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中国紫菜养殖*

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摘　要

中国养殖紫菜,在目前,主要是群众性廉式养殖坛紫菜 *P. haitanensis* 和条斑紫菜 *P. yezoensis*。其养殖可分为两个阶段:首先,在室内培养、促熟壳斑藻 *conchocelis* 和全人工采壳孢子 *conchospore* 苗(坛紫菜通常用喷壳孢子水法);然后,在潮间带进行半浮动筏(篦)式养成。

关键词:

坛紫菜,条斑紫菜,壳斑藻培养,喷(泼)壳孢子水,人工采壳孢子苗,半浮动筏式养成。

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CULTIVATION OF PORPHYRA* IN CHINA

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Abstract

In China the cultivation of *Porphyra*, mainly *P. haitanensis* and *P. yezoensis*, is now being carried on popularly by screen. It can be divided two stages: first, the conchocelis culture, the promotion to be mature and the all artifical conchospore－collecting are all done indoors (the way of spraying (splashing) conchospore water is more usually used for *P. haitanensis*). Then the semi－floating raft screen cultivating is carried on the intidal zone.

Key Words:

Porphyra haitanensis, *P. yezoensis*, conchocelis culture, spraying (splashing) conchospores water, all artificial conchospore－collecing, semi－floating raft cultivation.

Introduction

The taste of *Porphyra* is delicious and the nutrition is rich. Since the ancient time, we, the Chinese people have loved to eat Porphyra. Early in North Wei dynasty, a kind of cooking and eating method of "Gau Jian zhicai"(*Porphyra* being fried by oil)was recorded in books[5]." In Song Daynasty (A. D. 906－1279) , Porphyra had already become a sort of local goods in Haitan Island of Fujian province and selected as a precious product in the local district for presenting to the emperor annually" [3]. This means that about one thousand years ago the people had already come to regard *Porphyra* as a kind of palace delicacy. In the recent years, as

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the studying progress of abstracting phycocolloid, in 1985the market for *porphyra* production in Fujian Province has been expanded by the agar (J, 1986) produce in the last *P. haitanensis*. The economic beneficial result has been raised obviously.

In 1949, when K. M Drew discovered the life-history of *Porphyra*, the Chinese phycologist began to devote themselves to the study of the artificial *Porphyra* cultivation in 1950s. [2][3][4][5][6][7][8] During the period of 1960s they had overcome a most serious difficulty on the artificial cultivation of *P. haitanensis*, popularized rapidly the development of the modern mass cultivation in a large scale[17] and developed the artificial cultivation of *P. yezoensis*[3].

With the method of the artificial cultivation by screen, the *P. haitanensis* is cultivated in the south od Yangtze River, and in the north P. yezoensis. In addition, in Shantou of Guangdong Province a small quantity of *P. guangdongensis* [31][32] as well as in Penhu County of Taiwan Province *P. anguata* are also cultivated [8][12]. Now in China 2700 m^2 of the screen area is equivalent to 1 hectare. In 1988 all the artificial cultivation by screen accounted for littoral farms about 64745 ha. The size of screen covers cultivating area 25-27% or so. Thorough artificial *Porphyra* cultivation by the screen in China is owing to the different species in various regions. The yield per unit area also makes a great difference. It listed as follows:

Tablel: The porphyra output of unit and area in different regions on the artificial porphyra cultivation by net-screening in China

Locality	Species	Yield (t dry wt ha^{-1})	Year	Remarks
North, Guangdong			1986	Fish. Bur. shantou
South, Fujian	*P. haitanensis*	1.50 —— 2.25	1986	Fish. Dep.
North, Zhejiang			1980	Lin, etc.
North, Fujian			1986	Fish. Dep.
	P. haitanensis	2.25 —— 3.00		
South, Zhejiang			1980	Lin, etc.
Nantong, Jiangsu	*P. yezoensis*	1.13 —— 1.50	1986	Gu, etc.
Penhu, Taiwan	*P. angusta*	1	1986	Lin

From the table 1 we may see that the *Porphyra* thalli of *P. haitonensis* is fat and big, grows fast, yields high, and especially its output is the highest in the more appropriate water temperature in the northern part of Fujian Province and in the southern part of Zhejiang Province. The yield of the abundant field reaches 3.00-3.75 t ha^{-1} of dried *Porphyra* products (Fish. Dep. Fujian, 1988). In the north of Zhejiang Province the water temperature is lower and in the south of Fujian Province and in the north of Guangdong Province the water temperature is higher, the output all decreases. In Jiangsu Province the thalli of *P. yezoensis* is

thin and tendor, grows slowly and the output is lower. Only the abundant field reaches 1.88－2.25t/ha of dry *Porphyra* products [10][11][13]. But the P. *angusta* yield in Penhu County of Taiwan Province is the lowest.

In 1988, with the method of all the artificial *Porphyra* cultivation by semi－floating raft screen net the total yield of the dry Porphyra products reaches 16498.5 t, one ton cost U. S. 4,000,the value of it goes to U. S. 65,994,000. Among which the yield of the *P. haitanensis* covers more than 95.5%, but 78.1% of *P. haitanensis* was produced in Fujian province.

The life－history of *Porphyra* is a kind of heterogeneraae alternaion, the red alga. The filamentous sporaphytic phase, or conchocelis phase is the seedling cultivated to take plase indoors by manpower, the leafy thalli gametophyte phase is the object of the sea cultivation. They demand different cultivation conditions, skills and techniques. The following account is the Chinese largescale cultivation:

1.Indoor cultivation of the filamentous conchocelis

I. The substrate and tank of the cultivating for the filamentous conchocelis

Along Fujian coast, where mass *P. haitanensis* cultivation is greatly developed, each pro-

