not influence flowering time, but there was difference on flowering time of these two cultivars, White Stem flowered earlier than Pingtung Green Stem. Hundred seeds weight was significantly influenced by planting dates, but not by cultural conditions. On the contrary, ave. length of each node per tiller was significantly influenced by cultural conditions, but not by planting dates. Ave. length of tiller per hill, ave. no. of nodes per tiller, no. of flowers per hill, no. of capsules per hill, straw weight, seed yield and grain/straw ratio of water convolvulus were significantly influenced by the planting dates and cultural conditions. Water convolvulus planted in upland conditions showed that the plant vigor and seed production potentiality were better than in paddy fields. Straw weight in upland culture was 6,839 kg/ha, higher than in paddy culture of 3,185 kg/ha. Seed yield was also higher in upland culture of 1,221 kg/ha than in paddy culture of 795 kg/ha. Between different planting dates, straw weight showed highest on July planting of 6,781 kg/ha and lowest on October planting of 3,352 kg/ha. However, seed yield showed highest on August planting of 1,332 kg/ha, second on July planting of 1,284 kg/ha and lowest on October planting of 553 kg/ha. The data showed that both White Stem and Pingtung Green Stem water convolvulus are more favourable for planting on upland condition in Southern Taiwan. Suitable planting dates for water convolvulus seed production culture are during late July to early August. This information may be valuable to farmers who are interested in water convolvulus seed production.

Water convolvulus (*Ipomoea aquatica* Forsk.) is a semi-aquatic vegetable, tolerant

1. Contribution No. 1017 from the Taiwan Agricultural Research Institute.
2. Assistant Horticulturist, Fengshan Tropical Horticultural Experiment Station, TARI, Fengshan City, Kaohsiung Hsien , Taiwan 830, ROC.

to heat and flooding. [3,6,7,9] It contains lot of proteins, minerals and vitamins. It is popularly cultivated by the farmers and welcome by the housewives in Southeast Asian countries, and has become a very important summer leafy vegetable in Taiwan due to its high yields, less occurrence of pest and disease, rapid growth rate and easy cultivation under high temperature, high moisture in summer tropical monsoon season. [4,5,8,11,12,13,14,15]

Water convolvulus culture in Taiwan is mainly cultivated with direct seed method whereas cutting method is subsidiary. [7,9] In accordance with statistical data, acreage of water convolvulus increased gradually each year, the case in 1978 was 3,605 hectares. [2] Therefore, more water convolvulus seeds are required each year. Various seed production method and impure water convolvulus varieties in local production area of Taiwan showed low seed yield. [1] A series approach on improvement of water convolvulus seed production techniques has become very important. This paper continued on previous research [10] for searching optimum planting dates of different cultivars of water convolvulus grown in paddy and upland conditions in Southern Taiwan.

Material and Methods

Two popular cultivars of water convolvulus, cv. Pingtung Green Stem (pointed leaf) and and cv. White Stem(broad leaf)were used. Both two cultivars were planted in paddy and upland fields with cutting methods. All cuttings were planted at experimetal farm of Fengshan Tropical Horticultural Experiment Station on July 10, August 10, September 10 and October 10 of 1978, respectively. Source of all cuttings planted in each planting dates were cut from old plants of the same nursery bed that have been seeded on June 15 of 1978. Soil texture of the experimental farm belongs to loamy soil. Both paddy and upland seed production cultures were a randomized complete block design with 4 replications. Fertilizer rate on the experiment were 20 ton/ha of compost, 200 kg/ha of nitrogen, 100 kg/ha of P_2O_5 and 200 kg/ha of K_2O. All fertillizers were applied with broadcasting method during land preparation. On paddy field land preparation was the same as rice culture. 4 m×1.4 m of bed was prepared in upland culture, however, nylon thread was used for labelling the position of the bed of the same size in paddy culture instead of making bed. Each plot contains three beds. Each bed planted 4 rows of 25 cm×25 cm distance between row and within plant hills. Each hill was planted two cuttings with 15—20 cm length. Plot size were 16.8 m^2. Acreages of each planting date were 268.8 m^2 and added 89.6 m^2 of guard row. Both paddy and upland cultivation were planted on the same time. Plant vigor and important horticurtural characters, such as the days of flowering after planting (DFAP), no. of tillers per hill, ave. length of tillers per hill, ave. no. of nodes per hill, ave. length of each node per tiller, no. of flowers per hill, no. of capsules per hill, flower drop percentage, fruit set percentage, ave. no. of seeds per capsule, 100 seeds weight, straw weight, seed yield and grain/straw ratio were recorded during experiment period. All investigation data were processed by the methods of combined analysis of variance. [16] Crop was managed in accordance with general cultivation method of water convolvulus.

