

A high yield glutinous rice "wx 126"

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多收性 찰벼 wx 126의育成

許文會

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ABSTRACT

From the cross Tongil²//IR833/IR1317 glutinous rice lines wx126 were bred. Some of the lines were earlier than standard variety and later than the glutinous check variety. Some of them yielded as much as standard variety and showed better resistances to blast, stripe disease and less brown plant hoppers than standard variety.

INTRODUCTION

About 50,000ha of paddy are planted to the glutinous rice varieties in Korea.⁹⁾ Their yield is much less (about 210kg/a)¹⁰⁾ than non-glutinous common rice. According to the Crop Experiment Station yield trial data,⁴⁾ glutinous rice varieties yielded 427-469kg/10a of brown rice. Less efforts so far were made in the improvement of glutinous rice varieties. Most of glutinous rice varieties grown in Korea are either the pure line selections from the old local varieties or introductions from Japan.

Because of constant demands in the market and home uses, most of farmers grow glutinous rice to some limited areas constantly in spite of lower yield. rice. If a glutinous rice variety which can yield as much as "Tongil" variety is bred, the

acreage to be planted by glutinous rice will be increased.

Harlan & Pope⁵⁾ suggested the back-cross method which is relatively efficient when a simple genetic trait of a non practical variety is to be transferred to a practical variety. Hence the back-cross technique was utilized in wheat by Briggs,²⁾ in maize by Richey,¹²⁾ in cotton by Knight⁸⁾ in tobacco and tomato by Thomas¹³⁾ and in other crops by many other breeders.¹⁵⁾ Briggs & Allard³⁾ pointed out three requirements for the success of back-cross breeding. They are a) the existence of satisfactory recurrent parent, b) retainability of doner character through the back-cross procedure, and c) the use of sufficient back-crosses. The variety "Tongil" which is newly bred high yielding non-glutinous would be qualified as a recurrent parent because of its simply inherited productive plant type character. The waxiness is controlled by single recessive gene,^{11,14)} and the retainability is expected to be perfect.

This paper reports the procedures which a "Tongil" typed glutinous rice wx 126 lines were bred through the back-cross technique. Some agronomical characteristics of the lines bred are also reported briefly.

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PARENTS AND HYBRID DEVELOPMENTS

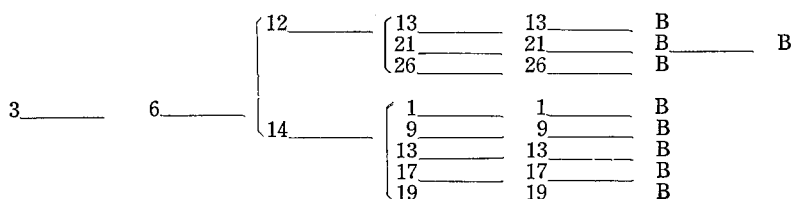
A semi-dwarf glutinous rice line IR 833-28-1-1-1 was crossed to a semi-dwarf medium early line IR 1317-315-5-B to transfer the waxiness into semi-dwarf high productive plant type. IR 833 is a cross between Gampai 15 and IR 262. Gampai 15 is a tall photo-sensitive Thailand glutinous variety and IR 262 is a photo-less-sensitive semi-dwarf variety derived from the cross Peta³/TNI. The cross IR 833 and IR 1317 is wx 13. The wx 13 was crossed by IR 667-98-1-2-2 pollen. It was assigned as wx 51. Among 12 hybrid plants of wx 51, 6 plants carried waxy pollen. This heterozygous waxy plants were crossed back by IR 667-98-1-2-2. This new cross was assigned as wx 126. The parent IR 667-98-1-

2-2 is the pedigree of "Tongil" which was named in 1971 as leading variety in Korea. The pedigree of wx 126 lines are shown in Table 1. Pollen of all the F₁ plants of wx 13, wx 51 and wx 126 were tested for the waxiness with potassium-iodide solution. Only plants which carrying waxiness were used as parent of next cross or next generation.