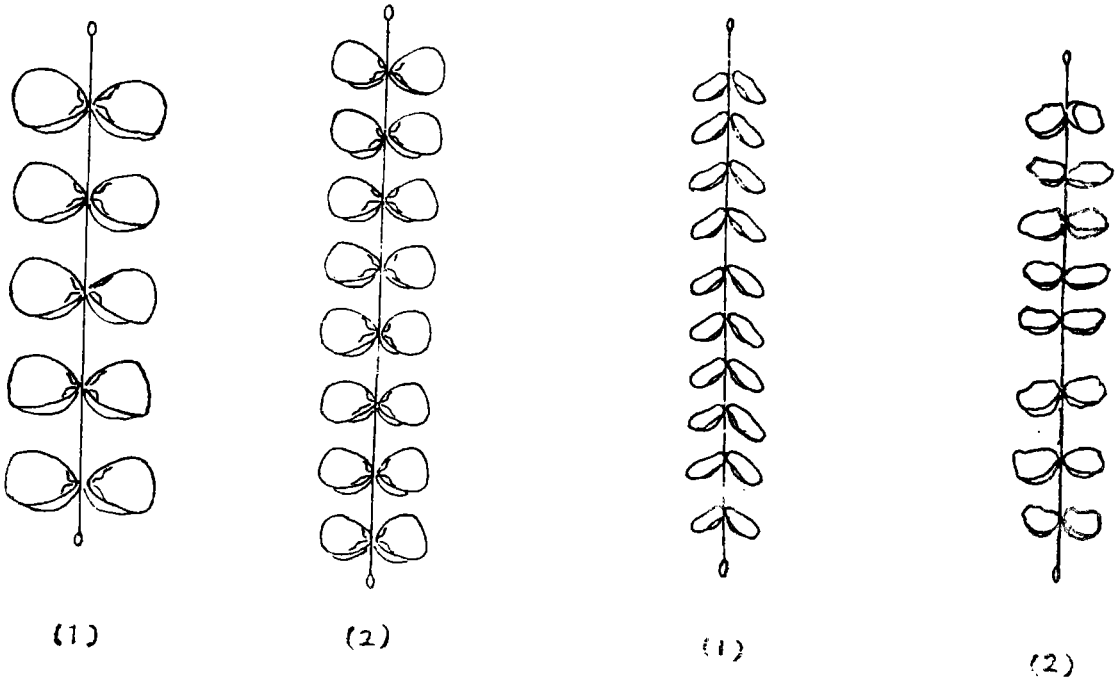
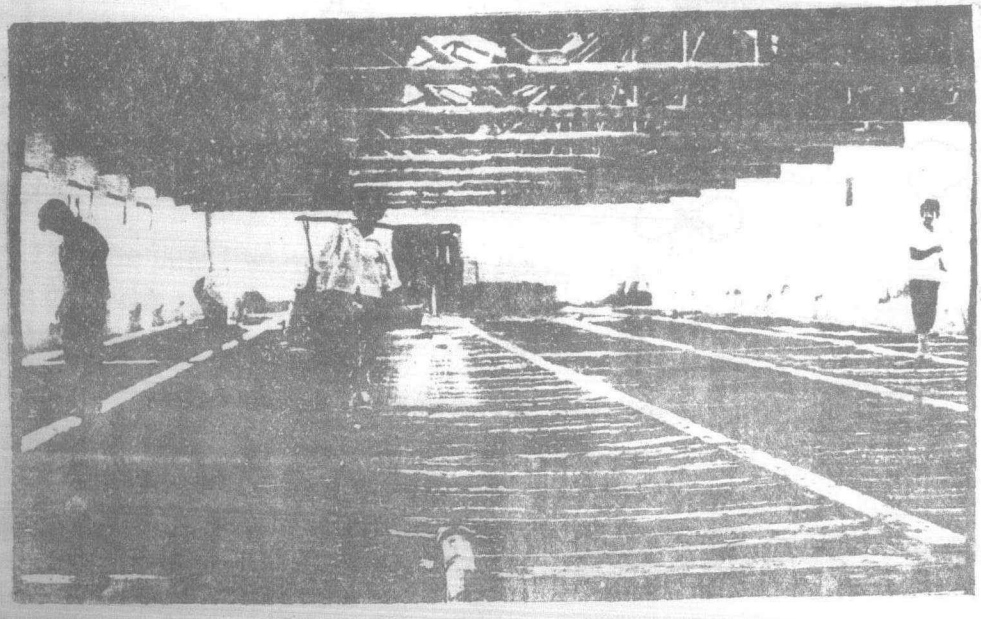


Fig 1－2 Stereoscopically cultivating filamentous shell string.
(1) big Meretrix meretrix shells string, 5 pairs and 30 cm in length
(2) small Meretrix meretrix shells string, 8 pairs and 35 cm in length
(3) ostrea plicatula epi－shells string, 10 pairs and 35 cm in length
(4) ostrea plicatula hypo－shells string, 8 pairs and 35 cm in length

duction brigades has its own conchocelis cultivating rooms, which get light mainly from side windows and subordinately from skylight. The large elongated shallow concrete cultivating tanks are about 1.5−2 metres wide and 0.5−0.7 metres deep (figs 3,4). The cultivating substrata are mostly made from the *Meretrix meretrix* shell. *Ostrea plicatula* shells are less used. Before being used, the shells should properly treated and disinfected cleanly. A hole is made on the top of the shell. There are also holes made in the middle of the side margin of *Ostrea* hypo−shell. and in the light of the big, middle and small difference they are strung with nylon silk in pairs every 5−8 cm. for the M. meretrix, 5−8 pairs each string (Fig. 1(1)(2)). *O. plicatula*, 8−10 pairs each (Fig. 2 (1)(2)) [2] [29]. Figs 1−3

(1)



(2)

Fig. 3 Stereoscopically harvesting *porphyra haitanensis* conchospores seedlings by: (1) combining the shell strings together, adding 80% water carpospores and getting it well mixed up, (2) After arranging the shell strings well, you spraying 20% water carpospores to make it well even and clear. And the adherent seedlings are growing evenly. (Photo by lin Y. s.)

II. The collection of carpospores seedlings

Generally speaking, in Fujian Province the seedlings are gathered in February, March and closed in early April or so. Carpospores seedlings are gathered from fine fresh strain *Porphyra* or frozen strain *Porphyra* chosen in the peak growing season. The mature thalli can spread out about $(1-2)\times10^5$ carpospores in each square cm carposporangium. The spreading, the collecting and the cultivating of carpospore are carried on in the dark sedimentation normal seawater which has been previously subjected to the dark sedimentation in the tank for at least three days or preferably seven days[17].

Gathering the carpospore seedlings demands $(1-2)\times10^2$ germling bodies cm^{-2} *Meretrix* shell[17], and $(5-6)\times10^2$ germling bodies cm^{-2} *Ostrea* shell[20]. The method of stereoscopically gathering seedlings is generally carried on according to the density of the carpospore in the concrete tank water, the water should go up to 4－5 cm above the upmost pair of shells. With *Meretrix* shell the density is about $91-2)\times10^2$ carpospores ml^{-1}. With *Ostrea* shell the density is about $(0.5-1)\times10^3$ carpospore ml^{-1} [20]. The small bamboo stickes with hanging shells strings should be *properly* pressed closer. First put 80% of all the carpospore into the tank, then, stir the carpospore in the water to even with a bamboo pole (Fig. 3(1)) and then put the small bamboo stickes with shells string in order. Finally, the left 20% of carpospore fluid should be sprayed (Fig. 3,(2)) evenly into the whole concrete tanks with a spraying pot, and make the density of the adherent seedlings growing on the upper and lower shells be more unifier. The two tanks of shells may also be merged into one to gather the carpospore seedlings, and divided again after the carpospores germinates to penetrate into the shell[2].

