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(54) **RICE TRANSPOSON GENES**

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(57) **ABSTRACT**

The present invention relates to a nonautonomous transposon gene, autonomous transposon gene and transposase gene of rice (*Oryza sativa*); and a method to transpose the transposon gene; and transformed plants by the transposition.

The inventors examined nucleotide sequence of rice genomes and discovered nonautonomous transposon genes, autonomous transposon genes and transposase genes and confirmed the transposition of a transposon in the rice cultivars transduced these genes.

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Nov. 8, 2001 (JP) 2001-343002
Jan. 18, 2002 (JP) 2002-9729

Figure 1

144010	144020	144030	144040	144050	144060	
TTTCAAGTAC	AATCTCAACT	TAGGAAAAGT	TGTGATTGAG	GGAGGATGTT	AGATAATGTT	
144070	144080	144090	144100	144110	144120	
AGTTAGTTTG	TTATAGAGAT	AGATTAGTTC	TGTTACCGCA	TGTACTTTCT	TGTATCTATC	
144130	144140	144150	144160	144170	144180	
TCTATATCCA	GGATTGTCTC	ASGTTGTIGA	GATTAATCCT	ATCCTTTGTA	CACGCCACGG	3' LTR
144190	144200	144210	144220	144230	144240	
FAGAGGCTCT	TTCTGCCTAT	ATCAACAAAG	GTGCGGCCCC	GTAAAGGGGT	TCAACGCTTC	
144250	144260	144270	144280	144290	144300	
TCATTCCGTT	TTACAATCCT	CCTTCTTCT	CCTGGTGTG	GAAATTCGTT	GATCGAGTTG	
144310	144320	144330	144340	144350	144360	
AAACTCTCAT	CCTTCATCAT	GTGCTGCAGA	AACTAACGCG	TGCACAGATG	ATGGATGGGT	
144370	144380	144390	144400	144410	144420	
GTGGTGTGAC	ATGAAAGTGG	ATCAATGACA	CGCGGCACAT	TTAGGGGAGT	GTGTCGTGTC	
144430	144440	144450	144460	144470	144480	
TTGACTTCTT	CATGCAAAAG	TATACCAACC	CTGTATAAGG	CCAGTCACAA	TGGCTAGTGT	
144490	144500	144510	144520	144530	144540	
CATTGCACGG	CTACCCAAAA	TATTATACCA	TCTTCTCTCA	AATGAAATCT	TTTATGAAAC	
144550	144560	144570	144580	144590	144600	
AATCCCCACA	GTGGAGGGGT	TTCACTTTGA	CGTTTCCAAG	ACTAAGCAAA	GCATTTAATT	
144610	144620	144630	144640	144650	144660	
GATACAAGTT	GCTGGGATCA	TTTGTACCCA	AAATCCGGCG	CGGCGCGGGA	GAATGCGGAG	Inverted Repeats
144670	144680	144690	144700	144710	144720	
GTCGCACGGC	GGAGGCGGAC	GCAAGAGATC	CGGTGAATGA	AACGAATCGG	CCTCAACGGG	
144730	144740	144750	144760	144770	144780	
GGTTTCACTC	TGTTACCGAG	GACTTGGAAA	CGACGCTGAC	GAGTTTCACC	AGGATGAAAC	
144790	144800	144810	144820	144830	144840	
TCTTTCCTTC	TCTCTCATCC	CCATTTCATG	CAAATAATCA	TTTTTTATTC	AGTCTTACCC	
144850	144860	144870	144880	144890	144900	
CTATTAAATG	TGCATGACAC	ACCAGTGAAA	CCCCATTGT	GACTGGCCTA	AGCATCTTTG	