Results and Discussion

I. Effects of planting dates on the vegetative growth period of different cultivars of water convolvulus grown in paddy and upland fields

Table 1 shows the days of flowering after planting (DFAP) of these two cultivars became shorten when planted late. DFAP showed that July planting was the longest and October planting the shortest. On White Stem, it needs ca. 49 days DFAP when planted in July, while, Pingtung Green Stem, needs ca. 80 days. Both White Stem and Pingtung Green Stem flowered on the following day after being planted in October, because cuttings had had flower bud when planted. Cultural conditions (paddy or upland) did not influence flowering time of these two cultivars. Difference on flowering time of these two cultivars was observed, White Stem flowered earlier than Pingtung Green Stem. Changes of flowering time and flower behavior of these two cultivars showed that water convolvulus was sensitive to day length. It might be a short day crop. How the water convolvulus flowering time responds to day length still needs future research.

Table 1. Effects of planting dates on the days of flowering after planting (DFAP) of different cultivars of water convolvulus grown under paddy and upland fields

Treatment	White Stem		Pingtung Green Stem		Difference (days)
	Date of planting	DFAP	Date of planting	DFAP	
Paddy culture	10.VII	49.0	10.VII	79.8	30.8
	10.VIII	27.5	10.VIII	51.8	24.3
	10.IX	7.0	10.IX	22.3	15.3
	10.X	1.0	10.X	1.0	0
Average (1)		21.1		38.7	17.6
Upland culture	10.VII	43.5	10.VII	78.5	35.0
	10.VIII	28.5	10.VIII	48.3	19.8
	10.IX	9.5	10.IX	22.5	13.0
	10.X	1.0	10.X	1.0	0
Average (2)		20.6		37.6	17.0
Difference (1) — (2) (days)		0.5		1.1	

II. Effects of cultivars, planting dates and cultural conditions on horticultural characters and seed production potentiality of water convolvulus

1. Comparison of horticultural characters, fruit setting and seed production potential

of White Stem and Pingtung Green Stem water convolvulus

As table 2 shows, all the horticultural characters did not vary much between these two cultivars. Positive correlation between straw weight and seed yield of thes two cultivars was found in Figure 1. The correlation coefficient of white Stem shows r=0.9830 and Pingtung Green Stem shows r=0.9470. The data showed almost the same plant vigor and seed production potentiality between these two cultivas.

Table 2. Comparison of horticultural characters, fruit setting and seed yield of two cultivars of water convolvulus.

Cultivars	Ave. No. of tiller per hill	Ave. length of tiller per hill (cm)	Ave. No. of node per tiller	Ave. length of each node per tiller (cm)	No. of flower per hill	No. of capsule per hill	Flower dropping %
White stem	7.41 a[a]	84.33 a	22.46 a	3.79 a	246.2 a	187.3 a	23.92 a
Green stem	7.84 a	83.86 a	23.71 a	3.48 a	254.5 a	197.2 a	22.51 a

Cultivars	Fruit setting %	No. of seed per capsule	100 seeds weight (%)	Straw weight (kg/ha)	Seed weight/ 16.8m² (kg)	Seed yield (kg/ha)	Grain/ straw ratio
White stem	76.08 a	3.6656 a	3.9719 a	5206.5 a	1.6414 a	977.0 a	0.1877 a
Green stem	77.49 a	3.7031 a	3.9845 a	5447.5 a	1.7457 a	1039.1 a	0.1908 a

a. Mean in a column followed by different letters are significantly different at 5% level according to Duncan's multiple range test.