When gathering the carpospores seedlings, the light must be ensured enough, regulated to 3000 lux or for about one week. After the carpospores germinated and penetrated into the shell, you may wash the shell, change the water, and turn it upside down.

III. Cultivation, management and maturity promoted for the filamentous conchocelis of *P. haitanensis*

To cultivate the filamentous conchocelis of *P. haitanensis* is a kind of mass cultivation. According to the difference of stage growing and developing conditions, at the natural temperature, regulating the light intensity and light period being controlled by a series of screens added by the fertilizer NO_3-N, PO_4-P of the different concentration and proportion, and planner to cultivate it on the 8th September or so, the filamentous conchocelis of *P. haitanensis*

will produce the maximal number of conchospores and be concentrated on matureness.

The shells are cleaned with very soft brushes. The culture seawater should be changed, the string of shells should be inverted up and down, and their position should be changed from one place to another. Those pieces of work may be carried out for once in half a month or one month (Fig. 4). In addition, the shells must be kept in clean and safety so as to make them into growth in accordance with their development.

Three stages are recognized: the first stage is the growing stage of the filamentous conchocelis, that is from the middle of February to early June the water temperature gradually rises from 13－16 ℃, and also the period for the active vegetation of the filamentous conchocelis. In this period light intensity is controlled at about 3,000 Lux early and gradually decreases down to 2,000 Lux in the middle of the fine day. And nitrogen (NO_3－N 5～10 PPM) and phosphorus (PO_4 － P 0.5 ～ 2 PPM) are mainly added in coordination with nutrients. Among them the nitrogen is first. The second stage is about from early June to the end of July or the beginning of August. In this period the water temperature rises from 23 ～ 26℃ to 27～29 ℃, and then a bit later gradually declines. This is the critical period for conchosporangial production, and the success or failure to obtain a good crop of conchospores depends on the correct handling of the light factor. The principle is to enhance the accumulation of the necessary reserves for conchosporangial formation but to delay the actual formation of the conchosporangial before the peak of the high temperature. After the peak and with the temperature dropping, the formation of conchosporangial should be promoted (encouraged). In this period it lowers the highest light intensity about 1,200 to 500 Lux and adds the nutrients to increasing to NO_3－N 10～15PPM, PO_4－P 2～5PPM. And the third stage is from the end of July or the beginning of August to the early September. During the period,since the middle August the water temperature has gradually dropped to about 28～25℃. This is the period of conchosporangial formation to promote the formation of conchospores. In the final period, in order to further lower the highest light intensity to about 500～800 Lux, and simultaneously we may use shading screens to reduce the light period to 8～10 hours per day. In thenutrients the phosphorus becomes the main matter. During this period (PO_4－P) and the concentration is increased to 10～15 PPM. Nitrogen (NO_3－N) decreases 2～5 PPM or does not increase at all, so as to produce the maximal number of conchosporangia and conchospores[10][17][29]. And in connection with the running water to promote its maturation, the result is even better.

In addition, in Longhai county of Fujian Province, there is a productive cultivation of free－living filaments of *P. haitanensis* on a small scale. The time of its collecting carpospores is the same as the shell filamentous conchocelis above mentioned. The density of carpospores is put in the 800 ml volume of the steamed and sterilized glass pots with $3X10^4$ carpospores. The cultivation of free－living filament uses the sea water which has been filtered out normally and cooled off gradually after being sterilized by 70 ～ 85 ℃ and is furthermore added by the nutritive salt. Cultivation should be mastered as shown in the below:

The light intensity and nutrition in the different stage of growth and development of the free-living filamentous conchocelis culture

Table 2 (from Chen, 1980).

Stage of growth and development	time	light intensity (L_x)	enriching the cultivation seawater (PPM)				change time and volume of culti vating seawater
			KNO_3-N	KH_2PO_4-P	$FeSO_4$-Fe	V_{12}	
Growth of the algal fila ments	Feb. – July	1000 – 2000	11.0	2.25	1.0	0.1	one or two months change a half volume of the cultivating seawater
Formation of the conchosporangial branchlets	early Aug. – late Sept.	2000 – 3000	5.0	5.0	2.0	0.1	Change a half volume of the cultivating seawater per month

In Putian County of Fujian Province, the later free-living filamentous conchocelis cultivation (July to September) has got better results by using less than 1000 Lux, the promoting mature stimulated andspreading in the sea [21].

The proper light intensity and light period of growth and development for the *P. yezoensis* is similar to the *P. haitanensis*. The proper-water-temperature is the same as the growing period of alga filaments [4] [17], but it is lower than the *P. haitanensis* as the formation of the branchlets and the conchospores is separately 20~ 25 ℃ and 15~ 20 ℃ [22]. So far as the cultivation is concerned, *the P. yezoensis* enriching the cultivation seawater NO_3—N14 PPM and PO_4—P 3.1 PPM has been satisfied [4]. Therefore in Qidong Country of Jiangsu Province and other places, the cultivation of conchocelis is chiefly made on the plan contralizing the light through the opening of skylight, and gathering carpospores seedlings is at the time from the early May to late May on shells of the mollusc *M. mertrix* at a density of $(2-3)X10^2$ carpospores cm^{-2} shell [4]. In the light of growth and development the P. yeszoenis will centralizingly be ripened into maturity in the late September and the conchospores seedlings will be gathered. In Rudong County of Jiangsu Province this method had been taken, When gathering seedlings, adjusting the light intensity once more should be about 1500 Lux. And later it won't change the light intensity and light period, work out cultivating, centralizingly ripening into maturity and the result being good (Lee & Zheng, 1980).

2.Artificial collection of conchospores seedlings

The development of *Porphyra* cultivation in China has gone through the naturally

gathering conchospore seedlings, semi－artificial gathering conchospore seedlings, all－artificial indoor gathering conchospore seedlings, and mass sprinkling(splashing) conchospores water on the surface of the sea gathering conchospore seedlings. The latter has been popularly adopted, at present in Fujian and Zhejiang Province, in production of *P. haitanensis*. The all－artificial indoor gathering conchosoores seedlings is the main method used for production of *P. yezoensis* in Jiangsu Province and the other places.