Figure 2

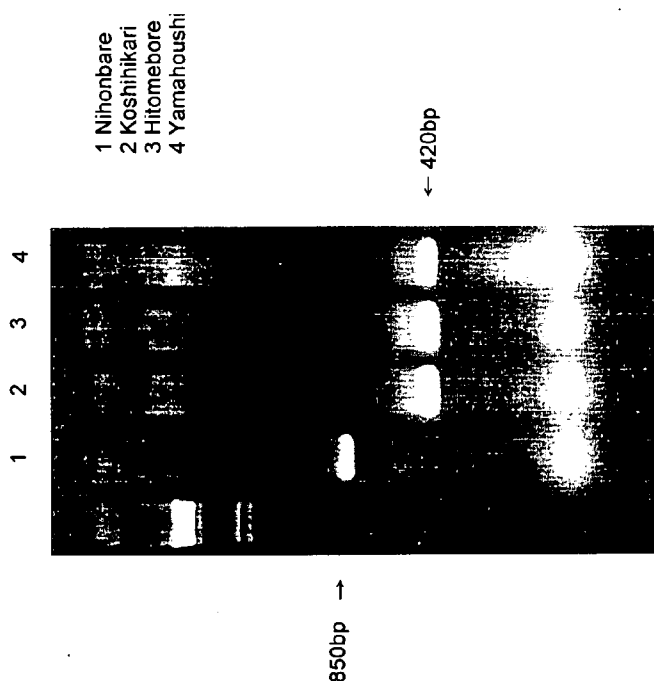


Figure 3

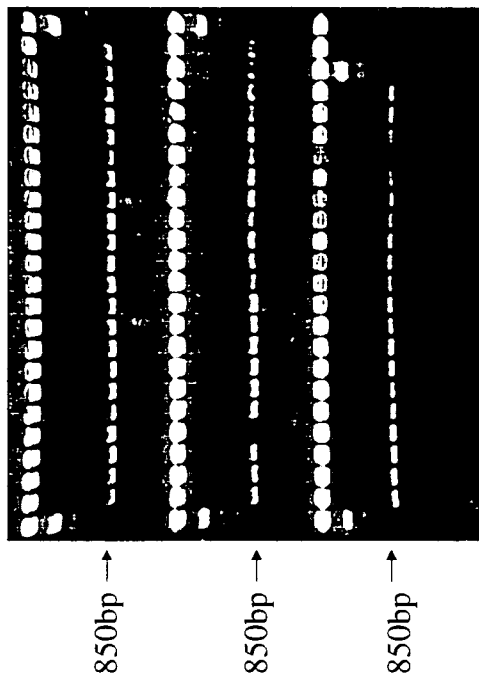


Figure 4

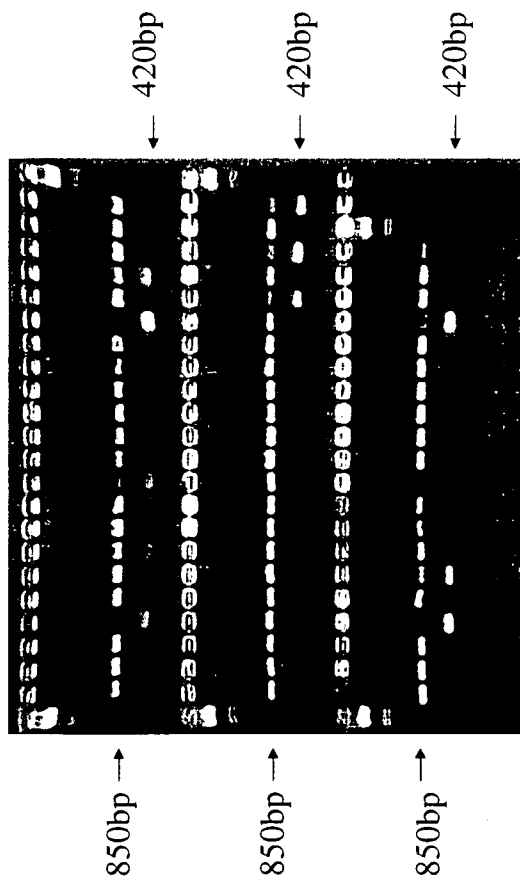


Figure 5

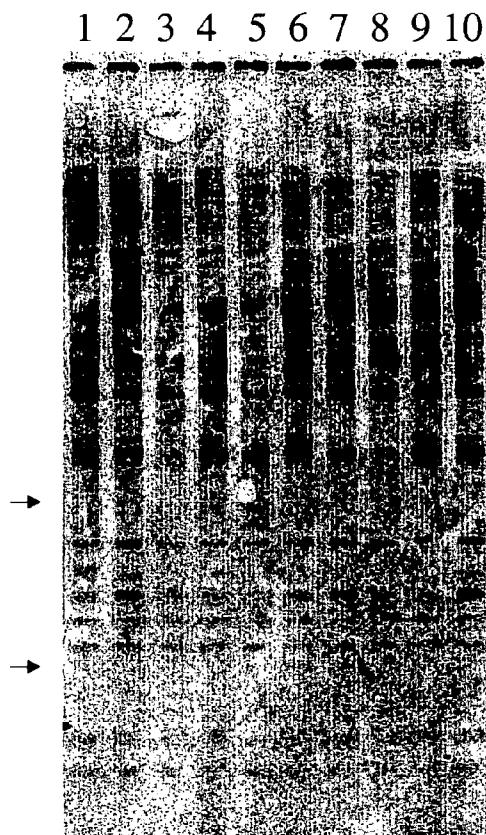


Figure 6



Figure 7

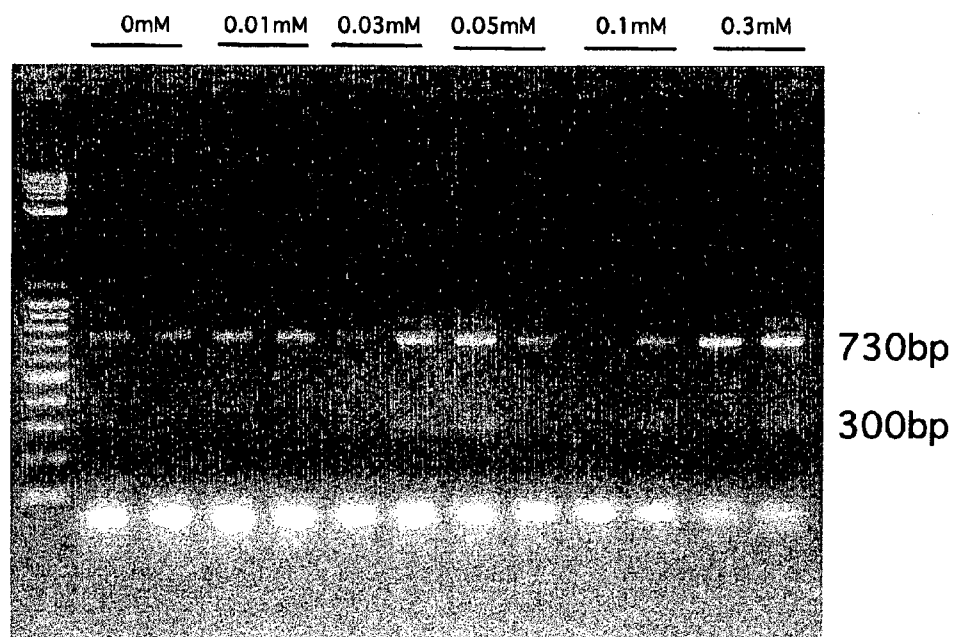


Figure 8

L05	ATGTAGTTTG	TCGGTAAGTT	TGATTATCAC	GGTAACCACA	AGTCAAGGGA
AzaC-callus1	ATGTAGTTTG	TCGGTAAGTT	TGATTATCAC	GGTAACCACA	AGTCAAGGGA
AzaC-callus2	ATGTAGTTTG	TCGGTAAGTT	TGATTATCAC	GGTAACCACA	AGTCAAGGGA
AzaC-callus3	ATGTAGTTTG	TCGGTAAGTT	TGATTATCAC	GGTAACCACA	-----
AzaC-callus4	ATGTAGTTTG	TCGGTAAGTT	TGATTATCaC	GGTAAC----	-----
L05	AAGATATGGA	CTCCTTAATA	AGGCCAGTCA	CAATGGGGGT	TTCACTGGTG
AzaC-callus1	AAGATATGGA	CTCCTTAA--	-----	-----	-----
AzaC-callus2	AAGATATGGA	CTCCTTAATA	A-----	-----	-----
AzaC-callus3	-----	-----	-----	-----	-----
AzaC-callus4	-----	-----	-----	-----	-----
L05	TGTCATGCAC	ATTTAATAGG	GGTAAGACTG	AATAAAAAAT	GATTATTTGC
AzaC-callus1	-----	-----	-----	-----	-----
AzaC-callus2	-----	-----	-----	-----	-----
AzaC-callus3	-----	-----	-----	-----	-----
AzaC-callus4	-----	-----	-----	-----	-----
L05	ATGAAATGGG	GATGAGAGAG	AAGGAAAGAG	TTTCATCCTG	GTGAAACTCG
AzaC-callus1	-----	-----	-----	-----	-----
AzaC-callus2	-----	-----	-----	-----	-----
AzaC-callus3	-----	-----	-----	-----	-----
AzaC-callus4	-----	-----	-----	-----	-----
L05	TCAGCGTCGT	TTCCAAGTCC	TCGGTAACAG	AGTGAAACCC	CCGTTGAGGC
AzaC-callus1	-----	-----	-----	-----	-----
AzaC-callus2	-----	-----	-----	-----	-----
AzaC-callus3	-----	-----	-----	-----	-----
AzaC-callus4	-----	-----	-----	-----	-----
L05	CGATTCGTTT	CATTCACCGG	ATCTCTTGCG	TCCGCCTCCG	CCGTGCGACC
AzaC-callus1	-----	-----	-----	-----	-----
AzaC-callus2	-----	-----	-----	-----	-----
AzaC-callus3	-----	-----	-----	-----	-----
AzaC-callus4	-----	-----	-----	-----	-----
L05	TCCGCATTCT	CCCGCGCCGC	GCCGGATTTT	GGGTACAAAT	GATCCCAGCA
AzaC-callus1	-----	-----	-----	-----	-----
AzaC-callus2	-----	-----	-----	-----	-----
AzaC-callus3	-----	-----	-----	-----	-----
AzaC-callus4	-----	-----	-----	-----	-----
L05	ACTTGATCA	ATTTAATGCT	TTGCTTAGTC	TTGGAAACGT	CAAAGTGAAA
AzaC-callus1	-----	-----	-----	-----	-----
AzaC-callus2	-----	-----	-----	-----	-----
AzaC-callus3	-----	-----	-----	-----	-----
AzaC-callus4	-----	-----	-----	-----	-----
L05	CCCCTCCACT	GTGGGGATTG	TTTCATAAAA	GATTTTCATT	GAGAGAAGAT
AzaC-callus1	-----	-----	-----	-----	-----
AzaC-callus2	-----	-----	-----	-----	-----
AzaC-callus3	-----	-----	-----	-----	-----
AzaC-callus4	-----	-----	-----	-----	-----
L05	GGTATAATAT	TTTGGGTAGC	CGTGCAATGA	CACTAGCCAT	TGTGACTGGC
AzaC-callus1	-----	-----	-----	-----	-----
AzaC-callus2	-----	-----	-----	-----	-----
AzaC-callus3	-----	-----	-----	-----	-----
AzaC-callus4	-----	-----	-----	-----	-----
L05	CTAACACTGA	ACTGATCAAA	GAGCATTAT	TATGGAAAGA	TGATTGTGTC
AzaC-callus1	----CACTGA	ACTGATCAAA	GAGCATTAT	TATGGAAAGA	TGATTGTGTC
AzaC-callus2	----CACTGA	ACTGATCAAA	GAGCATTAT	TATGGAAAGA	TGATTGTGTC
AzaC-callus3	-----CTGA	ACTGATCAAA	GAGCATTAT	TATGGAAAGA	TGATTGTGTC
AzaC-callus4	-----ACTGA	ACTGATCAAA	GAGCATTAT	TATGGAAAGA	TGATTGTGTC