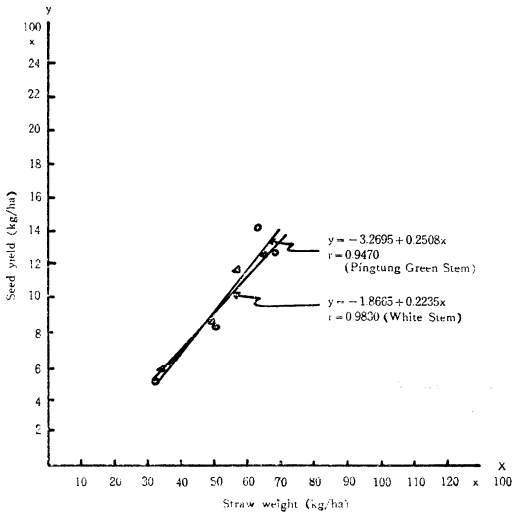


Fig. 1. Correlation between straw weight and seed yield of two cultivars of water convolvulus.

2. Effects of cultural conditions on horticultural characters, fruit setting and seed production potentiality of water convolvulus

Table 3 indicates that there are no significant difference between paddy and upland culture on some horticultural characters, such as no. of tillers per hill, flower drop percentage, fruit set percentage, no. of seeds per capsule and hundred seeds weight of

Table 3. Comparison of horticultural characters, fruit setting and seed yield of water convolvulus grown in paddy and upland fields.

Treatment	Ave. No. of tiller per hill	Ave. length of tiller per hill (cm)	Ave. No. of node per tiller	Ave. length of each node per tiller (cm)	No. of flower per hill	No. of capsule per hill	Flower dropping %
Paddy culture	7.81 a[a]	53.46 b	22.17 b	2.63 b	182.9 b	139.5 b	23.73 a
Upland culture	7.44 a	109.72 a	24.01 a	4.63 a	317.9 a	245.0 a	22.93 a

Treatment	Fruit setting %	No. of seed per capsule	100 seeds weight (g)	Straw weight (kg/ha)	Seed weight/ 16.8 m² (kg)	Seed yield (kg/ha)	Grain/ straw ratio
Paddy culture	76.27 a	3.6688 a	3.9592 a	3815.3 b	1.3351 b	794.7 b	0.2089 a
Upland culture	77.07 a	3.7000 a	3.9983 a	6838.7 a	2.0520 a	1221.4 a	0.1786 b

a. Mean in a column followed by different letters are sighifijcantly different at 5% level accordijng to Duncan's multiple range test.

water convolvulus. It showed significant difference between paddy and upland culture on ave. length of tillers per hill, ave no. of nodes per tiller, ave. length of each node per tiller, no. of flowers per hill, no. of capsules per hill and grain/straw ratio. Table 3 and

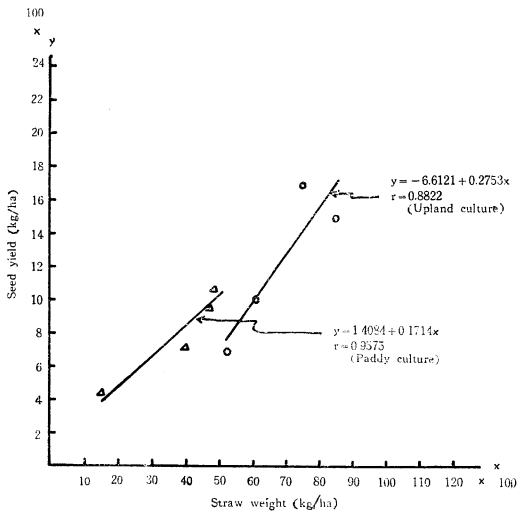


Fig. 2. Correlation between straw weight and seed yield of water convolvulus grown under paddy and upland field conditions.

