

DEVELOPMENT OF RICE GENOTYPE TOLERANT TO ACID SULFATE AND SALINE SOILS USING NUCLEAR TECHNIQUE.

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ABSTRACT

Nuclear technique has been used to induce mutation in a traditional aromatic rice variety, Tam Xoan (TX). Three promising mutants have been selected possessing high tolerance to slightly acid sulfate soils, namely TXDB-1, TXDB-83 and TXDB-93. TXDB-93 exhibits high tolerance to saline soil (0.4%). Cooked rice of TXDB-1 could retain typical aroma of the variety, while the other two TXDB-83 and TXDB-93 genotypes express high yield and long grain appearance which meets the current exporting standards. A positive correlation between hull colour and aroma was recorded. Further studies should be carried out to elucidate the event.

INTRODUCTION

For the last several decades, nuclear technique has become an important tool in crop improvement. A great number of new varieties developed by using this tool exhibits higher yield and better quality than the original varieties. Bhatia et al. (1991) recorded that yield of mutant blackgram bean has increased from 11 to 17%, while other components, such as 100-grain weight, increased from 7.6 to 24.2%. Similarly, mutant cotton variety possessing higher yield and longer fiber than its mother variety (Özbek et al. 1991). Improvement of 20% protein content in grain of winged bean (*Psophocarpus tetragonolobus* L. (DC) has also been reported (Klu et al. 1991). In cereal, induced mutants have been obtained with shorter height (Kihupi 1997, Purivirojkul and Vithayatherrarat 2000; Nguyen et al. 2001; Asencion et al. 2000); early maturity (Narahari and Bhugwat 1984., Yamagata et al. 1989, Nguyen et al. 2001); better resistance to powder mildews on wheat, oat (Jorgensen 1991); or *Xanthomonas campestris* pv. *oryzae* on rice (Nakai 1991). Syukur et al. (1991) has improved saline tolerance in tobacco (*Nicotiana plumbaginifolia viviani*). Improvement of tolerance to acid sulphate and saline soils in rice has also obtained (Nguyen et al. 2001; Pham and Do 2000). The present study addresses the results obtained in improvement of some characters of Tam Xoan, a traditional aromatic rice variety, using

nuclear technique at Cuu Long Delta Rice Research Institute.

MATERIALS AND METHODS

a- Materials:

- Tam Xoan (Nam Dinh), a landrace has been obtained from gene bank of the Institute of Vietnam Agricultural Science (VASI).
- Gamma ray with ⁶⁰Co source has been provided by Institute of Atomic Energy, Dalat.

b- Methods:

- Dry seed of Tam Xoan has been treated with gamma ray ⁶⁰Co at 15Krad. Untreated seeds have been used as control. M₁ seeds were sown and each individual was separately collected. Selection was carried out in the experimental field of Cuu Long Delta Rice Research Institute (CLRRI). Promising lines were enlisted in the observation and yield trials with three replications in the RCB design. Statistical analysis was followed the method by Gomez and Gomez (1984). Greenhouse and nursery screening for insect pest and disease tolerance of promising lines were conducted by Plant Protection Department. Grain and cooking quality properties were also analysed.

RESULTS AND DISCUSSIONS

1-Improvement of some agronomical characters of Tam Xoan

a- Reduction of plant height and maturity

Data in the table 1 indicated that growth duration of TXDB-1, TXDB-83 and TXDB-93 were shorter than that of their mother variety from 55-63% (i.e from 160-170 days to 93-107 days) depending on seasons and ecosystems. Reducing maturation time and eliminating photosensitivity has made a considerable increment of rice productivity through increase of number of crop per year. The achievement, on the other hand, has helped promote the application of this technique in development of other crops with early/super- early maturity such as cassava, cotton etc. to avoid flood in the wet season or escape salinity damage in the dry season in Mekong Delta of Vietnam.