Figure 9

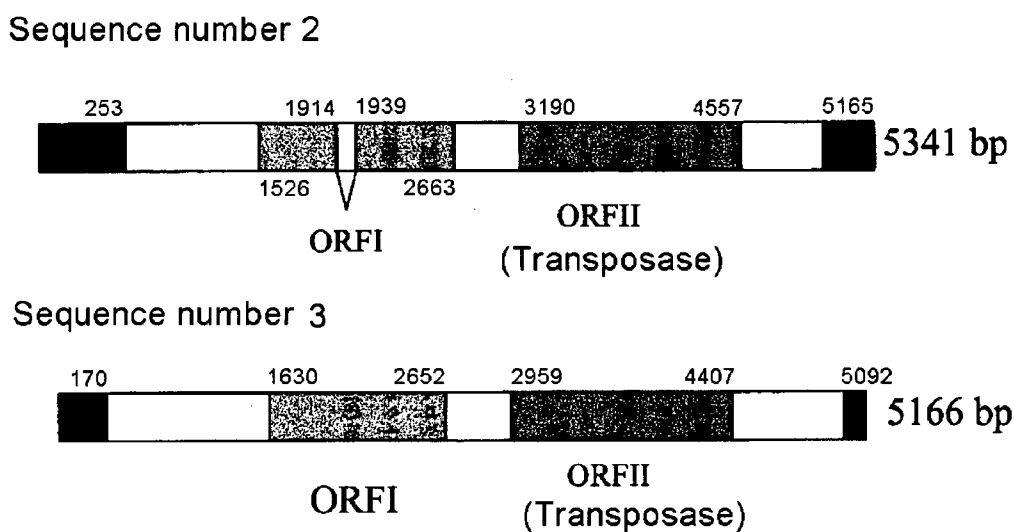


Figure 10

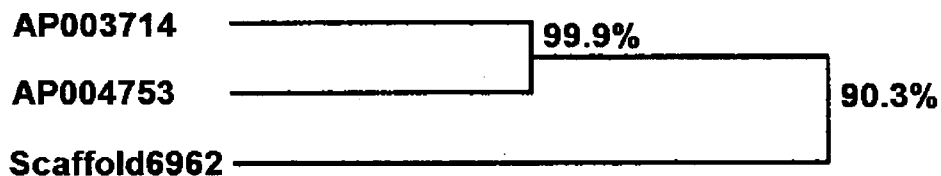


Figure 11

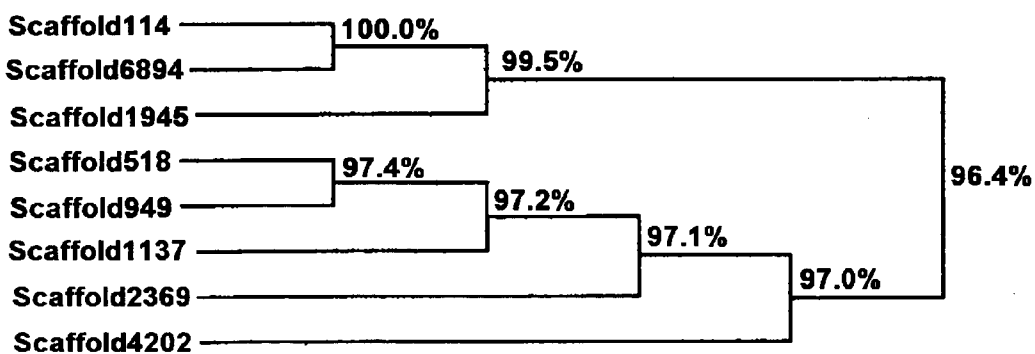


Figure 12

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MS GNENQIPVSL
MQSLAISLLL SETHSLFSHT KTSSLLSLLF LSSSKMSEQN TDGSQVPVNL
* * * *
LDEF LAEDEI MDEIMDDVLH EMMVLLQSSI GDLEREAADH RLHPRKHIKR
LDEF LAEDEI ID----DLLT EATVVVQSTI EGLQNEASDH RHHPRKHIKR
***** * * * * * * * * * * * * * * * *
PREEAHQNLV NDYFSENPLY PSNIFRRRFR MYRPLFLRIV DALGQWSDYF
PREEAHQQLV NDYFSENPLY PSKIFRRRFR MSRPLFLRIV EALGQWSVYF
***** * * * * * * * * * * * * * * * *
TQRVDAAGRQ GLSPLQKCTA AIRQLATGSG ADELDEYLKI GETTAMDAMK
TQRVDAVNRK GLSPLQKCTA AIRQLATGSG ADELDEYLKI GETTAMEAMK
***** * * * * * * * * * * * * * * * *
NFVKGIREVF GERYLRRPTV EDTERLLELG ERRGFPGMFG SIDCMHWQWE
NFVKGQLQDVF GERYLRRPTM EDTERLLQLG EKRGFPGMFG SIDCMHWHWE
***** * * * * * * * * * * * * * * * *
RCPTAWKGQF TRGDQKVPTL ILEAVASHDL WIWHAFFGVA GSNNDINVLS
RCPVAWKGQF TRGDQKVPTL ILEAVASHDL WIWHAFFGAA GSNNDINVLN
*** * * * * * * * * * * * * * * * *
RSTVFINELK GQAPRVQYMV NGNQYNEGYF LADGIYPEWK VFAKSYRLPI
QSTVFIKELK GQAPRVQYMV NGNQYNTGYF LADGIYPEWA VFKSIRLPN
***** * * * * * * * * * * * * * * * *
DXG/AF/F motif
TEKEKLYAQH QEGARKDIER AFGVLQRRFC ILKRPARLYD RGVLRDVVLG
TEKEKLYADM QEGARKDIER AFGVLQRRFC ILKRPARLYD RGVLRDVVLA
***** * * * * * * * * * * * * * * * *
YREK motif
CIILHNMIVE DEKEARLIEE NLDLNEPASS STVQAPEFSP DQHVPLERIL
CIILHNMIVE DEKETRIIEE DLDLNVPPSS STVQEPFSP EQNTPFDRVL
***** * * * * * * * * * * * * * * * *
EKDTSMRDL AHRRLKNDLV EHIWNKFGGG AHSSGNYVFI LHY
EKDISIRDRA AHNRLKNDLV EHIWNKFGGA AHRTGN
*** * * * * * * * * * * * * * * * *

