BREEDING DEEP WATER RICE IN THAILAND

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Present status and problems to be solved

Although the High Yielding Varieties have been in production in Thailand for at least 7 years the area planted is still comparatively small and primarily limited to the good irrigated sections in the dry season. It is estimated that these comprise no more than 5 percent of the total rice producing region which consists of about 8.5 million hectares. In contrast, most of Thailand's rice is grown during the monsoon season when water is more plentiful and little or no energy is required to put water into the paddy fields. As such, much of it can be classified as rainfed rice.

It is believed that three major factors are responsible for the lack of HYV planted in the main (monsoon) season. These are (1) their lack of photoperiod sensitivity (2) inability to tolerate water depths over 50 cm and (3) susceptibility to drought during the early vegetative stage. When farmers are queried as to their reasons for changing to traditional tall photo-sensitive varieties in the monsoon season they may also add to the above that the HYV seedlings are too short for transplanting in the deeper water and their taste is not as good as the older varieties.

Recent remarkable results

By crossing floating rice varieties with the semidwarf HYV we have been able to obtain segregates which are photoperiod sensitive, remain short in height if the water is not deep, exhibit high tillering ability, drought tolerance and are capable of elongating and surviving water depths of more than one meter. Recent studies have shown that they are more responsive to fertilizers than the traditional forms in water depths of up to one meter and far superior to the best HYV at depths greater than 50 cm. When grown under cultural conditions favorable

Table 1. Major characteristics of some new deep water promising lines.

Cross	Selection No.	Elongation* ability	Ht. **	Remarks (Photoperiod)
IR262/Pin Gaew 56	BKN6986-147-2	Fair	120	Sensitive
IR262/Pin Gaew 56	BKN6986-167	Good	160	Sensitive
IR262/Pin Gaew 56	BKN6986-81-5	Good	160	Sensitive
IR262/KNN 11	BKN6987-161-3	Good	120	Sensitive
IR262/Pin Gaew 56	BKN6986-108-3	Good	135	Non-Sen.
IR262/Pin Gaew 56	BKN6986-66-2	Fair	125	Non-Sen.
IR262/KNN 11	BKN6987-128-2-17	Fair	130	Non-Sen.

* Good elongation means similar to T442-57 but less than Pin Gaew56.

** Height in shallow water.

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for high yielding varieties, the deep water experimental lines are equal in yield.

Thus, it appears that high yielding types can be developed for those large areas of Thailand where farmers presently consider it too risky to grow the present types in the monsoon season. This has been accomplished by combining some hardiness traits from floating rice with the high yielding characteristics of the modern HYV.

Nine of the more promising newly developed lines are presented in Table 1. Most have dwarf stature but two are considered intermediate in height. Four of the nine have strong sensitivity to photoperiod which is considered important for use in the deep water areas. However, we believe that some of the better water control regions may prefer a non-sensitive variety which can tolerate flooding if necessary, hence, our reason for also developing some of these. Several of the above lines show promise to drought tolerance in preliminary screening tests. These may be discussed further in the oral presentation.

Breeding technologies for deep water tolerant rice

1 Elongation test. Five grams of pregerminated seed are planted after 12 hour soaking and 24 hour subsequent incubation. The seedbed is prepared wet similar to those used for growing seedlings for transplanting, however we use rows 125 cm long. Seedbeds are kept moist by sprinkling water two to three times per day for approximately 5 days until seedlings have become established. Thirty days after seeding, the water level is increased. The first increase is made to a water level of twenty-five centimeters, and then a rate of ten centimeters every other day is maintained until the desired final depth is reached. The varieties RD1, T442-57 and GP56 are used as checks and planted every 20 rows. The scoring system which was formulated in 1974 and continued to the present is as follows:

Score	Elongation ability
1	Similar to PG56
3	Better than T442-57 but poorer than PG56
5	Similar to T442-57
7	Better than RD1 but poorer than T442-57
9	Similar to RD1

2 Yield testing under shallow and intermediate water depths. We assess the yield potential of the advanced breeding lines by testing their yielding ability under shallow water and comparing them with our best standard high yielding varieties such as RD1 and RD7 at several of our rice stations in order to determine their adaptation.

In order to evaluate performance in deeper water we test yield using several of our popular traditional tall and floating varieties as checks. These are planted at our 2 deep water stations plus other deep water sites and in farmer fields where water is usually deep in the monsoon season.

3 Submergence tolerance test. We plant 5 grams of seed which has been soaked for 24 hours and incubated for 2 days in rows on seedbeds 1.25 meter long. A 2-row plot for each testing line is easier to evaluate and allows more plants to be observed. Distance between rows is 25 cm. Seedbeds are kept moist by sprinkling water until seedlings have become established. In the farmer fields flooding may occur at any time and cause damage to the rice plant. The assumption here is that the most susceptible stage of a plant is the seedling; thus, an age of 20 days is suggested for this test. The water is maintained about 30 cm over the tops of the tallest lines for 10 days. The average height per plot is measured just prior to increasing water in order to observe differences in the degree of submergence tolerance that may be attributed to tall seedlings. Original percent stand of each plot is recorded for comparison with final survival readings. Three check varieties, Nam Sa Gui 19, Pin Gaew 56 and BKN6986-108-3 are used as standard checks for good tolerance to submergence. Ten days after submergence

the water is drained to allow plants to recover. We wait 10 days before scoring using the following system developed at IRRI:

Score	Percentage of dead plants
1	Less than 1%
3	1 ~ 5%
5	5 ~ 25%
7	25 ~ 50%
9	More than 50%

4 Other screening tests. We are conducting research on methodology to use in screening for "kneeing" ability, to produce nodal roots and withstand drought in the early vegetative stage. Our results to date have not been conclusive thus, methodology will not be presented here although the investigations are continuing.

