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RICE IMPROVEMENT THROUGH RADIATION- INDUCED MUTATION FOR CULTIVATION IN SOUTH VIETNAM

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For past years, rice varieties cultivated in South Vietnam originated from domestic hybridisation or from IRRI. Rice mutation breeding has been initiated for recent years. To meet the requirement of rice production diversification in different agro-ecological areas and rice genetic resources, from 1993 Institute of Agricultural Science of South Vietnam has carried out rice improvement by induced mutation of radiation. The mutagen was gamma rays of ^{60}Co . The goal is to create inherited variations, which cannot be obtained from other breeding methods, specially important characters of rice varieties (high tolerance to acid sulfate soil, lodging resistance combined with early maturity), which were difficult to gain by hybridisation.

With ^{60}Co gamma rays, doses of 10-20 krad, dose rate of 280 krad/h, dry and germinated seeds of introduced and local rice varieties (IR 64, IR 9729, IR50404, IR 59606, Jasmine 85, Nang Huong, Tam Xoan) were irradiated. The irradiated seeds were immediately sown within 24 and 94 hrs for wet seeds and dry seeds after treatment, respectively. Population of 10,000-15,000 plants were established and evaluated by IRRI evaluation standard from M2-M7 generations.

365 lines, varieties were selected with better behaviours than original varieties as lodging resistance, earliness, potential yield, leaf characters, tolerant ability to adverse conditions etc.

Some good varieties (VND95-19, VND95-20) have been approved as leading national varieties and released for large- scale production in South Vietnam.

1. MATERIALS AND METHODS

1.1. Materials

Experimental materials included original rice varieties (IR64, IR9729, IR50404, IR59606) which having fairly high yield, short duration and some good other characters. However, these varieties have some undesirable behaviours, which need to improve, especially for linkage characters.

Some aromatic rice varieties were Jasmine 85, Nang Huong, Nang Thom Cho Dao which are good quality, but long duration and susceptible to diseases and insects

1.2. Methods

Dry and germinated seeds were treated with gamma rays of ^{60}Co in Nuclear Research Institute, Dalat city, South Vietnam. The doses of 10-20 krad and dose rate of 280 krad/h were applied for seed treatment. The wet seeds were treated at 68-72 hours after soaking and incubating. The dry seeds were broadcasted at 94 hours after irradiating.

Population of 10,000-15,000 plants were established and evaluated by IRRI's evaluation standard from M2-M7 generations.

2. IMPLEMENTED PROCESS

In Summer-Autumn crop 1993, dry and germinated seeds of IR64, IR9729 were irradiated and seeded directly in M1.

In Winter-Spring crop from 1993-1994 to 1995, M2-M5 individual plants were transplanted in lines. The best lines selected for yield trials. In Winter-Spring crop from 1994-1995, promising varieties as VND95-20, VND95-19, VND95-26 were identified through in comparison with control varieties. In 1995-1996 the yield trials of multi-location were carried out in different Agro - ecological areas of HCM city, Dong Nai, Tien Giang, Soc Trang, Long An, Ninh Thuan provinces etc. The pilot-demonstrations of promising varieties were implemented for farmer's evaluation.

Rice varieties as IR50404, IR59606, and IR59656 were irradiated with gamma rays of ^{60}Co from 1995, the selection procedure as the same ways above mention.

1997-1999, results of research and development in mutant varieties were reported. Two varieties: VND95-19 and VND95-20 were approved as national varieties in south Vietnam by scientific council of ISA and Ministry of Agriculture and Rural Development of Vietnam (MARD).

3. RESULTS AND DISCUSSION

3.1 Research and Assessment on Characters of Mutant Varieties

3.1.1 Mutant varieties VND95-19 and VND95-20

Agronomic characters

VND95-20 with growth duration of 90-102 days, which is of 7-10 days shorter than IR64, the original variety. With early maturity, the variety can be cultivated 2-3 crops per year and can avoid flood and drought influence. VND95-19 is the same growth duration as IR64.

These two varieties have better plant types than IR64, stiff stems and non-spreading culm arrangement, therefore that can be able to give higher yield to 1.0-1.5T/ha than IR64 does in the same intensive cultivated conditions.