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Figure 13

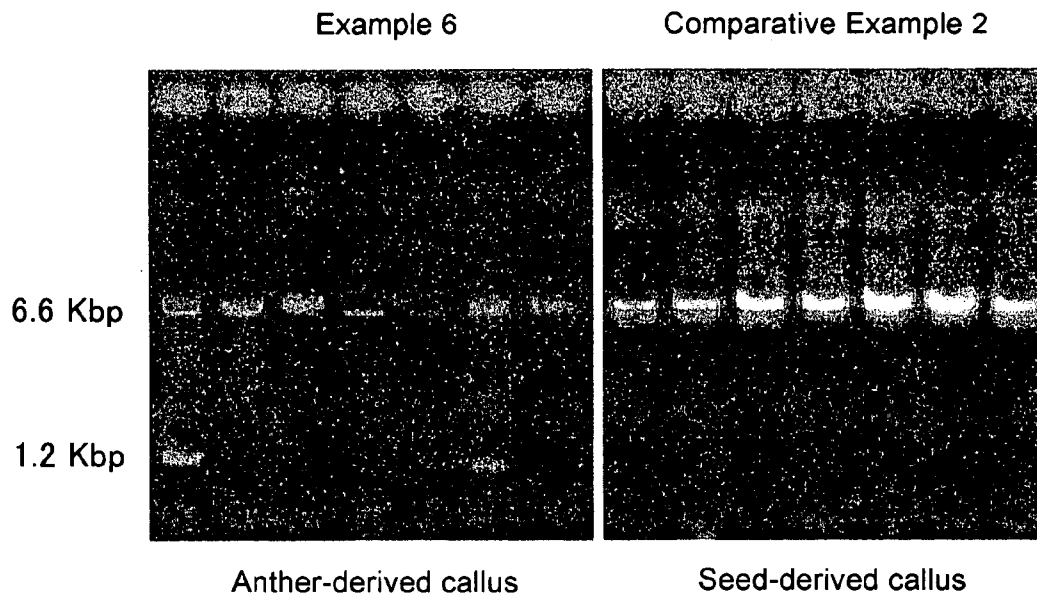


Figure 14

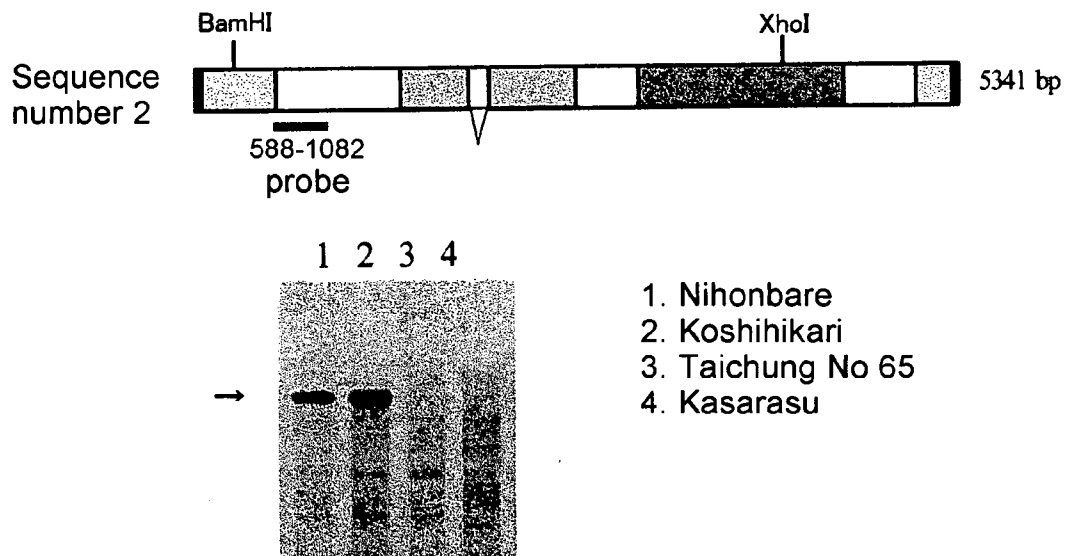


Figure 15

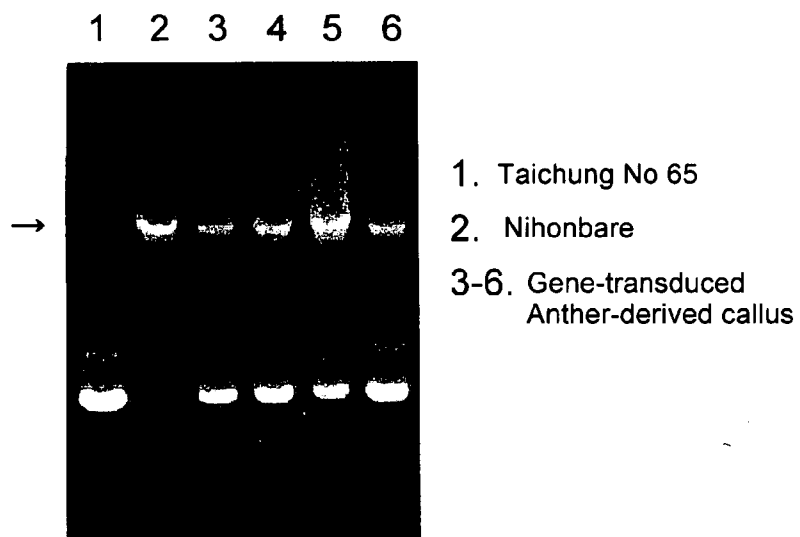


Figure 16

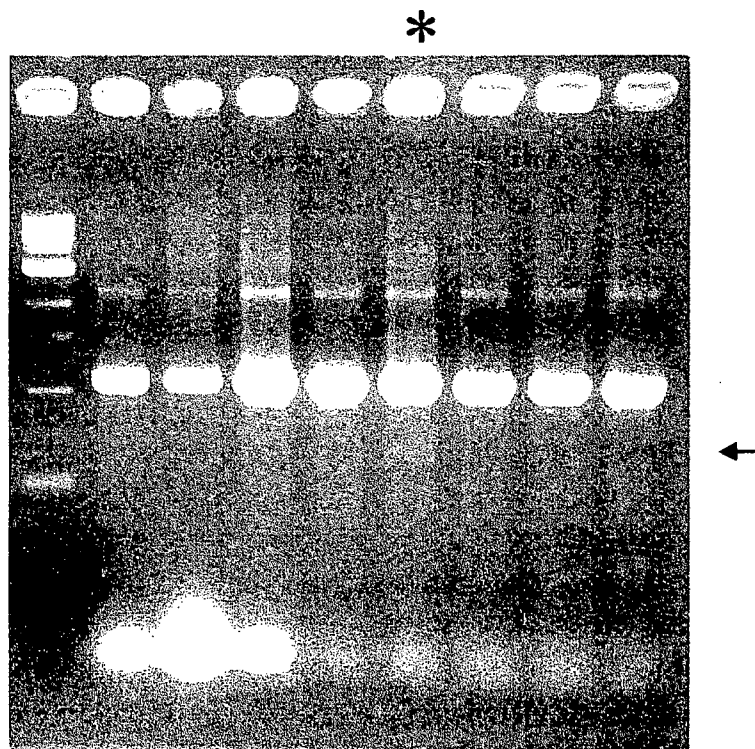


Figure 17

L02 GCGTGGACAC ACTGATTGGC CTGACAAAAC ATAGTTAGCA ATTTGCATTA
Seq GCGTGGACAC ACTGATTGGC CTGACAAAAC ATAGTTAGCA ATT——

L02 GGCCAGTCAC AATGGCTAGT GTCATTGCAC GGCTACCCAA AATATTATAC
Seq —————

L02 CATCTTCTCT CAAATGAAAT CTTTTATGAA ACAATCCCCA CAGTGGAGGG
Seq —————

L02 GTTCACTTT GACGTTTCCA AGACTAAGCA AAGCATTAA TTGATACAAG
Seq —————

L02 TTGCTGGGAT CATTGTACC CAAAATCCGG CGCGGCGCGG GAGAATGCGG
Seq —————

L02 AGGTGCGCAG GCGGAGGCGG ACGCAAGAGA TCCGGTGAAT GAAACGAATC
Seq —————

L02 GGCCTCAACG GGGGTTTCAC TCTGTTACCG AGGACTTGA AACGACGCTG
Seq —————

L02 ACGAGTTTCA CCAGGATGAA ACTCTTTCCT TCTCTCTCAT CCCCATTTCA
Seq —————

L02 TGCAAATAAT CATTTTTTAT TCAGTCTTAC CCCTATTAAA TGTGCATGAC
Seq —————

L02 ACACCAGTGA AACCCCCATT GTGACTGGCC TTACGGCAAC ATTTGGATAT
Seq —————

L02 CGAATTATGT CCAAAGAGCG AAGGTATCTG TTAGCTAATC ATCCGATCGG
Seq —ATGT CCAAAGAGCG AAGGTATCTG TTAGCTAATC ATCCGATCGG

Figure 18

L06 TGGTCCTCGA TACTGTTGCC TGTTGGTACG GCACCACACC ACTCTGTTTT
Seq TGGTCCTCGA TACTGTTGCC TGTTGGTACG GCACCACACC ACTCTGTTTT

L06 TATTAGGCCA GTCACAATGG CTAGTGTTCAT TGCACGGCTA CCCAAAATAT
Seq TATTAG-----

L06 TATACCATCT TCTCTCAAAT GAAATCTTTT ATGAAACAAT CCCCACAGTG
Seq -----

L06 GAGGGGTTTC ACTTTGACGT TTCCAAGACT AAGCAAAGCA TTTAATTGAT
Seq -----

L06 ACAAGTTGCT GGGATCATTG GTACCCAAAA TCCGGCGCGG CGCGGGAGAA
Seq -----

L06 TGC GGAGGTC GCACGGCGGA GCGGGACGCA AGAGATCCGG TGAATGAAAC
Seq -----

L06 GAATCGGCCT CAACGGGGGT TTTACTCTGT TACCGAGGAC TTGGAAACGA
Seq -----

L06 CGCTGACGAG TTTCACCAGG ATGAAACTCT TTCCTTCTCT CTCATCCCCA
Seq -----

L06 TTTCATGCAA ATAATCATT TTTATTCAGT CTTACCCCTA TTAATGTGC
Seq -----

L06 ATGACACACC AGTGAACCC CCATTGTGAC TGGCCTTAGA GGTAAGTTTG
Seq -----A GGTAAGTTTG

L06 ATAGTACAGC CCACTACCAG CTCTAAATCA GTCAATGTAG TAGCTAATTC
Seq ATAGTACAGC CCACTACCAG CTCTAAATCA GTCAATGTAG TAGCTAATTC

RICE TRANSPOSON GENES

FIELD OF THE INVENTION

[0001] The present invention relates to a nonautonomous transposon gene, autonomous transposon gene and transposase gene of rice (*Oryza sativa*); and a method to transpose the transposon gene; and transformed plants by the transposition.

DESCRIPTION OF THE PRIOR ART

[0002] Gene disruption method has been used as a tool to analyze genome of rice (*Oryza sativa*). To disrupt genomes of rice, a method to activate a segregation factor by mating an individual, wherein a transposase gene (transposition enzyme) is transduced as an activator, with an individual, wherein a segregation factor is introduced; a method to use T-DNA; and a method to use retrotransposon have been known. However, analysis of spontaneous mutants of rice has not served to find active transposons (Supplementary volume of Cell Engineering, Plant cell engineering series 14, "Plant genome research protocols" 2000, February, Shujun press Co.).

[0003] On the other hand, entire genome sequencing project is determining nucleotide sequences of many plants as well as rice and the results are data banked one after another. Furthermore, transposon genes, mobile genes in animal and plant, have, to some extent, a unique nucleotide sequence, whose information has been enable a research on the wider possibility of transposons. However, enough elucidation has not been demonstrated. Additionally, a nucle-

locus" Japanese Society of Breeding 100th Conference, Autumn meeting, 2001, October).

[0004] Problems to be Solved by the Invention:

[0005] The inventors discovered an inverted repeated sequence characteristic to transposon genes in rice genome nucleotide sequence under investigation. Examining various tests on the possible transposon nucleotide sequence, the inventors confirmed that the nucleotide sequence is ascribed to a transposon gene (nonautonomous transposon).

[0006] Furthermore, the inventors discovered autonomous transposon genes on the basis of the nonautonomous transposon gene. Moreover, the inventors identified transposase genes, which enable to transpose the transposon gene.

[0007] Means of Solving the Problems:

[0008] The inventors, starting from chromosome No. 1, examined long terminal repeats (LTR) in rice genome sequence, which is registered seriatim in database. The inventors noticed a LTR on the clone, accession number AP002843, as shown in Table 1, investigated the sequence in detail and discovered the inverted repeat sequence characteristic to a transposon gene at the site of 144459th-144473rd and 144874th-144888th bases at adjacent downstream of LTR (**FIG. 1**, Sequence Number 6). As disclosing in the example shown later, the inventors confirmed that the nucleotide sequence (Sequence Number 1) located between the inverted repeats is a nonautonomous transposon gene, markedly transposable by such artificial treatment as anther culture.

TABLE 1

AP002843 <i>Oryza sativa</i> genomic DNA, chromosome 1, PA					
ACCESSION	AP002843	NCBI SRS	Genome-Net		
ORGANISM	<i>Oryza sativa</i>	NCBI SRS			
LOCUS	AP002843	148762 bp	DNA	PLN	26-JAN-2001
FEATURES	Location/Qualifiers				
source	1..148762				
	/chromosome="1"				
	/clone="P0407B12"				
	/cultivar="Nipponbare"				
	/organism="Oryza sativa"				
	/sequenced_mol="DNA"				
LTR	139482..139690				
	/note="5' LTR"				
CDS	139739..144052				
	/gene="P0407B12.28"				
	/note="probably inactive due to frameshifts in CDS"				
	/note="pseudogene, similar to <i>Oryza longistaminata</i> probable gag/pol polyprotein U72725"				
	/pseudo				
LTR	144047..144255				
	/note="3' LTR"				
CDS	join(144653..144692, 145148..145311)				
	/codon_start=1				
	/gene="P0407B12.29"				
	/note="hypothetical protein"				
	/protein_id="BAB17191.1"				
	/translation="MRRSHGGGGGRKRSVPSSSHPEKKAIDRIKREDAGRRAGRVSIVQPLAAFPATDGGGGGLARLLRWW"				

otide sequence, assigned to putative transposon gene, has been found in a mutated rice, induced by γ -irradiation (Tetsuya Nakazaki et al., "Polymorphic insertion of transposon-like sequence in mutable slender-granule gene slg

[0009] Then, the inventors tried homological searches using the nonautonomous transposon gene (Sequence Number 1) as Query (DNA for homological search) by Blast search. Most of the results of the search was the nonauto-

nomous transposon gene (Sequence Number 1) itself, but additionally, accession numbers AP004236 and AP003968, which were expected as transposon genes, were found. Comparing the nucleotide sequence of AP004236 and AP003968, the inventors found that these are cloned on chromosome No. 6 and are the sequence of the identical overlapped region.