It was observed that plant height of the induced mutants was also approximately 70% shorter than original variety (table 1). Shorter-

plant height mutants could minimize yield loss due to lodging.

b- Improvement of grain length:

It is well known that one of the critical criteria for exporting rice is the length of rice kernel must be longer than 6,5mm. Mutagenesis is one of the effective tools to create an array of variants with different length in rice grain for selection. Data in the table 1 indicated that both TXDB-83 and TXDB-93 exhibit rice kernel longer than that of their original variety (7,1 and 6,8 mm, respectively as compared to 5,5mm wild type). This indicates an efficient potentiation of nuclear technique in improvement of some agronomical characters in rice.

Table 1. Some agronomical characteristics of Tam Xoan mutants (TXDB)

| Characters | Origin Var. | TXDB-1 | TXDB-83 | TXDB-93 |
|------------------------|-------------|-----------|-----------|-----------------------|
| Growth duration (days) | 160-170 | 100-107 | 95- 100 | 93-96 |
| Pl. height (cm) | 150-160 | 95-100 | 93-96 | 95 |
| Grain length (mm) | 5,5 | 5,8 | 7,1 | 6,8 |
| Yield (ton/ha) | 2,5-3,0 | 4,5-5,5 | 5,8-6,7 | 5,3-6,8 |
| Amylose (%) | 16,5 | 18,8 | 24,9 | 24,6 |
| % Chalkiness (9 score) | 0 | 0 | 2 | 1 |
| Protein (%) | - | 10,0 | - | - |
| Aroma | Aroma | Aroma | - | Slight Aroma |
| Rice blast (score) | 1-3 | 1-3 | 1-3 | 1-3 |
| BPH (score) | 7-9 | 3 | 3 | 3 |
| Abiotic tolerance | Acid Sul. | Acid Sul. | Acid Sul. | Acid Sul.and salinity |

-TXDB: Tam xoan mutant; BPH: Brown Plant Hopper reaction.

2- Yield improvement

Results in the table 1 indicates that all three mutants, TXDB-1, TXDB-83 and TXDB-93 produced higher yield than the origin variety from 1.5 to 2 or 3 times (4,5 to 6,8 ton/ha as compared to 2,5-3,0 t/ha). Apparently, yield improvement created by induced mutation has made the nuclear technique become extensively applicable to other crop improvement.

3- Improvement of rice kernel quality

The most sensitive and desirable property in rice quality is amylose content. Rice with high amylose content will be dry and harder after

cooking, while slight sticky will be derived from rice with lower amylose content. It is observed that an increase of amylose content from 18,8% (TXDB-1), to 24,6% (TXDB-93) and 24,9% (TXDB-83) and distinct from mother variety (16,5%) (table.1) has made quality of these mutants become more acceptable to a large group of consumer (amylose content of 25% is highly accepted). The analysis revealed that protein content of TXDB-1 is about 10% (Nomita, personal communication). Regarding chalkiness character, all three mutants show either no (TXDB-1) or neglective percentage of chalkiness (TXDB-83 and TXDB-93; table.1) However, cooked rice of TXDB-93 is softer

than TXDB-83, whereas cooked rice of TXDB-1 emits aroma and good taste similar to original variety. Interestingly, it is observed that there is a tight linkage between aroma and hull colour among Tam Xoan mutants. Those lines whose hull colour is similar to original

variety (dark-brown) could retain fragrance. Aroma emission depending on intensity of the dark – brown colour. Mutant lines with normal hull colour (straw-yellow), on the other hand, do not emit aroma.

Table 2. Yield of some rice genotypes tested in “rice–shrimp” pattern in Gia Rai, Bac Lieu, wet season, 2002.