In Fujian Province gathering the conchopores seedlings of *P. haitanensis* is under the water temperature and further to 28 ℃ below. It begins from 8th September. The duration of spring tide in the second ten days of September is the main period of gathering the conchospores seedlings. And its end will be in the last ten days of September. Because the monospore seedlings do not very obviously add, the density of conchospore seedlings should do harvest enough once. The conchocelis well cultivated and made into maturity (the spreading quality of conchospores is over $1X10^6$ conchospores per shell) was respectively put into the net bags or bamboo crates in the afternoon of the day before gathering the seedlings and shipped for a fixed anchored－position in the adaptable sea region where the sea water is flowing by the washed and cleaned sampan. Making the mature filamentous conchocelis be immersed in the sea water, let it be stimulated until the next morning and then washed, cleaned, dredged up, and spreaded out for seed harvesting.

I . Seedling process by water－spraying (splashing) conchospores

According to the study made by Zhu, Li & Wen 1964－1965, in Nanri and Xiang Zhi County in Fujian Province. The proportion of the ball－shaped conchospores is a little larger than that of seawater. The ball－shaped conchospores is floating on the surface of water in the moving seawater and drifting, with the waves. The adherent seedling of the ball－shaped conchospores goes downwards from the surface of water and suddenly decreases. In the plashing area on the surface of water and under the surface of water, 2.8cm, the sporlings are the dencest. Under the level of 10cm they are very few. Based on the above result and the principle, the conchospore is sprayed(splashed) on the string(net) －screen layer of the sea surface and the conchospores spread in the spaces between the string(net) －screen layer ropes in small water bodies, which form a small water mass in the string(net) －screen layer area, within this small water mass, the Conchospores are slow in missing while the water inside exchanges with the water outside, and benefit the contact of the ropes and the adherence of the conchospores. So it is not difficult to have seed harvesting by water－spraying conchospores on *Porphyra* production.

The stimulated and matured shell filamentous conchocelis was put in the dark precipitated, filtered, clean, and normal sea water in the cabin or tank to spread and take it out at eleven o'clock in the a fine day , counting the density of conchospores. The string(net) －screen gathering seedlings was handled quite well beforehand. The string－screen has some

10－12 layers of rope which are managed each other and held up together [7][9]. The two ends of the string－screen rope are separated by cutting from each other. To the middle and the two ends of the string－screen roped a small bamboo stick is closely tied up and down to constitute a plane. The two ends of 60－80 pieces of string(net) －screen are connected by a tiny bamboo stick separately so as to shrink the string(net) －screen well. And the two ends of the screen string(net) should be dashed forward with a small bamboo stick, well contracted and hard tugged. It's better for the string(net) －screen gathering conchopore seedlings to be hanged on the gathering seedling framework in the middle littoral zone on the same day . In 50～60 or 8～10 frames, each of them is about 2.5X1.8m^2 of size, the string(net) －screen conchospore seedlings of one ha can be gathered dividedly. The gathering seedling framework should be added more enough buoyancy. The layer of the string(net) screen gathering conchospores seedlings should be made surely floating in the wave layer within some 0～5～(10) cm of the most surface layer of the seawater. After gathering conchospores seedlings the framework of the string(net) －screen should be floating on the surface of seawater for more than three hours [7][9]. When the tide is Fig. 4

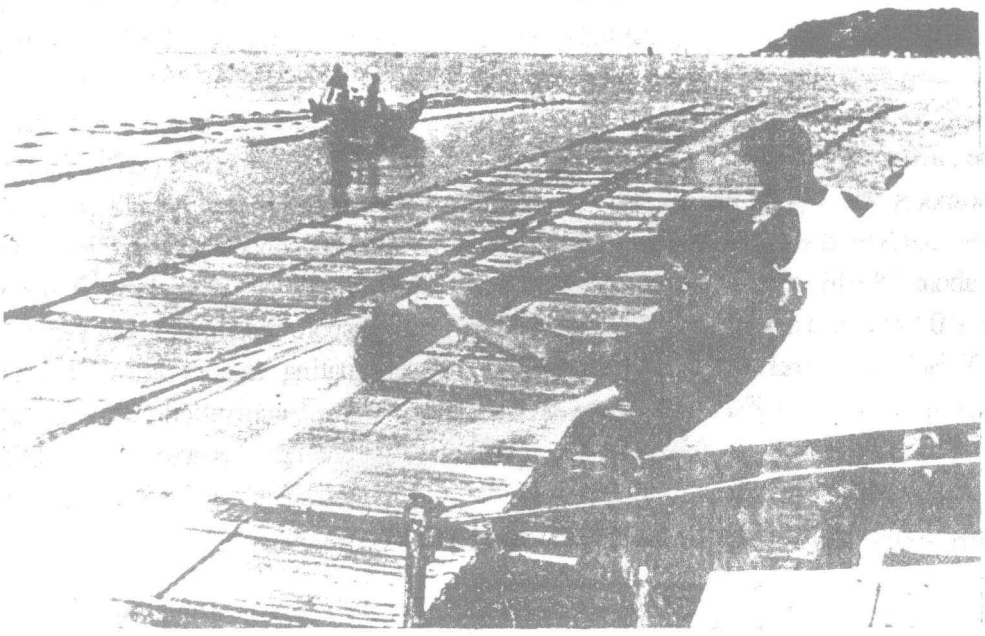


Fig . 4 harvesting *Porphyra haitanensis* seedlings using motor boat water－spraying conchospores at sea in September , Longhai County , Fujian Province . (Photo by Li X . L .)

flowing or ebbing, the conchospores seedlings can also be collected. It's better for collecting the conchospores seedlings to be in the gulf like a bag form or new moon (erscent moon) form. It is the best for it to be in force 3~4 wind and waves. In general, while the tide rises to 60%~70%, the evenly stirred conchospores water is prinkled or splashed equally on the screen in the internal gathering seedling framework or near the coast for collecting seedlings (Fig. 4). 10~16 kg of conchospores water contains (0.1−0.12)X10^9 conchospores, which can collect one ha of seedlings. Within 4 hours after the conchospores discharges in a peak gathering seedling can be proceeded[7][9]. The rate of the conchospores utilization can reach 4%[17] ~10%[6]. There are (1~1.6) X10^2 plants of seedlings cm^{-1} rope. The discharge quantity is more than 3X10^6 ranks of the mature shell filamentous conchocelis. Generally, 3300~4300 of the mature shell filaments can collect one ha of seedlings. Some 10 days later the seedlings can be seen by the naked eye, the separately hung screens for seedlings cultivation are made immediately[7][5].