Figure 2 show, in case of straw weight and seed yield, significant difference and positive correlation when it was grown under upland and paddy fields condition. The correlation coefficient was found to be r=0.8822 and r=0.9575, respectively. Straw weight in upland culture attained 6,839 kg/ha, higher than in paddy culture of 3,815 kg/ha. Seed yield also showed higher in upland culture of 1,221 kg/ha than in paddy culture of 795 kg/ha. It's clearly demonstrated, that water convolvulus seed production is more favourable for upland cultural conditions.

3. Effects of planting dates on horticultural characters, fruit setting and seed production potential of water convolvulus

Table 4. Effect of planting date on horticultural characters, fruit setting and seed yield of water convolvulus.

Date planted	Ave. No. of tiller per hill	Ave. length of tiller per hill (cm)	Ave. No. of node per tiller	Ave. length of each node per tiller (cm)	No. of flower per hill	No. of capsule per hill	Flower dropping %
10.VII.1978	7.50 a[a]	80.88 abc	25.78 a	3.14 a	233.4 bc	177.8 bc	23.81 a
10.VIII.1978	8.00 a	96.73 a	25.74 ab	3.69 a	323.4 a	258.7 a	20.01 a
10.IX.1978	7.25 a	95.19 ab	23.40 abc	4.09 a	264.6 ab	199.8 b	24.49 a
10.X.1978	7.75 a	63.57 c	17.43 d	3.60 a	180.1 c	132.8 c	26.26 a

Date planted	Fruit setting %	No. of seed per capsule	100 seeds weight (g)	Straw weight (kg/ha)	Seed weight/ 16.8m² (kg)	Seed yield (kg/ha)	Grain/ straw ratio
10.VII.1978	76.19 a	3.7375 a	3.9740 ab	6781.3 a	2.1571 ab	1284.0 ab	0.1893 ab
10.VIII.1978	79.99 a	3.6875 a	4.0909 a	6120.5 ab	2.2375 a	1331.9 a	0.2176 a
10.IX.1978	75.51 a	3.6875 a	3.9814 ab	5054.7 c	1.4506 c	863.5 c	0.1708 b
10.X.1978	73.74 a	3.6250 a	3.8666 b	3351.6 d	0.9290 d	553.0 d	0.1650 b

a. Mean in a column followed by different letters are singificantly different at 5% level according to Duncan's multiple range test.

Table 4 shows that there is no significant difference of planting dates on horticultural characters, no. of tillers per hill, ave. length of each node per tiller, flower drop percentage, fruit set percentage, no. of seed per capsule of water convolvulus. Horticultural characters, including ave. length of tiller per hill, ave. no. of nodes per tiller, no. of flowers per hill, no. of capsules per hill, hundred seeds weight, straw weight, seed yield and grain/straw ratio, showed significant differences due to planting dates. It seems that July and August planting are better ones and October planting worse. Straw weight was highest on July planting with 6,781 kg/ha and lowest on October planting with 3,352 kg/ha. Seed yield showed highest on August planting with 1,332 kg/ha, second on July planting with 1,284 kg/ha and lowest on October planting with 553 kg/ha. Since their is no significant differences between the seed yield of July planting and August

planting, we are not able to conclude whether August planting has the best straw yield for maximum seed production. The data showed that suitable planting time for water convolvulus seed production culture is during late July to early August in Southern Taiwan.