[0010] Therefore, the homology between 1st-253rd bases of the nonautonomous transposon gene (Sequence Number 1) and 89360th-89612nd bases of AP004236 was 252/253 (99%) and that between 254th-430th bases of the nonautonomous transposon gene (Sequence Number 1) and 94524th-94700th bases of AP004236 was 177/177 (100%). They are well-conserved sequences.

[0011] Both nonautonomous transposon gene (Sequence Number 1, 430 bp) and the transposon (Sequence Number 2, 5341 bp) have inverted repeats of 15 bp and TTA and TAA are recognized and inserted.

[0012] Open Reading Frame (ORF) was searched on the basis of Sequence Number 2 (5341 bp) and two kinds of putative ORFI and ORFII were obtained.

[0013] The structure of the transposon gene comprising nucleotide sequence of Sequence Number 2 is shown in the upper diagram of FIG. 9. The nonautonomous transposon gene (Sequence Number 1, 430 bp) is located at 1st-253rd and at 5165th-5341st bases, ORFI is located at 1526th-1914th bases and at 1939th-2663rd bases and ORFII is located at 3190th-4557th bases.

[0014] Furthermore, to obtain similar genes to the gene comprising nucleotide sequence of Sequence Number 2, the inventors performed homological searches using nucleotide sequence of Sequence Number 2 as Query (DNA for homological search) of Blast search and found accession numbers AP004753 (chromosome No. 2) and AP003714 (chromosome No. 6) as well as the sequence of Sequence Number 2 itself. These two clones have the identical nucleotide sequence (Sequence Number 3) and located on different chromosomes (several copies). Since the nucleotide sequence is present also in indica (a cultivar of rice), the gene must be conserved in many cultivars, from japonica to indica. The nucleotide sequence of Sequence Number 3 (5166 bp) has inverted repeats, as the sequence of Sequence Number 2 has, and TAA (3 bp) was also recognized and inserted.

[0015] Open Reading Frame (ORF) was searched on the basis of the sequence of Sequence Number 3 and ORFI and ORFII were obtained which may code two kinds of proteins. The structure of transposon gene comprising nucleotide sequence of Sequence Number 3 is shown in the lower diagram of FIG. 9. The nonautonomous transposon gene (Sequence Number 1, 430 bp) is located at 1st-170th and at 5092nd-5166th bases, however, the homological nucleotide sequence to the nonautonomous transposon gene (Sequence Number 1, 430 bp) is disappeared in the middle. ORFI is located at 1630th-2652nd bases and ORFII is located at 2959th-4407th bases.

[0016] The nucleotide sequence of Sequence Number 3 was compared between japonica (AP004753 and AP003714) and indica (Scaffold6962) and the homology of more than 90% was confirmed as shown in FIG. 10. Additionally, the inventors examined the mutation fre-

quency of nonautonomous transposon gene (Sequence Number 1, 430 bp) in indica, and confirmed that the sequence homology was more than 95% as shown in FIG. 11.

[0017] The inventors have no idea on the function of ORFI in Sequence Numbers 2 and 3, for the moment.

[0018] To examine whether ORFII encodes transposase (transposition enzyme) or not, the inventors checked whether the amino acid sequence of ORFII shares a conservative region with that of known transposase gene. The amino acid sequences of ORFII in Sequence Number 2 and in Sequence Number 3 are shown as Sequence Numbers 4 and 5, respectively. The alignment of amino acid sequences of these two ORFII (Sequence Numbers 4 and 5) is shown in FIG. 12 and the homology of these sequences was more than 75% (77%). These two amino acid sequences have DXG/AF/F motif and YREK motif (Q. H. Le, K. Turcotte and T. Bureau, Genetics 158: 1081-1088 (2001)), then it is concluded that they belong to IS transposase family.

[0019] Also, the homology of the nucleotide sequences of ORFII in Sequence Number 2 and that in Sequence Number 3 was more than 75% (79.3%).

[0020] Therefore, the present invention is a transposon gene of rice consisting of a nucleotide sequence which is at least 95% homological to Sequence Number 1. The DNA being at least 95% homological to Sequence Number 1 is considered to be functional as nonautonomous transposon, which is transposable by anther culture or by the treatment with chemical agents. Also, the present invention is the transposon gene of rice, wherein enhancers or promoters are inserted.

[0021] Furthermore, the present invention is the transposon gene of rice, whose nucleotide sequence is at least 90% homological to the nucleotide sequence of Sequence Number 2 or 3. The DNA being at least 90% homological to the nucleotide sequence of Sequence Number 2 or 3 is considered to be functional as an autonomous transposon gene, which is transposable by anther culture or by the treatment with chemical agents.

[0022] Also, the present invention is the transposase gene of rice, whose DNA being at least 75% homological to the nucleotide sequence of 3190th-4557th bases of Sequence Number 2 or the nucleotide sequence of 2959th-4407th bases of Sequence Number 3. The DNA being at least 75% homological to these nucleotide sequences is considered to be functional as the gene, which enables transposition of the transposons.

[0023] Also, the present invention is the transposase gene encoding a protein consisting of an amino acid sequence of Sequence Number 4 or 5 or an amino acid sequence wherein one or several amino acids are deleted, substituted or added in said amino acid sequence. Also, the transposase could be a transposon gene of rice, whose amino acid sequence is at least 75% homological to Sequence Number 4 or 5.

[0024] Moreover, the present invention is the transposase gene encoding this protein. Also, the present invention is the plasmid containing any one of said transposon genes. Still furthermore, the present invention is the plasmid containing promoters and any one of said transposase genes. Such binary vector as Ti plasmid and pBI-121 plasmid can be used

for the purpose. 35S promoter of cauliflower mosaic virus, heat shock promoter, chemotaxis promoter and others can be used for the purpose of this invention. There are no restrictions on the method of incorporation of promoters and said genomes and general method of genetic engineering can be applied.

[0025] Also, the present invention is the transformants, wherein any of said transposon genes are transduced. Preferably, plants, especially, rice, barley, wheat or maize are used as the host. To transform these plants, using general method of genetic engineering, we can insert these genomes into said plasmid and transform the plants.

[0026] Still moreover, the present invention is the transformants, wherein promoters and said transposase genes are transduced. Other transposon genes can be transduced, if necessary. Said promoters can be used for the present purpose. Preferably, plants, especially, barely, wheat or maize are used as the host. To transform these plants, using general method of genetic engineering, we can insert said genomes into said plasmid-and transform the plants.

[0027] Also, the present invention is the method for transposing any of said transposon genes, comprising subjecting said transformants to anther culture or treating any of the transformants with a chemical agent.

[0028] Furthermore, the present invention is the plant or the seed, which is transformed by the transposition of said transposon genes by any one of said methods. Preferably, rice or barley, a vicinal species of rice, wheat or maize is used as the plant.

[0029] Also, the present invention is a method for determining the integrated region of transposon gene, which comprises the steps of transposing any one of said transposon gene by any one of the above methods, extracting DNA from the plant obtained by the previous step, digesting said DNA by a restriction enzyme with no cutting sites inside the transposon gene, ligating said DNA fragments obtained by the previous step, conducting PCR for said DNA fragments obtained by the previous step, and determining the nucleotide sequence of said PCR products obtained by the previous step. The primers of said PCR involve the oligonucleotides, which comprises 10 consecutive bases, preferably 10-20 consecutive bases, more preferably 10-15 consecutive bases in the nucleotide sequence from the 5'-end of Sequence Number 1; and the oligonucleotide, which comprises 10 consecutive bases, preferably 10-20 consecutive bases, more preferably 10-15 consecutive bases in the nucleotide sequence from the 3'-end of Sequence Number 1, or the oligonucleotides, comprising the nucleotide sequences complementary to said sequences. Since the orionucleotide comprising 10-15 consecutive bases from the 5'-end of the nucleotide sequence overlaps with that comprising 10-15 consecutive bases in the nucleotide sequence from the 3'-end of that of Sequence Number 1, we can use single kind of primer, if the oligonucleotide bases comprises less than 15 consecutive bases. In other words, in this case, we can use the oligonucleotide comprising 10-15 consecutive bases in the nucleotide sequence from the 5'-end of Sequence Number 1 or the oligonucleotides complementary to said nucleotide sequences as the PCR primer. In this way, identification of the integration site of the transposon enables to find the disrupted genomes.

REFERENCES TO DRAWING

[0030] FIG. 1 shows apart (Sequence Number 6) of genomic nucleotide sequence of accession number AP002843. The inverted repeated sequences characteristic to the transposon gene are located at the positions of 144459 to 144473 and 144874 to 144888, immediately after LTR.

[0031] FIG. 2 shows the result of agarose gel electrophoresis of PCR products of the DNA region (accession number AP002843) containing the transposon DNA from four cultivars of rice mature leaves (example 2). An approximately 850 bp band in Nihonbare shows that a transposon gene (430 bp) is inserted in the region. While, approximately 420 bp bands for Koshihikari, Hitomebore and Yamahoushi show that transposon genes are not inserted.

[0032] FIG. 3 shows the result of agarose gel electrophoresis of PCR products of the DNA region (accession number AP002843) containing transposon DNA in calli derived from Nihonbare seeds (comparative example 1).