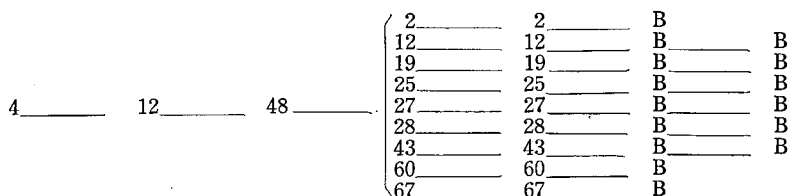
The original cross wx 13 was made in September and seeded in November 1970 in the greenhouse. The second cross wx 51 was seeded in March 1971, and the last cross wx 126 was seeded following July. During first one month after seeding, plants were grown under 16 hours long-day condition then they were kept 8 hours short-day condition until heading. During 1971-1972 winter, 150 glutinous F₂ seedlings of wx 126 were grown in greenhouse and 150 F₃ of wx 126 were grown out during 1972 summer in the field. 17 lines among 150 F₃ were bulk harvested and 7 of them were sent to IRRI where they were advanced one more generation during 1972-

Table 1. Pedigree of wx126.

| Cross No. or generation | wx13 F ₁ | wx51 F ₁ | wx126 F ₁ | F ₂ | F ₃ | F ₄ | F ₅ |
|-------------------------|----------------------------------|------------------------|----------------------|----------------|----------------|----------------|----------------|
| Combination | IR1317-315-5-B / IR 833-28-1-1-1 | wx13 / IR 667-98-1-2-2 | | | | | |



Pedigree



| Planting date | Nov. 2, '70 | Mar. 1, '71 | July 9, '71 | Dec. 1, '71 | Apr. 27 '72 | Dec. 1, '72 | Apr. 25, '73 |
|---|-------------|-------------|-------------|-------------|-------------|-------------|--------------|
| No. of days to heading | 71-74 | 60-69 | 90-100 | 80-91 | 99-119 | 81-88 | 97-103 |
| No. of plants or lines planted | 10 | 12 | 48 | 150 | 150 | 17 | 17 |
| No. of hetero wx plants or selected lines | 10 | 6 | 17 | 150 | 17 | 17 | |

1973 winter. During 1973, 7 of F₅ and 12 of F₄ lines (indicated by B in the table 1) were tested for their performance and their agronomical characteristics.

Performance test were made at 5 locations during 1973. At Suwon College farm and Chyongju Provincial ORD farm, 3 plantings that is early, ordinary and late season culture, were made with 17 lines. At Suwon Crop Experiment Station, ordinary season culture was made with 2 levels of nitrogen fertilizer that is ordinary and 1.5 times heavy amount. At both Honam and Youngnam Crop Experiment Station, ordinary season culture was made with ordinary amount of fertilizer. At the 3 Crop Experiment Stations only 7 of F₅ lines were tested. Among 17 lines tested in 1973, the most promising 2 lines, wx 126-12-21 and wx 126-48-67, were sent to the ORD for further tests in 1974.

AGRONOMICAL CHARACTERISTICS

All of the wx 126 lines which have tested were earlier 5 to 10 days than "Tongil" and later 5 to 10 days than "Olchal" under ordinary season culture as shown in table 2. This earliness is thought to be derived from the parent IR 1317-315-5-B.

All of the tested lines showed better exertion with longer culm length unlike "Tongil". This also seems to be derived from IR 1317-315-5-B parent. All the parents involved in this hybrid, though had essentially the same semi-dwarf gene, hybrids showed some modifying effects to the semi-dwarf gene.

Panicle length, number of panicles and number of grains per panicle were not much different from the recurrent parent except a line 48-43 which showed

Table 2. Agronomical characters of wx-lines. (Ordinary amount fertilizer in ordinary season at Coll. of Agri, S.N.U. 1973)