III. Vegetative growth stage factor regulating seed production potentiality of water convolvulus

Water convolvulus is a very important summer leafy vegetable in Taiwan due to its tolerance to heat, wet, boost growth rate and easy cultivation. It is also one of the higer plants which need optimum vegetative and reproductive growth for accelerating best growth and highest seed production potentiality. It flowers continuously from September to April of the following year. Seed production culture is concentrated in summer season as plants have enough time for vegetative growth for seed development after flowering. In order to find optimum planting dates for seed production, Pingtung Green Stem and White Stem were planted on July, August, September and October respectively on paddy and upland field conditions in this experiment. Figure 3 demonstrates that flowering time of water convolvulus has no apparent difference when grown under paddy and upland field conditions. But there appeared some differences within the two cultivars, White Stem flowered earlier than Pingtung Green Stem. Also revealed by this result is that different treatment of the same cultivar flowered at the same date regardless the

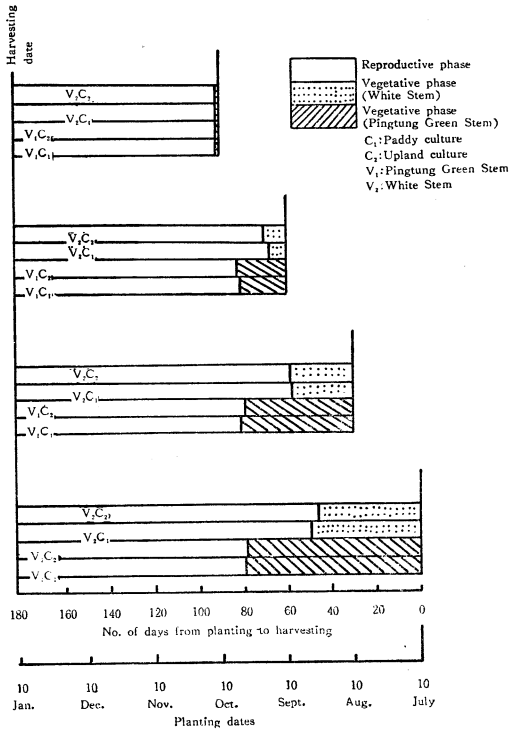


Fig. 3. Effects of planting dates on vegetative growth and reproductive growth of two cultivars of water convolvulus grown under paddy and upland fields.

planting date. It suggested that the flowering mechanism is probably controlled by photoperiod and different cultivar has different critical day length for flowering induction. However, the actual critical day length for these two cultivars is not determined by the data of this experiment. The flower inflorescene of water convolvulus is an auxillary cyeme with 3—7 flowers on each inflorescene. Flowering sequence of an inflorescence begins at lower node and continues to upper node.[10] Maturing stage of capsule on the plant does not take place at the same time due to continued flowering on elongated stem. Farmers cut whole plants when the capsules are 4/5 mature on the plants from December to early January each year. All plants were harvested on January 8th in this experiment. Seed yield of water convolvulus shows in Figure 4 has a positive correlation with straw weight and its $r=0.8839$. It indicates that higher straw weight will produce higher seed yield. Straw weight and seed yield obtained among each planting dates has been described previously. Biological yield of straw weight and seed yield varied between planting dates and cultural conditions as Figure 5 shows. Straw weight increased when planting date was postponed. It has no apparent difference between the two cultivars, but difference between cultural conditions. Upland culture attained higher straw weight than in paddy field. Seed yield is the highest on August planting. The above data shows that seed production potentiality of water convolvulus is actually regulated by the vegetative growth. Pingtung Green Stem needs more than 50 days vegetative growth and White Stem needs more than 30 days vegetative growth for acceleration of seed development. It also shown that the optimum duration for water convolvulus seed production culture in Southertn Taiwan is from late July to early August.