At present, on the production of *Porphyra* culture, waterspraying (splashing) conchospores, in which this application and experiment has succeed by The Fisheries Research Institute of Fujian Province Li, S. L. 1970~1971, has been adopted everywhere.

II. Gathering conchospores seedling process in tank

In Fujian Province the conchospore seedling of the *P. haitanensis* are commonly gathered in the cultivating tank. And the light intensity is adjusted to the height 3000 Lux. In general the mature shell filaments done well by stimulating in the soreads on the conchospores or uses conchospore water to gather them. The density of the adherent conchospore seedlings can be habitually calculated by using conchospore quantity per unit area[26]. (0.75~0.90)X10^8 conchospores ha^{-1}. The density of the dense adherent conchospore seedlings is about (1.20~1.50) X10^8 conchospores ha^{-1}. The density of the adherent conchospore seedlings generally is about (8~16) X10^{-2}X^{-1} adherent conchospoes (within a field of looking at the rope under 100 times of microscope). The dense adherent conchospore seedilings about (25~39) X 10^{-2} X^{-1}adherent conchospores, and within it the germinating rate of adherent conchos poresdis about 7.0%~8.9%[10][21]. Now, the production of *Porphyra*, cultivation demands that on per cm of the screen rope there can be (1~2) X 10^2 sporelings. Because of the different operating process of adhering conchospores on the screen after being spread. Every district, habitually, is still taking the following method of gathering conchospore seedlings:

1. To gather conchospore seedlings by rushing and flowing water

The mature shell filaments stimulated well in the pea can be put in a row in the tank of the gathering seedlings or in the spreading tank to scatter at 6 o'clock in the morning. The screen which has already been handled in advance, of which 24~28 sheets can be made up

into a hole and hele up into three storeys [7] is inserted loosely into or held in row in the gathering seedling tank, where the normal, fresh, and filtered or dark and sedimentary sea water added until the screen is submerged by the water. The water in the tank generally is about 40～60 cm in depth. When the conchospore seedlings are gathered by the conchospore water, it must be well sprinkled evenly on the screen in the tank. You may use the pump to draw the water from the gathering seedling tank and rush evenly the screen while the conchospore seedlings are being gathered. Some one installs several pipelines on which there are many small holes in the bottom of the tank so as to compress air and produce air bubbles. Making water flow and roll up and down and stir up conchospores floating as the water flows for increasing the contact opportunity in favour of attaching to the screen. Especially at about 9 o'clock in the peak period of the conchospore day discharging, it should be more careful to be swept by water of river or pool constantly and turn about the screen up and down to make the adherent conchospore seedlings even on screen. Generally m^{-2} gathering seedling tank can be collected conchospore seedlings 15～20 a. At present, in some places of Lianjian County and some regions of the southern part of Fujian province this method is adopted popularly.

2.By swinging bubble style to gather conchospore seedlings.

This swinging bubble style is an improvement over the Japanese bubble style to gather the conchospore seedlings. An air pipeline which is away 15 cm from the bottom of the gathering seedling tank, the length of which is equal to the tank, and on which there are many small holes, is installed and is swinging mechanically. The well stimulated and matured shell filaments are paved on the bottom of the tank. The gathering seedling water is 60 cm in depth. The screen, which has already been handled well, will be shrinked, strained, and put on the gathering seedling framework to harvest the conchospore seedlings in the gathering seedling tank. In a m^{-2} gathering seedling framework 16～18 a screen can be held. The conchospore water can be also used to sprinkle evenly on the screen in the gathering seedling framework to collect conchospore seedlings. Within a fixed time the screen should be turned up and down, and the air pipeline is used to produce bubbles ad well as oscillation in order to make water roll constangly. Thus the conchospores float up as the water runs and is attached to the screen rapidly and evenly[2][17]. It can gather 2～3 batches of concholspore seedlings per day. In each of 9 X 1.5 X 0.7m^3 tank, it can gather 4.32～7.29 ha seedlings per day. It is suitable for a large area to gather the conchospore seedlings. this method began to be used in the big and small Deng Islands of Tongan County in 1970s.

In addition, in some counties like Xiapu county of Fujian Province the cleaning screen is also used to be submerged in the stirred evenly conchospore water, that is 50 kg of sea water containing(0.98～1.20) X 10^8 conchospores ha^{-1} to gather seedlings. When the conchospore is attached to the screen, the fresh sea－water is added again and loosen the screen in the tank so as to make conchospore seedlings grow for the time being. And then the screen to which

conchospores adhered is hung up on the semi-floating raft frame in the sea for cultivating. In some regions of Zhejiang Province the method of gathering conchospore seedlings by artificial stirring is also adopted.

Gathering conchospore seedlings by using free-living filaments of *P. haitanensis* needs to pack the this filaments into the bolting silk bag NXX No. 64, which was promoted to be matured by the running water rushing or the stimulation in the sea. After that it discharges to be conchospore water, and its temperature is 22~26℃. Under the various methods mentioned above gathering seedlings. The weight of the fresh free-living filaments is about 10~13g which can gather 1 a. The period of gathering seedlings is generally postponed one month later than the shell filaments in Fujian Province[1][2][9][13].

In Qidong County of Jiangsu Province gathering the *P. yezoensis* conchospore seedlings is postponed in order for some half one month later than gathering the *P. haitanensis* in Fujian province[16]. The water surface temperature of the sea dropped below 22~17℃. The shell filaments doesn't need to be put in the sea for stimulation. A large number of gathering conchospore seedlings are under the temperature 21.5~17.5℃ in the tank, and should be in the discharge quantity over 1 X 10^6 conchospores shell-1 filaments rank to gather conchospore seedlings by rushing and flowing style. The depth of water generally is about 15 cm. The density of the adherent seedlings is now 15~20 conchospores mm^{-2} No. 20 bolting silk 50~80 conchospores cm^{-1} 20^s synthetic fibres

In general 6.67~12.34 a can be gathered one time in 10 m^2 the gathering seedling tank. When the day discharge quantity appears in the peak, the time needed for having finished gathering the conchospore seedlings is shorten,2~3 batches of conchospore seedlings can be gathered in one day [4]. Owing to its monospore seedlings being added luxuriantly[4][6], it is favourable to harvest conchospore seedlings.