[0033] FIG. 4 shows the result of agarose gel electrophoresis of PCR products of the DNA region (accession number AP002843) containing transposon DNA in various calli derived from Nihonbare anthers (example 3). The DNA bands of approximately 420 bp demonstrate that the transposon gene is deleted.

[0034] FIG. 5 shows the result of agarose gel electrophoresis of DNA from various calli derived from Nihonbare anthers (example 4). Lane 1 shows control Nihonbare and Lanes 2-10 show plant regenerated from anther derived-calli. DNA bands were detected using a probe comprising a part of the transposon nucleotide sequence. Lanes 2 and 6 show new bands (indicated by arrowheads), which were not found in control Nihonbare.

[0035] FIG. 6 is a photograph of a phenotypic transformer found in regenerated rice in example 4. The leaves of the rice are curly and short.

[0036] FIG. 7 shows the result of agarose gel electrophoresis of PCR products of the DNA region containing the transposon DNA from various calli derived from Nihonbare seeds (example 5). The numbers on the upper margin indicate concentrations of 5-azacytidine. The DNA bands of approximately 300 bp demonstrate that the transposon gene (430 bp) is deleted.

[0037] FIG. 8 shows the base sequence of 4 clones, from which the transposon gene (430 bp) is deleted.

[0038] FIG. 9 shows the structure of the transposon genes with nucleotide sequences of Sequence Numbers 2 and 3.

[0039] FIG. 10 shows the homology of nucleotide sequence between japonica (AP004753 and AP003714) and indica (Scaffold6962) in the region of Sequence Number 3.

[0040] FIG. 11 shows the mutation frequency of transposon gene (Sequence Number 1, 430 bp) in indica.

[0041] FIG. 12 shows the alignment of amino acid sequence of ORFII in Sequence Number 2 and in Sequence Number 3. The homology of their sequence is more than 75% (77.8%; in the figure, the homological amino acids are shown by *) and both sequences have DXG/AF/F motif and YREK motif. The upper line shows the amino acid sequence of Sequence Number 4 (correspond to ORF II of Sequence

Number 2), and the lower line shows that of Sequence Number 5 (correspond to ORF II of Sequence Number 3).

[0042] FIG. 13—left shows the result of agarose gel electrophoresis of PCR products of the DNA region (accession number AP004236) containing transposon DNA in various calli derived from anthers of Nihonbare (example 6). The DNA bands of 1.2 kbp indicate deletion of the transposon gene. **FIG. 13**—right shows the result of agarose gel electrophoresis of the DNA region (accession number AP004236) containing the transposon DNA in various calli derived from seeds of Nihonbare (comparative example 2).

[0043] FIG. 14 is the result of gel electrophoresis of DNA, which shows presence or absence of the autonomous transposon gene (Sequence Number 2; shown on the upper margin of the photograph) in various rice cultivars (example 7). A DNA band (shown by an arrow) indicating the presence of the autonomous transposon gene (Sequence Number 2) was found in Nihonbare (lane 1) and in Koshihikari (lane 2), while, the DNA band was absent in Taichung No.65 (lane 3) and in Kasarasu (lane 4).

[0044] FIG. 15 is the result of gel electrophoresis of DNA from calli derived from anthers of Taichung No.65, wherein the autonomous transposon gene from Nihonbare (Sequence Number 2) was transduced (example 8). The DNA bands (shown by an arrow) indicating that the autonomous transposon gene (Sequence Number 2) was absent in original Taichung No.65 (lane 2), but present in calli derived from anthers of Taichung No.65 (lanes 3 to 6), wherein the autonomous transposon gene (Sequence Number 2) was transduced.

[0045] FIG. 16 is the result of gel electrophoresis of PCR products of the DNA region containing the nonautonomous transposon gene of calli derived from anthers of Taichung No.65, wherein the autonomous transposon gene from Nihonbare (Sequence Number 2, example 8) was transduced. On L06 gene locus, such size of DNA band (shown by an arrow) that is suggestive of deletion of the nonautonomous transposon gene, was observed.

[0046] FIG. 17 shows the nucleotide sequence of such size of DNA fragment that is suggestive of deletion of the nonautonomous transposon gene located in L02 gene locus. The nucleotide sequence of the nonautonomous transposon gene (Sequence Number 1) is deleted.

[0047] FIG. 18 shows the nucleotide sequence of such size of DNA fragment that is suggestive of deletion of the nonautonomous transposon gene located in L06 gene locus. The nucleotide sequence of the nonautonomous transposon gene (Sequence Number 1) is deleted.

FEATURE OF EMBODIMENT

[0048] First of all, this invention is the nonautonomous transposon gene (Sequence Number 1) of rice with the DNA size of 430 bp. This transposon gene has terminal inverted repeats with the size of 15 bp and has a symmetric structure with 215 bp (CT).

[0049] Then, two kinds of transposon genes (Sequence Numbers 2 and 3) encode transposases (Sequence Numbers 4 and 5) and are autonomous transposon genes.

[0050] An autonomous transposon gene is characteristic in encoding transposases, is mobile and induces transposition

of a nonautonomous transposon gene. Whereas, a nonautonomous transposon gene is lacking a transposase, is not mobile and needs a help of autonomous transposon gene to transpose. The comparison structurally of autonomous transposon gene with nonautonomous gene, demonstrated the characteristics that the nucleotide sequences of both genes are homological and are well conserved except the DNA region deleted.

[0051] The plants carrying the transposon of this invention; or the plants transformed by the transposon of this invention; or the plants carrying the transposase gene of this invention; or the plants transformed by the transposase gene of this invention enable to transpose the transposons of this invention by activation, induced by irradiation; induced by treatment with chemical agents; or induced by anther culture. Since transposons can be greatly activated by these methods, transposition of an artificial transposon takes place easily.

[0052] Treatment with chemical agents is carried out by treating seeds, leaves, roots, and stems of axillary buds of a plant such as rice; or by treating calli derived from them, with chemical agents. For example, the treatment of these plants with 5-azacytidine or 5-azadeoxycytidine is generally carried out by transplanting them on solid or liquid medium containing 0.01–5 mM, preferably 0.05–2 mM of these chemical agents. As used therein, callus means a cellular mass, formed by dedifferentiation of differentiated plant organs, obtained by culturing plant organs such as roots, leaves or stems in an appropriate medium supplemented with appropriate concentrations of auxin or cytokinin. This cellular mass is not differentiated and has totipotency in differentiation. Totipotency of differentiation means that the cellular mass can regenerate new organs such as buds or roots. For example, a single leaf can produce hundreds of clones, mediated by callus.

[0053] Anther culture is a kind of method to produce doubled haploid breeding. Anthers are taken out from the tip of stamens of rice and are cultured in a medium supplemented mainly with such hormone as auxin together with such polyploidy-inducing chemicals as colchicine and others. Since haploid cells can easily turn to diploid, it is easy to obtain diploid cells from anthers, i.e. haploid cells with a set of genes. Anther-derived callus of rice spontaneously doubles the number of chromosome, resulting in doubled haploid breeds, during prolonged culture period. A homozygote seed, a mutant plant, can be obtained by regeneration culture of the callus. We mainly, for regeneration culture, used the medium supplemented with such hormone as cytokinin.

[0054] The disrupted transposon gene, due to the insertion of transposed transposon gene, could be identified using the probe prepared by PCR using a primer set derived from appropriate two different nucleotide sequences in the transposon gene. An examination of correlation between transformed rice mutant and its gene enables to clarify the function of the gene.

[0055] It is a challenging object to identify easily a disrupted gene by a transposon tagging system. A lot of methods are known to determine the exact integration site of a transposon such as transposon display. However, they usually accompany complicated handlings. We inventors established a simple method using inverse PCR. In this

method, an important key step is the design of PCR primers in the interior of the transposon gene. DNA is isolated from plants, digested by a restriction enzyme (we used AluI in this example), which has no cutting sites in the internal region of the transposon gene, and ligated intramolecularly to circularize the DNA by a ligase. On the basis of the obtained circular DNA as a template, we performed a PCR reaction using a primer set, which originally pointed away each other but which, after ligation, will prime towards one another around the circular DNA. The designed primer set, which consists of the oligonucleotide comprising at least 10 consecutive bases from the 5'-end of the nucleotide sequence of Sequence Number 1, and the oligonucleotide comprising at least 10 consecutive bases from the 3'-end of the nucleotide sequence of Sequence Number 1, preferably in the internal region of terminal inverted repeats (15 consecutive bases from both the 5'- and 3'-end of Sequence Number 1); or oligonucleotides comprising the nucleotide sequence complementary to them, can be used for the inverse PCR. DNA sequencing of the obtained PCR products clarifies the integration site of the transposon gene. As an example of application of the nonautonomous transposon (Sequence Number 1), integration of enhancers or promoters into the internal region of the nonautonomous transposon enables to induce transposition of these enhancers or promoters together with the nonautonomous transposon. More specifically, transducing the genome, wherein enhancers or promoters are inserted, into rice or other plants; or culturing of anthers; or treating them with chemical agents; or inducing the transposition of the genome, we can demonstrate active expression other genomes flanking to the integration site of the transposed genome and, as a result, we can get a lot of mutants with gain-of-function.