Two these mutant varieties have larger panicles, more grain number (80-250 grains/panicle) while the original variety has 60-130 grains/panicle. The weight of 1000 grains of two mutant varieties are heavier than IR64 (table 1)

Table 1. Agronomic characters of two mutant varieties VND95-19&VND95-20

Character	VND95-19	VND95-20	IR64 (check)
Growth duration (day)	98-108	90-102	98-110
Plant height (cm)	85-100	85-100	85-100
Stem stiff	Very stiff	Stiff	Less stiff
Seedling vigor (score)	1	3	5
Culm angle (score)	1	1	3
Grains/panicle	80-250	60-200	60 -130
Wt.of 1000 grains (g.)	25 -26	25 -26	24-25
Grain yield (T/ha)	5 -11	5 -10	4-8
BPH (score)	3- 4	3- 5	3-5
Bl (score)	3-5	3 - 5	3-5
ShB (score)	5	5	5
Leaf yellow (score)	5	5	5
Acid sulfate tolerance	Good	Fair	Intermediate

Source: - National Center of Testing and Certification for Crop Cultivars
 - Institute of Agricultural Science of South Vietnam

On tolerance ability, two varieties VND95-19 and VND95-20 are tolerant to disease as well as IR64 in Blast and Leaf Yellow, but VND95-19 is more tolerant to BPH and acid sulfate soil. VND95-20 is more adaptability in comparison with IR64. It has adapted in different locations to the original variety. Two mutant varieties are stronger seedling vigor which can be better competitive to weeds at early stage than IR64.

Physiological characters

Table.2a Some agronomical & physiological characters of new promising lines and varieties

No	Variety	Flag leaf area (cm ²)	Flag leaf angle (score)	Heading To harvest (day)	Harvest index	Fulfilled grain number	Sink Capacity (g/m ²)
1	VND 95-19	41.1	1	29	0.54	119	1020
2	IR60819-34	40.6	1	28	0.55	128	1051
3	IR65619-6	23.6	3	24	0.44	74	800
4	IR65621	25.0	3	24	0.47	65	925
5	OMCS94	26.5	1	24	0.46	77	837
6	IR 64	25.5	1	26	0.47	71	970
	CV%	8			4	5	7
	LSD 0.05	5.3			0.02	10	118

In experiments of assessing physiological characters of mutant varieties in comparison with promising lines of new plant type of IRRI, the results showed that VND 95-19 had some aspects as dry mater yield, chlorophyll content a,b, flag leaf area, harvest index are higher than that of original variety. These natures are closely positive correlation with grain yield (Table 2. a, b).

Table 2b. Some physiological characters and grain yield of new lines & varieties

No.	Variety	Dry matter weight (g/m^2)			Chlorophyll content ($\mu g/ml$)		Grain yield (T/ha)	
		20 DAT	Harvest		5DAH	15DAH	W-S	A-S
			Straw	Panicle				
1	VND95-19	140.9	679.1	820.7	5.49	4.19	7.28	6.09
2	IR60819-34	132.4	646.7	816.3	5.70	4.40	7.57	6.14
3	IR 65619-6	78.5	711.7	560.8	3.58	2.08	5.03	5.13
4	IR 65621	86.1	711.8	627.8	4.23	2.79	5.87	5.32
5	OMCS 94	92.9	696.1	582.5	5.06	3.71	5.73	5.11
6	IR 64	83.9	477.0	622.6	5.30	3.98	5.76	5.36
	CV%		5	3	5			
	LSD 0.05		62	0.30	0.32			

Source : Phan Van Phuc 1999

Remarks : DAT: days after transplanting, DAH: days after heading
W-S: Winter-Spring crop, S-A: Summer-Autumn crop

On grain and panicle characters, VND95-19 consisted of higher total grain number combining with higher percentage of grains with high specific gravity: 56.21% in comparison 43.52% of IR 64 (Table 2d.). This result was the same determination for two crops of W-S and S- A (Table 2c.).