| Pedigree | Heading date | Culm length | Panicle length | No. of Panicles per hill | No. of grains per pan. | Maturity rate | 1,000 grains | | Brown rice to rough rice | ADV | Blast | | Bacteria | SPH | BPH | GPH |
|-------------|--------------|-------------|----------------|--------------------------|------------------------|---------------|--------------|------|--------------------------|-----|---------|-------|----------|-----|-----|-----|
| | | | | | | | wt. | % | | | Nursery | IA-65 | | | | |
| wx126-12-13 | Jul. 31 | 66.3 | 20.8 | 16.3 | 122.0 | 84.5 | 26.4 | 81.3 | 2.8 | HR | MS | HS | R | MS | M | |
| -21 | Aug. 1 | 68.8 | 23.1 | 14.5 | 138.0 | 83.7 | 25.0 | 81.0 | 2.7 | HR | HR | HS | R | MR | S | |
| -26 | Aug. 4 | 68.4 | 22.5 | 14.6 | 151.7 | 70.8 | 23.8 | 81.2 | 2.7 | HR | HR | HS | M | S | S | |
| -14-1 | Aug. 3 | 68.1 | 22.4 | 15.6 | 117.3 | 82.2 | 24.1 | 80.8 | 2.6 | HR | HR | HS | R | MS | MS | |
| -9 | Aug. 1 | 68.6 | 23.5 | 14.9 | 140.0 | 82.9 | 25.1 | 80.7 | 2.4 | HR | R | HS | R | MR | S | |
| -13 | Aug. 5 | 73.8 | 23.2 | 16.4 | 125.0 | 80.9 | 24.7 | 81.0 | 2.9 | HR | R | MS | | S | MS | |
| -17 | Aug. 4 | 70.4 | 23.4 | 14.4 | 127.0 | 89.4 | 24.5 | 81.7 | 2.8 | HR | MR | S | R | HS | S | |
| -19 | Aug. 4 | 69.9 | 22.9 | 15.4 | 133.7 | 81.5 | 24.6 | 80.8 | 2.6 | HR | MR | HS | R | MS | MS | |
| -48-2 | Aug. 2 | 74.4 | 21.7 | 13.8 | 165.3 | 64.3 | 20.9 | 80.2 | 2.6 | HR | R | MS | R | HS | S | |
| -12 | Aug. 2 | 73.1 | 21.8 | 15.7 | 129.3 | 63.5 | 22.6 | 81.3 | 2.6 | HR | MR | HS | R | S | M | |
| -19 | Jul. 31 | 73.2 | 23.2 | 14.5 | 125.7 | 79.5 | 24.6 | 80.8 | 2.8 | HR | MR | HS | MR | MS | MS | |
| -25 | Aug. 4 | 73.1 | 21.3 | 15.1 | 152.0 | 81.5 | 25.3 | 81.3 | 3.2 | HR | MR | MS | M | S | MS | |
| -27 | Aug. 3 | 73.3 | 21.0 | 14.0 | 128.7 | 68.2 | 22.6 | 81.0 | 2.6 | HR | MR | HS | R | S | S | |
| -28 | Aug. 4 | 72.4 | 21.0 | 15.7 | 130.0 | 71.8 | 23.9 | 81.3 | 2.7 | HR | HR | MS | R | S | S | |
| -43 | Aug. 4 | 75.6 | 22.1 | 14.2 | 178.3 | 71.0 | 23.1 | 81.3 | 2.9 | HR | R | HS | R | S | M | |
| -60 | Aug. 2 | 70.5 | 21.9 | 14.1 | 134.0 | 72.4 | 25.8 | 80.7 | 2.9 | HR | MS | MR | R | S | MR | |
| -67 | Aug. 3 | 73.9 | 22.5 | 13.6 | 131.0 | 75.9 | 25.4 | 81.2 | 3.1 | HR | HR | HS | R | MR | S | |
| Ol Chal | Jul. 25 | 80.3 | 19.3 | 17.4 | 89.0 | 69.3 | 22.7 | 81.0 | 2.8 | R | HS | — | — | — | — | |
| Tong-il | Aug. 10 | 65.6 | 19.9 | 15.7 | 120.7 | 80.2 | 26.6 | 81.8 | 3.5 | R | HR | S | M | MS | MS | |
| Jin heung | Aug. 17 | 95.3 | 20.3 | 14.3 | 98.3 | 80.9 | 27.2 | 83.8 | 4.9 | S | HS | HS | S | S | S | |

Table 3. Yield of wx 126 lines in 1973.