| NO. | Varieties | Yield (ton/ha) | | Plant height (cm) | |
|-----|---------------------|----------------|----------------------|-------------------|----------------------|
| | | Fresh water | Saline-affected soil | Fresh water | Saline-affected soil |
| 1 | OM 2517 | 5.29 | 3.41 | 84.8 | 82.0 |
| 2 | OM 3536 | 3.80 | 3.26 | 98.4 | - |
| 3 | OM 2395 | 5.55 | 3.33 | 89.2 | 81.0 |
| 4 | TXDB- 93 | 5.43 | 3.60 | 98.4 | 87.7 |
| 5 | ST 3 | 3.87 | 2.54 | 98.4 | 80.7 |
| 6 | Busoc | 3.43 | 2.31 | 86.0 | - |
| 7 | Một Bụi đỏ (Check) | 5.32 | 3.35 | 87.0 | 75.8 |
| | CV % | 7.4 | 7.9 | 3.6 | 1.6 |
| | LSD _{0.05} | 0.615 | 0.999 | 4.419 | 2.726 |
| | LSD _{0.01} | 0.874 | 1.421 | 6.028 | 4.13 |

4- Improvement of tolerance to abiotic stresses

Development of rice varieties exhibit high tolerance to abiotic stresses is one of the most important objectives in rice improvement in Mekong Delta. Results obtained in this study indicate that all three mutants derived from Tam Xoan variety show high tolerance to acidity condition. Field trials at different locations in Mekong Delta such as Cu Chi (Ho Chi Minh City), Hon Dat (Kien Giang), Moc Hoa (Long An), Long Phu (Soc Trang) etc...proved tolerant potential to acidity condition of these mutants as compared to other varieties. Data in table 2 show that TXDB-93 also exhibits saline tolerance once cultivated in saline-affected paddy field in Gia Rai (Bac Lieu) and Tran Van Thoi (Ca Mau). This mutant yielded 3,6 ton/ha, the highest amongst testing varieties under the same condition and it showed no significant difference from local check variety, Mot Bui Do, statistically. This allows the mutant line could be selected as a promising variety supplying to varietal list after further testing. Introduction of rice genotypes to “rice–shrimp” cultivating system makes a significant contribution to food security and

effectively enhances the natural resource management in the region.

Improvement of tolerance to insect pest and diseases was also recorded, especially to brown plant hopper. A high resistance (score 3) was observed while this response in the original variety was scored 7-9 (table 1). Results from plant protection division indicate that all three mutants could retain high resistance to rice blast disease (*Pyricularia oryzae* L. ; score 1-3, table 1). Such resistance is highly accepted by growers in the areas where insecticide is restricted in terms of rice–shrimp cultivating in Mekong Delta.

Actually, these mutants have been developed in large scale areas to test their adaptability to Soc Trang, Kien Giang, Bac Lieu and Ho Chi Minh city.

FURTHER STUDIES

Development of rice varieties tolerant to acid sulfate soils and salinity is very important for rice improvement in Mekong Delta where two millions ha of land are roughly under effect of acidity and saline stresses. Nuclear technique has proved to be an effective and simple method in varietal development, it should be

further applied in rice and other crops for agriculture development. Further studies will focus

- To look for the relation of hull colour and aroma observed in case of Tam Xoan

variants, it should be explained at the molecular level.

- To identify the molecular characterisation of mutants which should be carried out to elucidate mutation mechanism induced by nuclear technique.