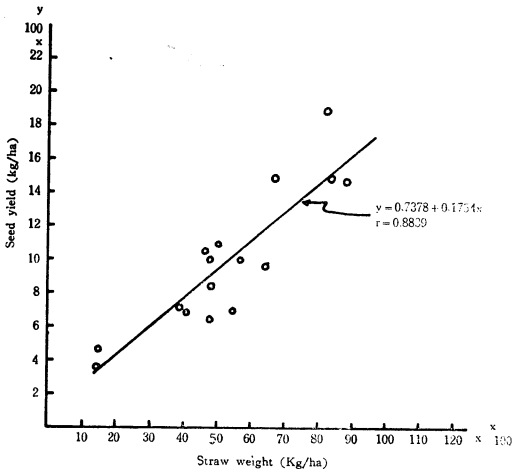


Fig. 4. Correlation between straw weight and seed yield of water convolvulus.

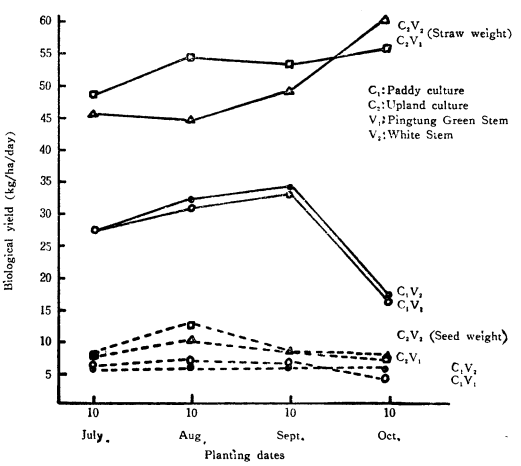


Fig. 5. Effects of planting dates on biological yield of water convolvulus grown under paddy and upland field conditions.

Acknowledgemcents : The author's thinks are due to Dr. Samson C. S. Tsou, Chemist and Program Leader of Nutrition, Environment and Management, AVRDC, Prof. M. L. Sheen, Dept. of Agronomy, NTU. Mr. T. F. Sheen, Director of the Station and Mr. C. H. Lin, Dept. head of the Station for revising the manuscript and Mr. W. C. Chao for management the field work of the experiment.

Literature Cited

1. Chen, P. C. and I. L. Chen . 1970. A study on varietal purification of water spinach of Taiwan. 14pp. Reprinted from Report No. 24. Hsinchu District Agricultural Improvement Station, Hsinchu. (In Chinese).
2. Dept. of Agriculture & Forestry, Provincial Government of Taiwan. 1979. Taiwan Agriculture Yearbook. p. 209 (In Chinese) .
3. Harry, H. E. and B. W. C. Ho. 1969 *Ipomoea aquatica* as a vegetable crop in Hong Kong. Econ. Botany 23 (1) : 32-36.
4. Huan, P. C. and S. L. Yuo. 1975. Essential of Nutritions. 273pp. Corporation Book Co., Taipei . (In Chinese).
5. Li, P. N. 1960. Studies on price inflation of summer vegetables in Taiwan. Quarterly bank of Taiwan 21 (2) : 1-26. (In Chinese).
6. Li, Y. H. 1966. Water convolvulus. Agriculture Guide. Book VIII Horticultural crops. Chapter 2 Vegetables p. 309-313. Dept. of Agriculture and Forestry, Provincial Government of Taiwan. (In Chinese).
7. Liou, T. D. 1977. Lowland cultivation of water convolvulus. Harvest Farm Magazine 27 (14) : 36. (In Chinese).
8. Liou, T. D. 1977. Studies on the response of nitrogen application to the growth and protein content of five tropical leafy vegetables. Jour. Chinese Soc. Hort. Sci. 23 (3) : 114-128. (In Chinese with English summary).
9. Liou, T. D. 1980. Water convolvulus. Vegetables Growing, Revised 3rd Edition, Harvest Farm Magazine, Taipei . (In Chinese).
10. Liou, T. D. 1980. Studies on seed production techniques of water convolvulus (*Ipomoea aquatica* Forsk.). I. Flowering habit and seed production potential of different varieties of water convolvulus grown under lowland and upland fields. Jour. Agric. Res. China 29 (4) : 251-258. (In Chinese with English summary).
11. Martin, F. W. and R. M. Ruberte. 1975. Edible leaves of the tropics. Mayaguez Institute of Tropical Agriculture, Mayaguez, Puerto Rico. 235pp.
12. Martin, F. W. and R. M. Ruberte. 1978. Survival and subsistence in the tropics. Antillian College Press. Mayaguez, Puerto Rico. 243pp.
13. Ortaliza, I. C., I. F. Del. Resarie, M. M. Caedo and A. P. Alcaraz. 1971. The availability of carotene in some Philippine vegetables. Philippine Jour. of Sci. 98 (2) : 123-131.
14. Schmidt, D. R. 1971. Comparative yields and composition of eight tropical leafy vegetable grown at two fertility levels. Agronomy Journal 63 (4) : 546-550.
15. Schmidt, D. R., H. A. MacDonald and F. E. Brockman. 1971. Oxalate and nitrate contents of four tropical leafy vegetables grown at two soil fertility levels. Agronomy Journal 63 (4) : 559 -561.
16. Sheen, M. L. 1980. Combined Analysis of Variance. 13pp. Dept. of Agronomy, NTU. (In Chinese).