Table 2c. Characters of panicles and grains of promising rice lines & varieties in Summer-Autumn Crop

No.	Variety	Unfulfilled Grains		Intermediate S.G. grains		High S.G. grains		Total Grains
		/pan	%	/pan	%	/pan	%	/pan
1	VND95-19	30	20.7	38	26.6	77	52.7	145
2	IR60819-34	36	23.1	41	26.3	79	50.6	156
3	IR65619-6	30	28.0	52	48.1	26	24.0	108
4	IR65621	26	27.3	38	40.0	31	32.6	95
5	OMCS94	26	25.0	36	34.6	42	40.4	104
6	IR64 (check)	23	24.2	34	35.8	38	40.0	95
	CV%	16				11		
	LSD 0.05	8.2				8.9		

Remarks: Pan.: panicle
S.G.: specific gravity

Table 2d. Characters of panicles and grains of promising rice lines and varieties in Winter-Spring Crop

No	Variety	Unfulfilled Grains		Intermediate S.G.Grains		High S.G. Grains		Total Grains
		/pan	%	/pan	%	/pan	%	/pan
1	VND95-19	27	18.5	37	25.3	82	56.2	145
2	IR60819-34	33	20.5	44	27.3	84	52.2	161
3	IR65619-6	24	24.5	46	46.9	28	28.6	98
4	IR65621	22	25.3	32	36.8	33	37.9	87
5	OMCS94	23	23.0	33	33.0	45	44.0	100
6	IR64 (check)	22	23.4	31	33.0	41	43.6	94
	CV%		9			11	12	
	LSD0.05		3.6			9.2	9.0	

Remarks: Pan.: panicle S.G.: specific gravity

Quality of white rice and cooked rice

VND95-19 and VND95-20 had the same size of grains and milled rice as IR64, VND95-19 has lower 5 % head rice percentage than IR64. Chalkiness of VND95-20 is score 1 which is preferable for export. VND95-19 has light translucent, chalkiness as score 3-5.

The two varieties consist of protein, amylose content and alkali digestion score as the same IR64. Cooked rice of two mutant varieties were rather sticky event at cool cooked rice at 6 hours after cooking (table.3) and preferable taste for consumers.

Table 3. Rice quality of two mutant varieties: VND95-19 and VND95 - 20

Character	VND95-19	VND95-20	IR64 (check)
Grain length (mm)	7.25	7.23	7.20
Grain width (mm)	2.32	2.12	2.30
L/W ratio	3.10	3.40	3.10
Brown rice (%)	80.80	81.60	81.00
White rice (%)	73.00	74.00	72.00
Head rice (%)	50.40	56.70	55.70
Broken rice (%)	22.60	17.30	16.30
Chalkiness (score)	3-5	1	1
Protein (%)	9.30	9.10	9.60
Amylose (%)	20.50	20.00	21.50
Alkali digestion (score)	6	6	6
Stickiness	Fairly sticky	Fairly sticky	Very sticky

Source: - National Center of Testing and Certification for Crop Cultivars (1997)

- Institute of Post Harvest Technology (1997)

3.2 VND98-1 and promising varieties

3.2.1 VND98-1 variety

VND98-1 was induced mutation from IR9729. The variety has main agronomic characters as well as IR9729, original variety: yield, grain quality, and resistant ability to diseases and insects, except growth duration. The growth duration of VND98-1 has 85-92 days that is suitable to 2-3 rice crops per year. On the other hand, VND98-1 has large adaptability in different conditions of the Mekong River Delta.

3.2.2 Promising high yielding rice varieties

IR50404, IR59606, IR59656 have been cultivated in production since 1992 - 1993, however those varieties still have some undesirable behaviours: lodging, low quality of milled rice for export. Several promising mutant lines as VND1, VND6, VND65, VND80, VND126 (induced mutation from IR50404), VND229, VND305, VND361 (from IR59606) and VND404 (from IR59656). These mutant lines have improved characters better than that in the original varieties as: high yield, better quality, resistant ability to diseases, insects and adverse soils. Specially plant type, leaf character of almost mutant varieties are erect, stiff, non-lodging, consequently that support for higher yielding capacity (table 4)

Table 4. Some mutant rice varieties tested in different locations in South Vietnam

Variety	Original varieties	Dose (krad)	Types of treated seeds	Improved characters
VND1	IR50404	10	Germinated	Yield, resist to disease, insect
VND3	IR50404	10	Germinated	Yield, resist to disease, insect
VND6	IR50404	10	Germinated	Yield, resist to disease, insect
VND65	IR50404	10	Germinated	Yield, resist to disease, insect
VND126	IR50404	20	Germinated	Yield, resist to disease, insect
VND229	IR59606	20	Germinated	Yield, resist to disease, insect
VND305	IR59606	20	Germinated	Yield, resist to disease, insect
VND361	IR59606	20	Dry	Yield, resist to disease, insect
VND404	IR59656	20	Dry	Yield, resist to disease, insect
VND95-10	IR64	20	Dry	Earliness, plant type
VND98-1	IR9729	20	Dry	Earliness, plant type