REFERENCES

- Asencion AB, IS Santos, AC Barrida and FIS Medina III. 2000. Utilization of induced mutation techniques in rice improvement in the Philippines. *In: Seminar on Methodology for plant mutation breeding for quality effective use of physical/chemical mutagens. Oct 9-13th, 2000. p.21-33.*
- Bhatia CR, RG Thakare, SE Pawar, DM Kale. 1991. Induced mutations for yield and yield components showing altered partitioning of dry matter. *In: Plant mutation breeding for crop improvement. Vol2, IAEA, Vienna, p 43-53.*
- Do Huu At, Bui Huy Thuy, Nguyen Van Bich, Tran Duy Quy and Nguyen Minh Cong 2000: The use of induced mutation combined with crossing in high quality rice breeding. *In: Seminar on Methodology for plant mutation breeding for quality effective use of physical/chemical mutagens. Oct 9-13th, 2000. p.76-81.*
- Harun AR 2000. The effective of physical and chemical mutagens in the induction of mutation for crop improvement in Malaysia. *In: Seminar on Methodology for plant mutation breeding for quality effective use of physical/chemical mutagens. Oct 9-13th, 2000. p.58-67.*
- Kihupi A 1997. Plant type improvement of indigenous rice cultivars through induced mutations. *In: Improvement of basic food crops in Africa through plant breeding, including the use of induced mutations. Proc. of a final research Co-ordination Meeting of a FAO/IAEA Co-ordinated Research programme, held in Naples, Italy, 30th October-3rd November, 1995. P.45-54.*
- Klu GYP, TVO Lamptey, V Awafo. 1991. Radiation induced mutants for improved seed quality in the winged bean (*Psophocarpus tetragonolobus* L. (DC)).p. 179-181.
- Nakai H. 1991. Practical value of induced mutants of rice resistance to Bacterial Leaf Blight. P.113-127.
- Narahari P and SG Bhugwat. 1984: Studies on induced mutation in rice. *In: Semi-dwarf cereal mutants and their use in cross breeding II. IAEA-TENDOC-307. P.247-258.*
- Nguyen Trong Luong, Vuong Dinh Tuan and Pham Van Ro. 2001. Results of the regional rice mutant multilocation trials in Mekong Delta of Viet Nam. The Second meeting on "Reviewing Results and Planning of regional rice mutant multilocation trials. Malaysia Sept 3-7th, 2001"p. 174-180.
- Özbek N, AS Atila Oğuz, Ç Savaşkan. 1991. Radiation induced mutations for yield and quality in Cotton. P.157-161 (*Gossypium hirsutum* L). *In: Plant mutation breeding for crop improvement. Vol2, IAEA, Vienna, p 157-161.*
- Pham Van Ro and Do Huu At. 2000. Improvement of traditional local rice varieties through induced mutation using Nuclear techniques. *In: Seminar on Methodology for plant mutation breeding for quality effective use of physical/chemical mutagens. Oct 9-13th, 2000. p.90-94.*
- Purivirojkul W and P Vithayatharat. 2000. Progress on mutation breeding in Thailand. *In: Seminar on*

- Methodology for plant mutation breeding for quality effective use of physical/chemical mutagens. Oct 9-13th, 2000. p.52-57.
- Syukur S, M Jacobs, I Negrutiu. 1991. Analysis of mutant plants resistant to salt or water stress and to proline analogues obtained from the protoplasts of *Nicotiana plumbaginifolia viviani*. In: Plant mutation breeding for crop improvement. Vol2, IAEA, Vienna, p. 265-269.
- Yamagata HM, T Tanisaka, and Y Okumoto. 1989. Induction of extremely early heading mutants in wheat. *Jap. Breed.* 39 (1): 1984.
- Zakri AH. 1991. Breeding high yielding soybean using induced mutation. p. 163-169. Jorgensen. JH, 1991: Mutation studies on creal disease resistance, p. 81-91.

SUMMARY IN VIETNAMESE

Phát triển giống lúa chống chịu phèn, mặn bằng phương pháp đột biến

Kỹ thuật hạt nhân đã được ứng dụng để cải tiến giống lúa Tám Xoan Nam Định nhằm tạo ra những giống lúa mới có năng suất chất lượng cao, chống chịu được điều kiện bất lợi của đất đai vùng ĐBSCL. Các giống TXĐB-1, TXĐB-83 và TXĐB-93 đã được tạo ra bằng tia gamma, nguồn ⁶⁰Co ở 20Krad. Kết quả thử nghiệm cho thấy cả 3 giống đều chống chịu tốt với điều kiện phèn, giống TXĐB-93 chống chịu tốt với điều kiện mặn (0,4%). Hai giống còn lại đang được thử nghiệm tính chịu mặn. Cơm của giống TXĐB-1 vẫn giữ được mùi thơm, hai giống TXĐB-83 và TXĐB-93 là những giống có năng suất cao đạt tiêu chuẩn xuất khẩu. Ghi nhận có sự tương quan thuận giữa màu sắc vỏ trấu và mùi thơm ở các giống đột biến này.