3. Cultivation of leafy thalli in the littoral farm

All artificial gathering *Porphyra* seedlings cultivation begins from the screen being hung up to the sea, or after spraying (splashing) conchospore water on the screen of the water surface, and its *Porphyra* spore germinating gets into the stage of the *Porphyra* leaves growing through the stage of *Porphyra* seedlings and the production of *Porphyra* cultivation goes into the intervals between cutting and gathering. In Fujian Province the harvest stage of the *P. haitanensis* begins from the late October and about the February or late March[14][10]. In Jiangsu Province the harvest stage of *P. yezoensis* begins from the early December and ends to the late May[15].

The mass all-artificial *Porphyra* cultivation by screen in China began in an initiative scale to produce *P. haitanensis* in Fujian Province in 1966. So far in China the Porphyra production made by the littoral zone semifloating raft screen is first put forward[7][14][18]

1.The structure of the semi-floating raft screen

The *Porphyra* cultivation made by the littoral zone semifloating raft screen was invented by the aquaculture workers in 1958~1962,in Fujian Province. Later, it was constantly improved in production practice. At present, the main production methods adopted in different areas of Fujian Province are as follows:

1.The screen

The screen in Fujian Province are usually woven out of a)nylon and b) polyethylene mixed spun rope, often using mixed spun rope of 72 monofilaments=203/3 X 2 X (9a+3b) and 78 monofilaments=20^{3}/3X2X(11a+2b)

(1) A string-screen

The length of a string-screen is about (2.0~2.5) X (0.75~1.0)m. The interval between two strings of rope is about 4~5 cm, and its two ends are passing through, or just directly connected to a small bamboo stick or a rope (Fig. 5,6).

(2) A net-screen

In some southern parts of Fujian Province and some regions of Zhejiang Province net-screen is made in a square or rhombus form, which is about (2.0~2.5) X (1~1.5~2) m. The net-mesh is about 27~30 cm (Fig. 7~8)[2].

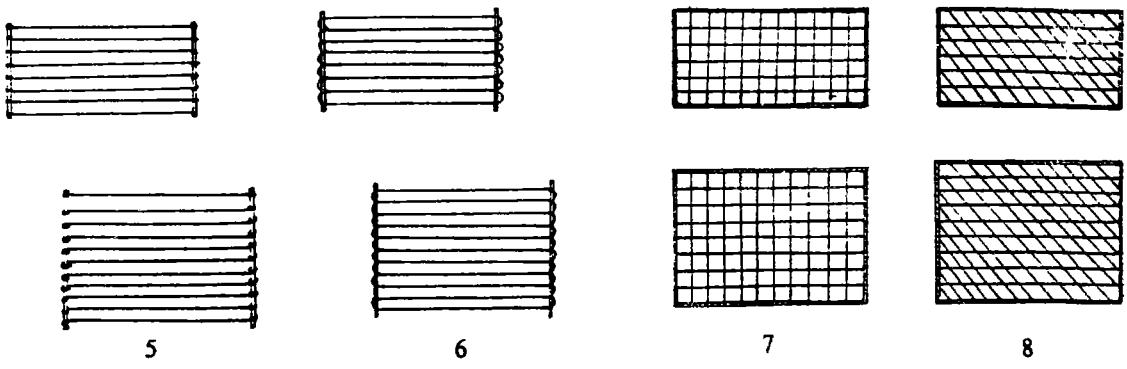


Fig 5~8 Diagram of the main specification for string-screen and net-screen

Fig. 5 A small bamboo stick of a rope are connected through the two ends of the string-screen (2 ~ 2.5) x (0.75 ~ 1.0) m.

Fig. 6 Threading a rope or a small bamboo stick through the two ends semimeshes of the string-screen (2 ~ 2.5) x (0.75 ~ 1.0) m.

Fig. 7 A square form net-screen (2 ~ 2.5) x (1 ~ 1.5 ~ 2) m, mesh 27 ~ 30 0r 20 ~ 25 cm.

Fig. 8 A rhombus form net-screen (2 ~ 2.5) x (1 ~ 1.5 ~ 2) m. mesh 27 ~ 30 or 20 ~ 25 cm.

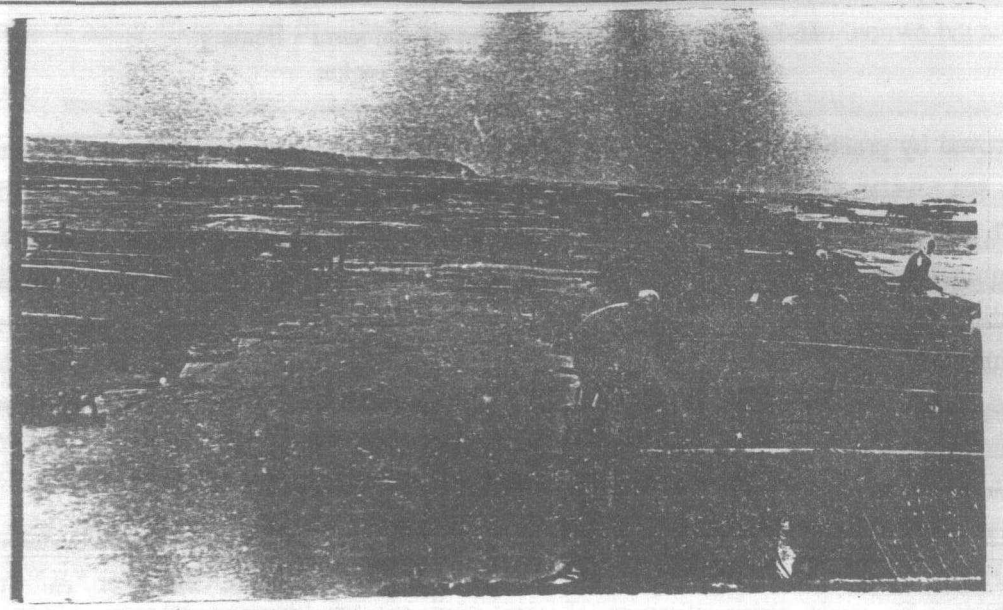
In Qidong County and other places of Jiangsu Province the P. yezoensis is produced by the 2 X 2.5 m net-screen woven in a rhombus form or a square form by the 90 monofilaments $=20^{s}/(27a+3b)$ X 3 mixed spun rope, and its mesh is 20~25 cm (Fig. 10) [16]