| Pedigree | S.N.U. | | | Cheong ju | | | Suwon C.E.S. | | | | Mean | Ratio to Olchal | Ratio to Tongil | Ratio to Jinheung | |
|-------------|--------|-------|-------|-----------|-------|-------|--------------|-------|-------|-------|------|-----------------|-----------------|-------------------|-------|
| | E. | O. | L. | E. | O. | L. | Stand- | Ho- | Yeon- | | | | | | |
| | | | | | | | ard | heavy | nam | gnam | | | | | fer. |
| wx126-12-13 | 661.6 | 615.8 | 562.0 | 621.1 | 599.8 | 579.9 | | | | | | 606.6 | 175.1 | 102.0 | 126.3 |
| -21 | 636.6 | 617.8 | 572.8 | 605.8 | 621.8 | 595.9 | 557.7 | 628.5 | 516.9 | 603.9 | | 595.8 | 172.0 | 100.4 | 124.0 |
| -26 | 593.2 | 585.9 | 454.3 | 581.9 | 574.0 | 572.3 | | | | | | 561.5 | 162.1 | 94.7 | 116.9 |
| -14-1 | 591.5 | 578.1 | 444.4 | 591.3 | 560.3 | 529.2 | | | | | | 549.1 | 158.6 | 92.6 | 114.3 |
| - 9 | 608.8 | 549.0 | 481.7 | 631.7 | 584.5 | 568.0 | | | | | | 570.6 | 164.8 | 92.2 | 118.8 |
| -13 | 577.1 | 551.9 | 522.3 | 591.8 | 565.7 | 561.5 | | | | | | 561.7 | 162.2 | 94.7 | 116.9 |
| -17 | 590.4 | 587.2 | 480.9 | 495.1 | 542.5 | 516.1 | | | | | | 535.4 | 154.6 | 90.3 | 111.5 |
| -19 | 617.5 | 583.6 | 523.6 | 615.2 | 601.9 | 573.3 | | | | | | 585.9 | 169.2 | 98.8 | 122.0 |
| -48-2 | 488.7 | 401.9 | 398.5 | 617.9 | 571.2 | 562.7 | | | | | | 506.8 | 146.3 | 85.4 | 105.5 |
| -12 | 554.1 | 470.3 | 464.8 | 634.0 | 638.1 | 602.6 | 487.7 | 557.5 | 468.0 | 599.4 | | 547.7 | 158.2 | 92.3 | 114.0 |
| -19 | 523.6 | 499.3 | 428.0 | 509.0 | 457.9 | 477.3 | 548.1 | 619.1 | 516.0 | 639.2 | | 521.8 | 150.7 | 88.0 | 108.6 |
| -25 | 671.2 | 605.8 | 536.5 | 625.8 | 645.2 | 559.4 | 544.9 | 608.5 | 530.0 | 638.4 | | 593.9 | 171.5 | 100.1 | 123.1 |
| -27 | 592.9 | 492.0 | 494.8 | 670.2 | 672.1 | 596.5 | 538.1 | 596.6 | 504.5 | 654.0 | | 581.2 | 167.8 | 98.0 | 121.0 |
| -28 | 665.4 | 572.4 | 527.4 | 622.2 | 622.4 | 590.0 | 508.7 | 569.0 | 500.0 | 645.1 | | 586.3 | 169.3 | 98.8 | 122.1 |
| -43 | 633.0 | 491.3 | 514.0 | 705.1 | 621.5 | 614.3 | 519.7 | 593.2 | 498.0 | 631.8 | | 582.2 | 168.1 | 98.1 | 121.2 |
| -60 | 587.3 | 523.3 | 509.7 | 586.3 | 518.3 | 566.3 | | | | | | 548.5 | 158.4 | 92.5 | 114.2 |
| -67 | 598.7 | 529.7 | 465.8 | 708.6 | 674.2 | 646.9 | | | | | | 604.0 | 174.4 | 101.8 | 125.8 |
| Ol Chal | 403.3 | 326.4 | 447.4 | 192.2 | 362.8 | 416.4 | 390.8 | 473.2 | 165.0 | 285.1 | | 364.3 | 100.0 | 58.4 | 72.1 |
| Tong-il | 633.3 | 564.4 | 576.8 | 619.8 | 606.4 | 612.0 | 563.3 | 605.9 | 530.0 | 620.0 | | 593.2 | 171.3 | 100.0 | 123.5 |
| Jin heung | 531.4 | 412.6 | 506.9 | 434.5 | 459.7 | 467.0 | 499.1 | 540.4 | — | — | | 480.3 | 138.7 | 81.0 | 100.0 |
| L.S.D. | 5% | 56.9 | 71.9 | 54.5 | 59.3 | 59.7 | 42.7 | 30.6 | 58.9 | 30.7 | 45.1 | | | | |
| | 1% | 76.1 | 96.2 | 72.9 | 79.3 | 79.9 | 57.2 | 41.9 | 80.7 | 42.0 | 62.5 | | | | |

club panicle type. For the grain size, there were some variability among the tested lines. That is, the 1,000 grain weight ranged from 20.9 grams to 26.4 grams. The lighter in 1,000 grain weight, were generally the slender in grain shape. Brown rice recovery ranged from 80.2% to 81.7%. This is essentially equal to "Olchal" and slightly lighter than "Tongil". But, it is significantly lighter than "Jinheung". Alkali-digestibility is also almost same as other glutinous rice ranging from 2.4 to 3.2.

The blast resistance were tested at two blast nurseries that is one was made at ordinary blast nursery and the other was made at isolated nursery where the new blast race IA-65 was inoculated. In the ordinary blast nursery, all the tested lines showed HR but in the isolated nursery, reactions were variable as shown in table 2. Against to the bacterial blight, non of the line showed resistance.

Resistance to the smaller brown plant hoppers were R to MR while the resistance to the brown plant hopper and green leaf hopper were S to MS. Thus, the resistance to the diseases and insect pests of the bred lines were not worse than "Tongil" nor "Jinheung", but improved much from "Olchal".