VND361 and VND404 have been tested and produced in large-scale production of MRD, SE, and CCA of South Vietnam. Two varieties yielded 5 to 8 T/ha in Wet and Dry season crops respectively. With 95-105 day-duration, stiff stems, resistance to BPH, BL, YL. , VND361 and VND404 can develop in different agro-ecological areas and crops. Due to good quality, these varieties are produced for export.

On treated genetic materials, the results indicated that germinated seeds treated with 10 krad that induced more effectively desirable characters than that with the same dose for dry seeds. In dry seed treatment, with 20krad, produced more mutant variations of characters and lower dead percentage in comparison with the same dose with germinated seed treatment.

3.2.3. Aromatic rice varieties

Improvement of rice is difficulty in combination of parent characters as aroma, high yield and resistance to diseases and insects in a certain progeny plant due to linkage genes. The induced mutation of radiation is an effective tool for rice breeders.

Many promising lines have been selected from mutant aromatic populations of Jasmine 85, Nang Huong and Tam Xoan varieties irradiated. These lines have higher yield, shorter duration, stiff culm, resistance to BPH, BL.

Table 5. Improved characters of mutant and their check aromatic varieties

No	Character	<u>Jasmine85</u>		<u>Nang Huong</u>		<u>Tam Xoan</u>	
		Mutant	Check	Mutant	check	Mutant	Check
1	Growth duration (day)	100	100	95	165	100	145
2	Plant height (cm)	93	95	90	167	95	135
3	Stiff culm	Good	Fair	Good	Poor	Fair	Poor
4	Weight. of 1000grains (g)	26.5	25.4	26.6	22.4	23.4	20.5
5	Grain yield (T/ha)	4.9	4.2	4.7	3.5	4.3	3.2
6	BPH	MR	MS	MR	S	MS	S
7	BI	MR	MR	MS	MS	MR	MR
8	Aroma	Fair	Fair	Fair	Fair	Strong	Strong

3.3 Results of testing and production

3.3.1 VND95-19 variety

Since 1995-1996, VND95-19 have been tested and produced in for different areas as: Mekong River Delta (MRD), South Eastern Vietnam (SE), Central High Land (CHL), South Central Coast (SCC). VND95-19 gave high yield with 6.4 -10.5T/ha in Winter-Spring crop (Long An, Tien Giang, Dong Thap, Kien Giang, Daklak provinces). Average yield of 8.1T/ha, it is about 1.0-1.5T/ha higher in comparison with IR64 at the same conditions.

In Summer-Autumn crop, generally the variety yielded 4.2-6.5T/ha in various conditions. Due to good plant type, resistant to acid sulfate soil and leading diseases and insects, VND95-19 adapted in areas where having acid sulfate soil and intensive cultivated conditions.

Table 6. Grain yield of VND95-19 and VND95-20 in some provinces of South Vietnam, 1998-1999

Province	Grain yield (T/ha)					
	VND95-19		VND95-20		IR64 (check)	
	W-S*	S-A*	W-S	S-A	W-S	S-A
Tien Giang	6.7-9.8	4.2-6.5	8.4-9.6	5.0-6.7	7.6	4.2
Long An	6.4-10.5	4.5-6.2	5.6-7.1	4.5-5.6	6.5	4.0
Dong Thap	6.7	5.6	7.2	4.8	6.5	4.6
An Giang	10.5	4.7	6.9	5.2	6.0	5.2
Kien Giang	7.5	4.8	7.0	5.4	6.8	-
Can Tho	7.2	-	6.8	5.1	7.1	4.6
Soc Trang	7.8	5.5	7.2	4.7	-	3.8
HCM City	7.1	5.2	6.5	4.8	6.0	4.2
Binh Duong	7.5	5.5	6.9	4.8	5.6	4.2
Binh Thuan	8.2	4.9	8.4	5.1	4.5	4.5
Ninh Thuan	7.8	4.6	7.6	5.0	-	-
DakLak	10.5	5.1	7.1	5.2	6.8	5.4
Average	8.1	5.2	7.2	5.1	6.5	4.4