2.A semi-floating raft frame

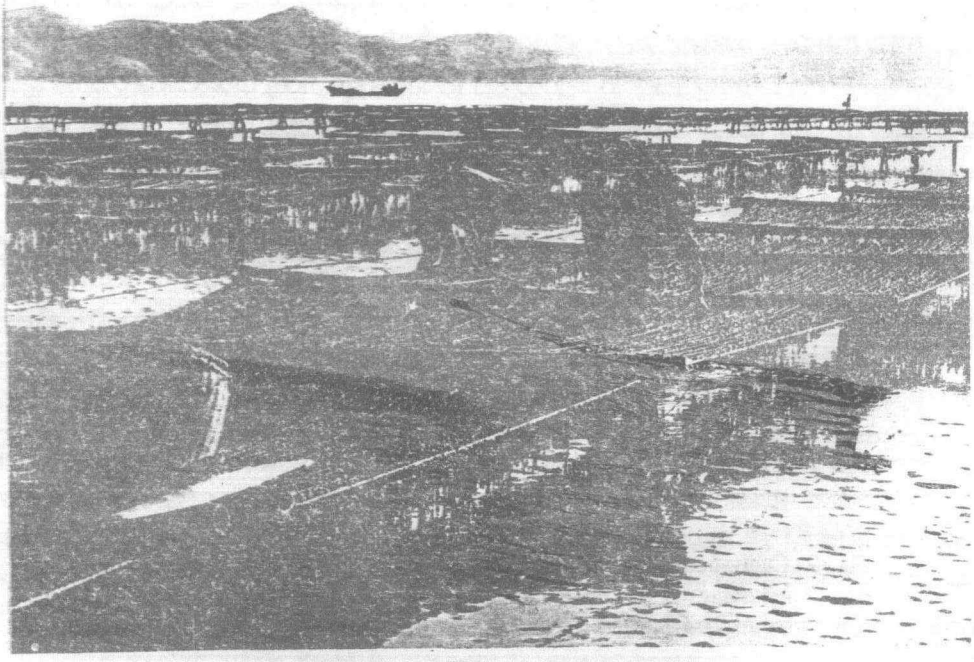
The two parallel floating ropes are usually made up of 450~900 polyethylene monofilaments. Upon the ropes interval between two frames are about (2~2.5 m) equal to the length of the screen. The two ends of the single-storey frame (2.5~5.8) X (0.5~0.7) m are connected together firmly on the two parallel ropes by using ropes of 90 polythylene monofilaments .The two ends or the middle part of each semi-floating raft frame (or two ones) are tide up on a doublestorey frame (2.5 ~ 5.8)X(0.5 ~ 1)X(0.5 ~ 0.7)m, in order to increase its firmness and buoyancy. With the anchor rope the raft frame is tide firmly to the stone, bamboo, and wood pile in the cultivating littoral frame, forming a semifloating cultivating raft frame. In Fujian Province, the length of the big semi-floating raft frame, which hangs string (net) -screen of about 6.67ha, is about 70~80 m (Fig.11), but that of the small one with string (net) -screen of about 3.33ha, is about 90 m. In Qidong County of Jiangsu Province, the semi-floating raft frame with net-screen of about 3.33~4.77ha for cultivating the *P. yezoensis* is generally about 100 ~ 110 m (Fig. 10).

The "floating rafts fixed with poles" are constituted the semi-floating raft frame. The string screen is 60 X 1.5 m (3.33ha), a small area is 0.67 ~ 1 ha. It is also used to culture the *P. haitanensis* in some parts of Putian County and other places of Fujian Province [19].

Fig. 10 Cultivation of *Porphyra yezoensis* in simi-floating raft netscreen on the ebb, in April, Qidong County, Jiangsu Province.
(Photo by Lin Y. S.)



(1)



(2)

Fig. 11 Harvesting the *Porphyra haitanensis* which on string screen of the semi-floating raft are growing at low tide. Note thenet-screen rest on the beach with the help of short legs. (1). Net-screen (photo by Lin Y. S.), Dongan, Fujian, Oct. (2). String-screen (photo by Zhang T. F.), Xiapu, Fujian, Nov.

II. Installation and arrangement of the semi－floating raft frame in the cultivating sea region

Proved by practice, the littoral regions where string (net) －screen appears on the surface of the sea－water about 2 ～ 5 hours in a spring tide or 2 ～ 3 hours in a neap tide or doesn't appear at all about 2 ～ 3 days are all suitable for *Porphyra* cultivating farms. The cultivating frame is usually divided into small (1ha) and big (33.3ha) areas in the large cultivating region. At present, in Fujian Province *P. haitanensis*, every 10 rows small or 5 rows big semi－floating raft string (net) －screen constitute one small area, and its interval is distinguished about 8m、10m. Every 3 small areas make a big one. The interval between the two small and big areas is distinguished about 30m、80m, used as a sailing channel (Figs9,11). For the beach in Fujian Province is relatively small, so it can only be divided into two to three small cultivating areas from the upper part to the lwoer. Most of the arrangement shapes of cultivating semi－floating raft string (net) －screen are like the Chinese Character "品" (pin) (Fig. 9).

Fig. 9: Cultivation of the semi－floating raft string－screen with *Porphyra haitanensis* at low tide. Note its installation and arrangement in the sea region. Longhai, Fujian, Nov. (photo by Li S. L.)

The beach in Jiangsu Province is relatively large so it can be divided into 5 － 6 small areas in ladder－shaped arrangement (Fig. 10) and sea－water flows more easily. The structure number of the semi－floating raft frame in both small and big area in Jiangsu Province is similar to that of the small ones of the *P. haitanensis* in Fujian Province. The interval between the two semi－floating raft net－screen in the small area is 6 ～ 8 m. A sailing channel should be 20 m between the two small areas. The distance between the upper and the lower small

area is about 50 m. A 60 m sailing channel should be separated between the two big areas [16].

III. The conchospore germinating and its sporeling growing

In Fujian province, the *P. haitanensis* conchospores adhering to the screen, flat knoll-shaped, about 12.6 ~ 13.9um diam., in the sea farm, germinatesin about 2 ~ 3 days, two-pole divisions into 2 ~ 4 cells (20.3 X 13.1 ~ 52.3 X 11.6μm), coming to its germling stage. During this stage the first germling is made up of uniseriate cells. When it is divided into 6 ~ 14 cells (58.2 X 17.4 ~ 120.6 X 20.1 μm), it begins longitudinally dividing into leafy thalli. It will last 10~13 days before the adhering conchospores becomes sporelings of about 0.1 ~ 0.2 cm, which can be seen by naked eye. The sporeling needs about 12 days to grow from the length of 0.1 ~ 0.2 cm to 1 cm, the sporelings begin to protuberate denticle from the lower part upward, about 13 days for that from 1 cm to 5 cm and about 15 days for rapid growth from 5 cm to 30 cm. Then it can be harvested for the first time. It generally needs about 50 days for the conchospores to adhere to screen up to being harvested for the first time.