[0056] As promoters and enhancers for said example, we can use the 35S promoter of cauliflower mosaic virus and four sets in series of enhancer region (at positions -90 to -440 in the sequence) in the 35S promoter, respectively. There are no restrictions on the integration site for the enhancer except the internal region of the inverted repeats of the genome with Sequence Number 1. Also on the integration site of the promoters, there are no restrictions except the internal region of the inverted repeats of the genome with Sequence Number 1 and except nonexistence of methionine in the adjacent downstream region of the integrated site. Preferably, both enhancers and promoters are integrated at position around 250 of Sequence Number 1, if there are no troubles in the transposition of the transposon. To integrate enhancers and promoters, we can use the restriction enzyme site, which divides in two the nucleotide sequence of the genome of Sequence Number 1 or use the cloning sites prepared by PCR.

[0057] Effects of the Invention

[0058] The present invention, for the first time, demonstrated mobile transposon genes of rice, since previously these rice genes have not been known. Furthermore, inventors confirmed, by such simple method as anther culture and others, that nonautonomous transposon genes are transposable. In other words, we succeeded to provide a new method to transpose artificially a nonautonomous transposon gene.

[0059] Also in the examples, we demonstrated that nonautonomous transposon genes are deletable by such artificial treatment as anther culture and others. Furthermore, we

directly confirmed the genetic locus, wherein nonautonomous transposon genes are inserted. Since we found artificially transposable transposon genes, we succeeded, for the first time, in preparing an artificial system of transposon tagging in rice.

[0060] Furthermore, the present invention demonstrated autonomous transposon genes (Sequence Number 2 and 3) of rice and transposase genes included in the genomes. The inventors confirmed, by such simple method as another culture or drug treatment, that the transposon gene could be transposed in rice, wherein the autonomous transposon gene was transduced. In other words, the present invention provides a method to transform these plants easily and artificially, whereby the autonomous transposon genes or transposase genes are transduced artificially into rice and other plants.

[0061] The autonomous transposon genes of this invention can be used as a source of random mutagens and can produce a system of transposon tagging in rice and other plants. This invention can be used to produce several dozen of plant breeds, wherein the transposons are randomly transposed. Since spontaneous transposition in growing natural plants are very rare, efficient induction of transposition can be achieved in callus derived from induced anthers in plant tissue culture or callus derived from seeds treated with 5-azacytidine. It is possible to induce efficient transposition in plants other than rice, wherein the autonomous transposon genes of this invention are transduced by a transformation method. The mutated plants thus obtained can be analyzed by genetic analysis or by reverse genetic analysis.

[0062] Genetic analysis is a method to isolate a causal gene from phenotypes of mutants. If a transposon gene of this invention is linked to a phenotype of mutants, the causal gene of the phenotype can easily be isolated by the help of tagging (the transposon).

[0063] For example, if one wishes to look for a rice breed tolerant to salt, one may examine the tolerance of rice grown from seeds from the system of transposon tagging and may find the desired rice.

[0064] Reverse genetic analysis is a method to isolate a mutant, wherein genetic function is lost, from a pool of wild host. If a desired gene of a plant is tagged by the transposon, the phenotype related to the gene should be mutated. DNA is isolated from various mutants and a genomic library of a tagged genome is prepared. We can request a transposon tagging system from a public stock centers. Screening the transposon tagging system, we can isolate tagged desired gene-transposon ensemble by PCR.

[0065] Recent progress of genome project made it cyclopaedically possible to prepare a set of mutants corresponding to entire genomes of rice and to prepare a database for the site of insertion of transposon corresponding to the mutants. User can order seeds of desired mutant by searching the database.

[0066] The following examples illustrate this invention, however, it is not intended to limit the scope of the invention.

EXAMPLE 1

[0067] DNA was extracted from mature leaves of Nihonbare, a rice cultivar (Kikuchi et al. (1998) Plant Biotech-

nology 15: 45-48). To amplify the central DNA region between both inverted terminal repeats located on both ends of transposon DNA, we used the oligonucleotide comprising the sequence of Sequence Number 7 as PCR primers. We carried out PCR using GeneAmp9600 system (ABI Co.). Each reaction mixture (100 μ l) contained 200 ng of DNA, 2.5 units of TaKaRa Ex Taq (Takara Co.), 10 μ l of 10 \times Ex Taq buffer, 8 μ l of dNTP mixture (2.5 mM each dNTP) and 200 pmol of primers. Each cycle of the polymerase reaction consisted of a denaturation step at 94 $^{\circ}$ C. for 30 sec, an annealing step at 55 $^{\circ}$ C. for 1 min and an extension step at 72 $^{\circ}$ C. for 12 min. This cycle was repeated 35 times. After the reaction, DNA was separated on 1% SeaKem GTG agarose (FMC Co.). The amplified DNA fragment with approximately 450 bp was recovered from the gel and it was subcloned in plasmid pCRII-TOPO using TA cloning kit (In Vitrogen). The nucleotide sequence of the obtained clone was determined using 310 DNA sequencer (ABI Co.). The nucleotide sequence thus determined was shown as Sequence Number 1, consisted of 430 bp.

EXAMPLE 2

[0068] DNA was isolated from leaves of 4 cultivars of rice, Nihonbare, Koshihikari, Hitomebore and Yamahoushi. To amplify the DNA region containing the transposon DNA (accession number AP002843) by PCR, we used the oligonucleotides comprising the sequences of Sequence Number 8 and 9 as PCR primers. Each reaction mixture (100 μ l) contained 200 ng of DNA, 2.5 units of AmpliTaq Gold (ABI Co.), 10 μ l of GeneAmp10 \times PCR buffer (contains 15 mM MgCl₂), 10 μ l of Gene Amp Mixture (2 mM each dNTP) and 200 pmol of primers. Each cycle of the polymerase reaction consisted of a denaturation step at 96 $^{\circ}$ C. for 30 sec, an annealing step at 55 $^{\circ}$ C. for 1 min and an extension step at 72 $^{\circ}$ C. for 1 min. This cycle was repeated 35 times. After the reaction, DNA was separated on 2% L03 agarose (Takara Co.) FIG. 2 shows the result of the agarose gel electrophoresis. The DNA band of approximately 850 bp was found only for Nihonbare (lane 2). The DNA band of approximately 850 bp indicates the DNA fragment, including the transposon gene (430 bp) of Sequence Number 1 as described in example 1. While, DNA fragments of 420 bp, not including the transposon gene, were found for Koshihikari, Hitomebore and Yamahoushi. The fact that the gene comprising the sequence of Sequence Number 1 was found only for Nihonbare among these rice cultivars suggests that the gene may function as a transposable element.

COMPARATIVE EXAMPLE 1

[0069] The seeds of Nihonbare were sterilized in 3% sodium hypochlorite solution for 15 to 30 min, washed with sterilized water, inoculated on a 90 \times 20 mm of Petri dish (Iwaki Co.) containing 20-30 ml of media at the rate of 9 seeds per dish and subjected to growth culture under light for 24 h at 30 $^{\circ}$ C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 0.3 g of casamino acids (DIFCO), 0.1 g of myo-inositol (Sigma Co.), 2.878 g proline (Wako), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium. On the 10th day of inductive culture, the calli derived from induced seeds were transplanted to a 90 x 20 mm of Petri dish (Iwaki Co.) containing 20-30 ml of

medium and subjected to growth culture under light for 24 h at 30 $^{\circ}$ C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 0.3 g of casamino acids (DIFCO), 0.1 g of myo-inositol (Sigma Co.), 2.878 g proline (Wako), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium.

[0070] DNA was extracted from calluses derived from seeds in growth culture for two weeks. To amplify the DNA region containing the transposon DNA by PCR, we used the oligonucleotides comprising the sequences of Sequence Number 8 and 9 as PCR primers as described in example 2. Each reaction mixture (100 μ l) contained 200 ng of DNA, 2.5 units of AmpliTaq Gold (ABI Co.), 10 μ l of GeneAmp10 \times PCR buffer (contains 15 mM MgCl₂), 10 μ l of Gene Amp Mixture (2 mM each dNTP) and 200 pmol of primers. Each cycle of the polymerase reaction consisted of a denaturation step at 96 $^{\circ}$ C. for 30 sec, an annealing step at 55 $^{\circ}$ C. for 1 min and an extension step at 72 $^{\circ}$ C. for 1 min. This cycle was repeated 35 times. After the reaction, DNA was separated on 2% L03 agarose (Takara Co.) FIG. 3 shows the result of the agarose gel electrophoresis. Only a single DNA band of approximately 850 bp was found. The DNA band of approximately 850 bp indicates the DNA fragment, including the transposon gene. The expected DNA band of 420 bp, wherein transposon gene was deleted, could not be found. The probability that the band of size of approximately 420 bp is found was 0 callus per 64 calli (0%). Therefore, it was confirmed that transposon genes were not mobile in seed (scutellum)-derived calli.

EXAMPLE 3

[0071] Spikes of Nihonbare were harvested at pre-emergence, kept in cold treatment for 10 days at 10 $^{\circ}$ C., sterilized in 1% sodium hypochlorite solution for 1 min and washed with sterilized water. Then, anthers were picked out from the floret, seeded in a 35 \times 10 mm Petri dish (CORNING Co.) containing 3 ml of liquid medium at the rate of 50 anthers per dish and subjected to induction culture under light for 24 h at 30 $^{\circ}$ C. We used a liquid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 30 g of sucrose (Wako) in 1 L of medium. After 3-4 weeks of inductive culture, the calli derived from induced anthers were transplanted to a 90 \times 20 mm of Petri dish (Iwaki Co.) containing 20-30 ml of medium and subjected to growth culture under light for 24 h at 30 $^{\circ}$ C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 ml of α -naphthalene acetic acid solution (Sigma Co.), 2 ml of kinetin solution (Sigma Co.), 3 g of casamino acids (DIFCO), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium.