Remarks : W-S = Winter- Spring, S-A = Summer-Autumn crop

Recently, VND95-19 has being cultivated in Long An, Kien Giang, Dong Thap, Soc Trang, Ben Tre (MRD), Tay Ninh, HCM city, Lam Dong, Ba Ria-Vung Tau (SE), Daklak, Gialai (CHL) Ninh Thuan, Binh Thuan (SCC) provinces. Cultivated areas of this variety estimated up to 65,500 ha in Summer-Autumn crop 1999 and W-S crops 2000 (Table 5& 6)

3.3.2 VND95-20 variety

Since 1996, VND95-20 has been tested and cultivated in MRD, SE, CHL, CSC. In demonstration fields, average yield of VND95-20 got 7.2 T/ha (in Winter- Spring crop) and 5.1 T/ha (in Summer-Autumn) which were 15-20% higher than original variety.

Table 7. Cultivated area of VND95-19 and VND95-20 in some selected provinces of South Vietnam, S-A 1999 and W-S Crops, 2000.

Province, region	Area (ha)		Adapted regions	
	VND95-19	VND95-20	VND95-19	VND95-20
Long An, Dong Thap, Kien Giang, Soc Trang, Tien Giang, Can Tho (MRD)	38,000	150,500	Acid sulfate soil (ASS) (2 crops/year)	Alluvial soil, light acid sulfate (3 crops/year)
Tay Ninh, HCM city, Binh Duong, Dong Nai, Lam Dong (SE)	10,500	12,500	Acid sulfate soil	Intensive cultivation
Daklak, Gialai-Kontum (CHL)	4,500	4,000	Intensive cultivation	Intensive cultivation
Binh Thuan, Ninh Thuan, Phu Yen, Binh Dinh (CSC)	12,500	9,500	Intensive cultivation, ASS.	Intensive cultivation
Total area	65,500	176,500		

At present, VND95-20 is a leading variety in a varietal group of good quality for export in South Vietnam. Cultivated area of VND95-20 is speedily increased due to the variety having preferable characters as very early, high yield, good grain quality, large adaptability.

Nowadays, the cultivated areas is developed in more 176,500 ha in different regions, specially in MRD (Table 6)

3.3.3 VND 98-1 variety and other promising mutant varieties

VND 98-1 was tested and planted in pilot - production in MRD, the variety is very short growth duration (85-92 days), high yield and good grain quality. Therefore, in many locations, this variety has been rapidly developed, especially in regions which affected by flood and drought.

Promising varieties as VND1, VND6, VND65, VND229, VND230, VND305, VND361, VND 404 have being tested and produced in multi-locations at SE, CSC, those varieties seem to be adapted in intensive cultivated areas, acid sulfate soil areas, and in both two crops (W-S and S-A crop). Nowadays those varieties have been cultivated in large scale production of South Vietnam. VND361 and VND404 are suggested as regional varieties.

4. CONCLUSIONS

Through these results of trials and large-scale production, mutant rice varieties indicated some properties as following:

- VND95-19 variety can yield more than 10T/ha, better plant type, more resistant to lodging and acid sulfate soil than the original variety.
- VND95-20 variety can give higher yield up to 15-20 % in comparison with original variety at the same conditions. The variety is more adaptability, good quality, shorter growth duration and can be suitably cultivated with 3 crops per year.
- Promising lines and varieties as VND98-1, VND1, VND6, VND65, VND229, VND305, VND361, VND 404 have better behaviors as higher yield, stiff stems, high tolerance to acid sulfate soil than original varieties.
- Mutant varieties above have been stable for many crops in large-scale production. Cultivated area of two new national varieties in South Vietnam estimated, Winter-Spring crop 1999-2000 as 65,500 ha and 176,500 ha for VND 95-19 and VND 95-20 variety, respectively.
- Induced mutation of radiation is effective to apply in improvement of aromatic rice varieties combined with other desirable characters .
- Radiation - induced mutation is an effective method in rice improvement; especially for application in the case of improvement of plant type and other agronomic, physiological characters that conventional methods are too difficult to be implemented

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