Grain yield were tested in 10 experimentations made at 5 different locations as shown in table 3. Yield of wx 126 lines ranged from 5.07 to 6.06 ton/ha. This is the increase of 46-75% of "Olchal". Non of the bred line yielded less than the common recommended variety "Jinheung". At S.N.U. (College farm), 14 lines in early season culture, 14 lines in ordinary season culture and 6 lines in late season culture yielded as much as "Tongil" or more than it. At Cheongju (Chungchong-puk-do Provincial Office of Rural Development farm), 15 lines in early season culture, 14 lines in ordinary season culture and 9 lines in late season culture yielded as much

as "Tongil" or more than it. At both locations, the earlier planting yielded the more. At 3 Crop Experiment Stations, only 7 lines among 17 lines were tested. 4 lines at Suweon C.E.S., 2 lines at Honam C.E.S. and all of the 7 lines at Youngnam C.E.S. yielded as much as "Tongil" or more than it. Most of the lines showed favourable fertilizer response as we see in Suweon C.E.S. heavier fertilizer plots. In average, 8 lines out of 17 tested, showed the same productivity of "Tongil".

DISCUSSIONS

The results of International blast nursery test which started by F.A.O. and later on took over by IRRI, instigated the rice breeder to practice the remote crosses utilized Indica varieties in Korea. While, the semi-dwarf plant type gene was also attractive to the rice breeder.¹⁾ The combined application of these two disciplines that is remote crossing and dwarfing, were treated as indifferently in this country until 1969 when the semi-dwarf plant type IR 667 received first attention. Dwarfness not necessarily accompany high productivity but highly productive semi-dwarf plant type derived from "I-geo-ge" could be identified from other dwarfness with moderate confidence. For yield wise, no better plant type gene is utilized in this country at present.

The semi-dwarf variety "Tongil" which is selected from IR 667 cross in Korea, is a good yielding variety, and deserves as a good recurrent parent in back-cross breeding program. The glutinous rice is controlled by one recessive gene wx ,^{11,14)} and has perfect heritability. Moreover, this character can be easily distinguished by chemical aids before pollination. To transfer the glutinous rice to "Tongil" from any glutinous variety is simple matter, but to avoid the hybrid sterility is not predictable simplicity. The induction of wx gene from IR 833 to "Tongil", as a result, was not a illegitimate one, though the wx 126 lines do not possess fully recovered "Tongil" plant type.

Selections for the yield were not practiced during proceeding until F_3 of last cross. Nevertheless, the bred lines yielded essentially the same yield of rec-

urrent parent. This may imply that, semidwarf plant type of recurrent parent has potentiality to bring high yield under reluctant environments and that, this potential plant type has relatively high heritability.

It was suggested earlier by this writer that the back-cross technique could be applied in rice breeding efficiently.⁹⁾ From the result of this program it was also proved that the back-cross breeding technique is efficient in rice improvement too.

Most of the wx 126 lines show wide variability in many traits yet, but their pronounced high yield and grain appearance deserves to be released as a variety. Many blemishes they still remain will be ameliorated through further efforts.

SUMMARY

From the cross Tongil²//IR 833/IR 1317 glutinous rice lines wx 126 were bred. Some of these lines were earlier than standard variety and later than glutinous check variety. Some of them yielded as much as standard variety and showed better resistances to blast, stripe diseases and smaller brown plant hopper than standard variety. It was discussed that, through the breeding procedure, following points were proved, 1) back-cross program in rice breeding was efficient, 2) semi-dwarf plant type of "Tongil" has high yielding potentiality and 3) the variety "Tongil" was a good for recurrent parent for back-cross program.

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摘 要

“통일”과 같은 程度의 耐病 · 耐倒伏 · 多收性인 semidwarf 찰벼 品種을 育種하고자 통일²/IR833/IR1317의 連續交配 F₂ 世代까지를 溫室에서 繼代養成하고 F₃ 世代에서 圃場選拔을 하여 그들의 F₄ 또는 F₅ 世代에서의 特性 및 收量性を 檢定하였다. 그 結果를 要約하면 다음과 같다.

1. wx126 F₅ 계통들 중에는 “통일”과 같은 程度의 收量性を 갖인 계통들이 있었다.
2. 이들 계통들은 出穗期 · 耐病性 · 耐蟲性等도 “통일”과 同等하거나 그보다 우수하였다.
3. 비교적 短期間에 小面積에서 實用品種을 育成하는데 Back-cross 育種法이 有效하였다.
4. “통일”은 短稈多收性 誘導를 爲한 反復親으로서 有效하였다.
5. 一回親의 찰 形質은 數回 back-cross하는 동안에도 그 特性이 變하지 않았다.