When the seedlins become 3~5cm in length, their form, wideth and thickness are of little difference no matter they growing on the screen or on the rock. But the seedlings on the screen become wider, thicker than those on the rock. They become greenash purple gradually. These differences becom more apparent in the course of their growth.

Usually in Fujian Province *P. haitanensis* can be harvested 8 ~10 times every year, whereas in Jiangsu Province *P. yezoensis* 9 ~ 13 times per year.

The water temperature of about 24.9 ~ 27.8℃ fits the germinating of conchospores of *P. haitanensis*. The germling grows most rapidly at the temperature of about 27.6 ~ 29.5℃. The water temperature of about 25℃ is suitable for the sporeling growing[2,4]. The water temperature of about 19.9 ~ 14.4℃ is more appropriate for leafy thalli growth[9].

The sporeling rate is high in the middle[11] and high[10] tide zones in Fujian Province. The growth of early stage (October, November) increases from the upper tide zone to the lower. In the middle stage (December, January), with water temperature dropping, the growth speed in the middle and high tide zones increases in December. The growth speed of *Porphyra* in these three tide zones tends to be the same [2],[29] and similar to that of the *Porphyra* growing on the Porphyra Rocks [34]. In January the *Porphyra* in the low tide zone grows slowly, while those in the middle and high tide zones grow well, both maintaining quite the same [2], In the last stage (February, March) the *Porphyra* begins to decline from the lower tide zone to the upper tide zone[10]. And it is just contrary to the Porphyra growing on the *Porphyra* rock in the high tide zone which declines [34].

P. haitanensis belongs to a kind of diffusing growth species. The remaining basic part

cm of early and middle stages grows relatively slow, while that of about 3 ~ 10 cm grows morerapidly with its length increasing. The *Porphyra* can be cut when it comes to the length of about 20 ~ 30 cm. The basic part left of about 8 cm will be more appropriate [17]. In the peak growing stage, the *Porphyra* can be harvested once every 8 ~10 days if it is properly cut and left [29]. In other stages there is only one harvest every 15 days. In the last stage, the alga comes to wane and becomes wide and thick but its length grows slower than previous stages, and the interval between the two harvest stages is longer, in this case, the basic part of *Porphyra* should be left at the length of about 5 cm [17]. The yield is the highest in the lower tide zone in Shaodong of Tongan County of Fujian. The yields in the middle and high tide zone are respectively 97.3% and 75.2% of that in the lower tide zone. The output of *Porphyra* in November, December and January amounts to 67.3% of that in the whole year[10]. When the water temperature drops to below 10 ℃ in winter in Dinghai County of the northern part of Zhejiang Province, the Growing graph obviously shows the shape of saddle. The output of *Porphyra* stage of suitable temperature before the first ten days of December takes up 45.1% of all the output in the year [15].

The suitable water temperature of growth for *P. yezoensis* is lower than that for *P. haitanensis*. The sporeling rate of adhering conchospores in Qidong County of Jiangsu Province is higher in the upper tide zone but its growth is slower and its output is only 45% of that in the middle tide zone and the growing graph takes on a shape of saddle. The first peak stage appears when water temperature drops to 10 ℃ or so, but the second peak stage appears when water temperature goes up to about 4 ~ 5 ℃ after winter, the second peak stage is larger than the first peak stage. The output of *Porphyra* in March and April takes up 57% of the whole year's [16].

Conclusion

The Chinese phycoculture workers have made efforts to study cultivating *Porphyra* for more than 30 years and developed it into a mass modern artificial cultivation of *Porphyra* in screen. At present, the main production is *P. haitanensis* which is fat, tender, delicious, and in high output. The next is the delicate *P. yezoensis* in lower output.

Under the natural temperature, No_3 – N, Po_4—— P should be applied enough to the filament conchocelis moll seashell according to its need.

Porphyra haitanensis depends mainly on the cultivation of stereoscopically gathering seedlings, by adjusting the light intensity, and reducing the light period. At the late stage, Po_4——P(10 ~ 15PPM) is the main fertilizer, which has an obvious result in promoting it to be mature. *Porphyra yezoensis* is to be cultivated mainly by harvesting seedlings on the plane. In addition to adjusting the light intensity and reducing the light period, it may also use all the 1500 luxes to be shone in a whole day for its cultivation so as to master the growing and developing law of filament conchocelis, work out cultivating till harvesting seed-

ling season (on the 8th of September for *P. haitanensis*, on the 23th of September for *P. yezoensis* or so), and concentrate on maturity in large quantities. All these have already have good results.

By water-spraying (splashing) conchospore on the surface of the sea, the flushing and flowing water or adding the air bubbles any further indoors the conchospores seedlings are gathered. The conchospores seedlings can adhere to the screen more quickly by this way. The effect of it is good. And it is appropriate for harvesting seedlings in a large scale. Now, the fact that *Porphyra* produced well proved that the rightly early and reasonably dense seedlings harvested is a effective measure to raise the *Porphyra* output and quality.

In addition, in 1970s the cultivation of free-living filaments of *P. haitanensis* in China has been directly engaged in a small scale in Longhai County of Fujian Province.

The Chinese Coastal line is very long. At present the main method of cultvating Porphyra is the semi-floating screen in the intertidal zone. The *Porphyra* seedlings floats on the surface of the water, enjoys enough sunlight and absorb nourishments in the water as the tide is flowing. After the tide is ebbing the screen semifloating raft framework with the help of short legs rests on the sea beach, the *Porphyra* are made an appearance directly in the air or basked in the sunshine so as to lighten the threats of accessories and anti-doddery. The germinating seedlings grow well, suitable for production of *Porphyra* in a larger sea area of winds and waves, of the tidal range, and the smaller sea area of transparencies. All this covers a Chinese characteristic.

In some parts of Fujian Province interculturing Porphyra in a small scale has been proceeded under the *laminaria japonica* shaped to raft along the lower littoral zone. It has also very large latent potentialities on development of production.

The principal climate of producing *P. haitanensis* is at 19.9 ℃ ~ 14.4 ℃ in Winter. And the *P. yezoensis* is at 4.5 ℃ ~ ℃ in10Spring. In the South and North of Yangtze River there are favourable conditions of production in double seasons for development of both *P. haitanensis* in Winter and *P. yezoensis* in Spring. This will make the Chinese Porphyra production raise a new level. Exchanging the cultivating Porphyra skills and technique and the Chinese productive achievements will have an active significance to promote the international development of cultivating Porphyra.

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