蕹種子生產改進技術之研究

Ⅱ. 種植時期與栽培方式對不同品種蕹菜種子生產力之影響[1]

劉 政 道[2]

摘 要

屏東青骨尖葉蕹菜與白骨大葉蕹菜分別於 7 、 8 、 9 及 10 月種植於水田與旱田不同之栽培生育環境中，這兩品種蕹菜除開花時間隨種植時期之延緩而縮短到達開花所需之日數外，其餘各項園藝性狀與種子生產潛力幾乎相似， 7 月份種植者到達開花所需之日數，白骨蕹菜約爲 49 天，青骨蕹菜約爲 80 天，而 10 月份種植者因爲插植時插穗已帶有花蕾，於種植後翌日即開花，栽培環境對兩品種蕹菜之開花時間幾乎沒有影響，但品種間則有差異，白骨蕹菜比青骨蕹菜較早開花。蕹菜之每欉分蘖數、落花率、結實率、蒴果種子數等受種植時期與栽培環境之影響不顯著，種子百粒重受栽培環境之影響不顯著而受種植時期之影響顯著，平均分蘖節間長度受種植時期之影響不顯著而受栽培環境之影響顯著，蕹菜之每欉分蘖長度、平均分蘖節數、每欉花數、每欉蒴果數、藁重、種子產量與種子／藁比等均顯著的受種植時期與栽培環境影響，旱田栽培之蕹菜生育與種子產量均比水田栽培者佳，旱田栽培之藁重每公頃高達 6,839 kg，幾乎爲水田栽培 3,815 kg 之兩倍。種子產量亦以旱田栽培之每公頃 1,221 kg 比水栽培之 795 kg 爲多。各種植時期中以 7 月份種植之藁重最多 ， 每公頃高達 6,781 kg， 10 月份種植者最低，每公頃僅 3,352 kg 而已。種子產量以 8 月份種植之每公頃 1,332 kg 最多， 7 月份種植之 1,284 kg 次之， 10 月份種植之 553 kg 最少。由此試驗結果顯示，在臺灣南部地區蕹菜採種栽培無論青骨蕹菜或白骨蕹菜均以採用旱田栽培爲宜，其最適當之種植時期應爲 7 月下旬至 8 月上旬，可爲農民蕹菜採種栽培之依據與學術研究之參考。

1. 臺灣省農業試驗所 研究報告 第 1017 號。本文承蒙亞洲蔬菜研究中心鄒博士篤生、國立臺灣大學農藝系沈副教授明來、沈分所長再發斧正，林主任昭雄賜閱，趙文慶先生協助，特此深致謝忱。

2. 本所鳳山熱帶園藝試驗分所助理研究員。臺灣省 鳳山市。