Characteristics and culture of floating rice

Thailand has a total rice area of about 8.5 million hectares of which about 800,000 hectares are suitable for deep water rice only, due to high water levels which sometimes attain four meters during the growing period. The cropping season usually begins in April when farmers burn the straw accumulated from the previous crop. After that, large 65 horse-power diesel tractors with disc ploughs are hired to plough the land when it is dry or slightly moist, depending on the rainfall. Farmers who cannot afford to hire a tractor usually wait until after sufficient rain has fallen and then use their own buffaloes for ploughing. Seeds of deep water rice varieties are broadcast sown several weeks after the first ploughing, following some rain. A tractor again ploughs the land, destroying new weed growth and simultaneously covering the rice seeds with moist soil. The rice grows first under upland conditions until the full force of the monsoon season arrives in June or in some years as late as August. During this period the rice frequently comes under severe drought- stress, which has led to the belief that drought tolerance in the vegetative stage has evolved from this natural selection. Fertilizers are not used by most farmers. Water levels rise in the fields during September or October at a rate of about seven cm per day and recede completely by harvest time in December or January. The yield and quality of deep water rice have been rather poor in the past because inferior varieties were used with such common defects as shortness of grain. Starting in the nineteen fifties, through pure line selection and quality contests, deep water rice varieties with standard long grain, improved cooking quality and good yielding ability were obtained. In deep water rice areas diseases and insects cause minimal losses. This does not imply that this type of rice is highly resistant but more likely that the deep water environment is not conducive

Table 2. Major characteristics of each of the seven recommended varieties

Variety name	Maturity	Year released	Elongation ability
Tapow Gaew 161*	Early	1959	Fair
Jek Chuey 159 *	Early	1959	Fair
Leb Mue Nahng 111	Medium	1959	Good
Khao Nahng Nuey 11	Late	1969	Good
Pin Gaew 56	Late	1959	Good
Khao Puang 32	Late	1969	Good
Nahng Chalawng **	Early	1959	Fair

* Semi deep water rice

** Glutinous endosperm

to pests. In a recent survey, many farmers reported drought during early growth stages and sudden floodings as major problems. For a long time, deep water varieties have received less attention than the ordinary lowland forms because they are more difficult to handle and are grown under poor management conditions.

The Rice Division presently recommends seven superior varieties of floating rice to the farmers as shown in Table 2.

In summary, we believe that through exploitation of valuable genes contained in floating rice varieties, it is possible to develop high yielding varieties more tolerant to stresses such as deep water and drought. The point is that breeders may be overlooking valuable characters in locally evolved cultivars in favor of parents which already have a good genetic background but may be deficient in genes which permit them to withstand physical stresses.

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Discussion

S. Samoto, Japan: How about insect pests and diseases in deep water rice?

Answer: Although such problems exist in deep water rice, they are less important than

in low-land rice. Some of the recommended varieties are susceptible to pests and diseases, for instance YOLV has been observed in Thailand many years ago.

H. Fujimaki, Japan: Which role does the glutinous cultivar play in the case of deep water or floating rice grown in Thailand?

Answer: There is a glutinous variety among the recommended ones but it is not popular with the people living in the area where deep water rice is being grown, unlike other regions of Thailand where glutinous varieties are widely appreciated and grown.

C. Kaneda, Japan: What is your experience with the method of rapid generation advancement in the case of deep water rice?

Answer: I am not very much involved in this project and will ask Dr. Hill for more information.

G. S. Khush, The Philippines (answer to Dr. Kaneda's question): I would like to inform Dr. Kaneda that we have started handling some of the crosses between floating and non floating rice varieties by using the rapid generation advancement method at IRRI. F_4 or F_5 populations will be grown under actual deep water conditions next year to find out whether this method can be applied to improve this variety of rice.

J. T. Rao, India: What is the photosynthetic efficiency of deep water rice? If the high-yielding varieties have high photosynthesis efficiency, how do the hybrids behave?

Answer: I am afraid but at the present time I have not studied this aspect.

K. Kawano, Colombia: I understand that you are trying to select your materials both for drought tolerance at the early stage of growth and for deep water tolerance. Are these two characters genetically independent?

Answer: We are fortunate enough that most of the local floating rice varieties are both tolerant to drought and to deep water. This may be due to an adaptation of floating rice to the broadcasting culture as shown in the slides.

S. Sakaguchi, Japan: Have you any information about the genetic behaviour of stem elongation capacity in your materials? Have you any information on correlated characters at the seedling stage and floating behaviour?

Answer: 1. No, not at the present time.

2. The older seedlings have a higher ability of elongation than the young ones. Dr. B. S. Vergara from IRRI might give you more information on this subject.