[0072] DNA was extracted from calli derived from anthers in growth culture for 2 weeks. To amplify the DNA region containing the transposon DNA by PCR, we used the oligonucleotides comprising the sequences of Sequence Number 8 and 9 as PCR primers as described in example 2. Each reaction mixture (100 μ l) contained 200 ng of DNA, 2.5 units of AmpliTaq Gold (ABI Co.), 10 μ l of GeneAmp10 \times PCR buffer (contains 15 mM MgCl₂), 10 μ l of Gene Amp Mixture (2 mM each dNTP) and 200 pmol of primers. Each cycle of the polymerase reaction consisted of a dena-

turation step at 96° C. for 30 sec, an annealing step at 55° C. for 1 min and an extension step at 72° C. for 1 min. This cycle was repeated 35 times. After the reaction, DNA was separated using 2% L03 agarose (Takara Co.). **FIG. 4** shows the result of the agarose gel electrophoresis. As shown in **FIG. 4**, two DNA bands of approximately 850 bp and 420 bp were obtained. The DNA band of approximately 850 bp indicates the DNA band including a transposon gene. While, the band of approximately 420bp indicates that transposon genes were deleted. The probability that the DNA band of approximately 420 bp is observed was 11 calli per 64 calli (17.2%).

[0073] Since the DNA bands of approximately 420 bp, indicating the deletion of the transposon gene, was the PCR products from anther derived calli in this example, the amplified DNA fragments (approximately 420bp, N=5) were recovered from the gel and subcloned into plasmid pCRII-TOPO using TA cloning kit (In Vitrogen). The nucleotide sequence of 5 clones thus obtained was determined by 310 DNA sequencer (ABI Co.). The alignment of these nucleotide sequences clarified the absence of the transposon gene sequence in these 5 clones (data not shown). Therefore, the inventors confirmed the deletion of the transposon gene on the basis of nucleotide sequences.

[0074] In comparative example 1, the transposon gene in scutellum (seed) derived cell cultures was not mobile, however, in this example, the transposon gene in anther derived cell cultures was mobile highly frequently.

EXAMPLE 4

[0075] Spikes of Nihonbare were harvested at pre-emergence, kept in cold treatment for 10 days at 10° C., sterilized in 1% sodium hypochlorite solution for 1 min and washed with sterilized water. Then, anthers were picked out from the floret, seeded in a 35×10 mm Petri dish (CORNING Co.) containing 3 ml of liquid medium at the rate of 50 anthers per dish and subjected to induction culture under light for 24 h at 30° C. We used a liquid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 30 g of sucrose (Wako) in 1 L of medium. After 3~4 weeks of inductive culture, the calli derived from induced anthers were transplanted to a 90×20 mm of Petri dish (Iwaki Co.) containing 20~30 ml of medium and subjected to growth culture under light for 24 h at 30° C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 ml of α -naphthalene acetic acid solution (Sigma Co.), 2 ml of kinetin solution (Sigma Co.), 3 g of casamino acids (DIFCO), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium. The anther derive calli in growth culture for two weeks were transplanted in a 90×20 mm Petri dish (Iwaki Co.) with 20~30 ml of medium and were cultured for regeneration under light for 24 h, at 30° C. We used a solid medium consisting of 4.3 g of MS Basal Salt Mixture (Gibcobl Co.), 1 ml of MS vitamin solution (Sigma Co.), 10 ml of 6-benzylamino-purine solution (Sigma Co.), 2 ml of α -naphthalene acetic acid solution (Sigma Co.), 2 g of casamino acids (DIFCO), 30g of sorbitol (Wako), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium. The regenerated plant, in regeneration culture for 3~4 weeks, was transplanted in a growth culture and, when it was grown up, transferred to the soil. As a growth

medium, we used a solid medium consisting of 4.3 g of MS Basal Salt Mixture (Gibcobl. Co.), 1 ml of MS vitamin solution (Sigma Co.), 30 g of sucrose (Wako) and 2 g of gelrite (Wako) in 1 L of medium.

[0076] DNA was extracted from 9 young seedlings, regenerated from anther-derived calli by CTBA method. The extracted DNA was digested with a restriction enzyme HindIII, separated on 0.8% L03 agarose (Takara Co.) gel electrophoresis and transferred to a Nylon membrane (HybondN+) (Amersham Co.) by alkaline blotting. The DIG luminescence DNA detection kit (Roche Co.) was used for Southern hybridization. The PCR DIG Probe synthesis kit (Roche Co.) was used for preparation of probes. To amplify the internal DNA region containing the transposon DNA by PCR, we used the oligonucleotides comprising the sequences of Sequence Numbers 10 and 11 (both sequences are located inside the Sequence Number 1 (transposon gene)) as PCR primers as described in example 2. **FIG. 5** shows the result of the agarose gel electrophoresis. As shown in **FIG. 5**, two new bands (indicated by arrows), which were not observed in control Nihonbare, were found in Lanes 2 and 6. These two bands show that the transposon gene was inserted in these seedlings and then disrupted.

[0077] On the basis of the present example, it was clarified that the transposon gene was inserted to new genetic loci. Furthermore, an example of morphological mutation (the relevant gene is not determined) was found in regenerated rice as shown in **FIG. 6** and the example may suggest that genes related to morphology was disrupted by the insertion of the transposon gene.

EXAMPLE 5

[0078] Seeds of Nihonbare were sterilized in 3% sodium hypochlorite solution for 15~30 min, washed with sterilized water, inoculated on a 90×20 mm of Petri dish (Iwaki Co.) containing 20~30 ml of media at the rate of 9 seeds per dish and subjected to induction culture under light for 24 h at 30° C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 0.3 g of casamino acids (DIFCO), 0.1 g of myo-inositol (Sigma Co.), 2.878 g proline (Wako), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium.

[0079] After several days, calli were started forming from scutellum inside rice seeds and changed to cream-colored ones with 5 mm length on the 10th day of culture. The creamy-colored calli with 5 mm length were transplanted to growth media supplemented with 5-azacytidine (Sigma Co.) at either 0 mM, 0.01 mM, 0.03 mM, 0.05 mM, 0.1 mM or 0.3 mM, respectively, and subjected to growth culture under light for 24 h at 30° C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 0.3 g of casamino acids (DIFCO), 0.1 g of myo-inositol (Sigma Co.), 2.878 g proline (Wako), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium.

[0080] DNA was extracted by Dneasy plant mini kit (QIAGEN) from calli derived from seeds in growth culture for 2 weeks. To amplify the DNA region containing the transposon DNA by PCR, we used the oligonucleotides comprising the sequences of Sequence Numbers 12 and 13 as PCR primers.

[0081] As PCR reaction mixture, we used HotStarTaq Master Mix kit (QIAGEN).

[0082] Each cycle of the polymerase reaction consisted of a denaturation step at 96° C. for 30 sec, an annealing step at 55° C. for 1 min and an extension step at 72° C. for 1 min. This cycle was repeated 45 times. After the reaction, DNA was separated on 2% L03 agarose (Takara Co.).

[0083] Two DNA bands of approximately 730 bp and 300 bp were observed for calli cultured supplemented with 0.03 mM-0.3 mM of 5-azacytidine (FIG. 7). The DNA band of approximately 730 bp indicates the DNA band including a transposon gene. While, the DNA band of approximately 300 bp indicates the DNA bands not including the transposon gene (430 bp).

[0084] These DNA fragments (300 bp) were recovered from the gel and subcloned into plasmid pCRII-TOPO using TA cloning kit (In Vitrogen) The nucleotide sequence of 4 clones thus obtained was determined by 310 DNA sequencer (ABI Co.). The nucleotide sequences of 4 clones were subjected to a multiple alignment as shown in FIG. 8. No transposon gene sequence was found in these 4 clones.

[0085] This example showed that the transposition of the transposon gene of this invention could be induced even for seed-derived calli by means of 5-azacytidine, a demethylating agent. Based on this result, it can be expected that several hundreds of clones transposed by this transposon gene could be obtained from a single seed.

EXAMPLE 6

[0086] Spikes of Nihonbare were harvested at pre-emergence, kept in cold treatment for 10 days at 10° C., sterilized in 1% sodium hypochlorite solution for 1 min and washed with sterilized water. Then, anthers were picked out from the floret, seeded in a 35×10 mm Petri dish (CORNING Co.) containing 3 ml of liquid medium at the rate of 50 anthers per dish and subjected to induction culture under light for 24 h at 30° C. We used a liquid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2mg of 2, 4-dichloro-phenoxyacetic acid (Sigma Co.), 30 g of sucrose (Wako) in 1 L of medium. After 3-4 weeks of inductive culture, the calli derived from induced anthers were transplanted to a 90×20 mm of Petri dish (Iwaki Co.) containing 20-30 ml of medium and subjected to growth culture under light for 24 h at 30° C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2ml of α -naphthalene acetic acid solution (Sigma Co.), 2 ml of kinetin solution (Sigma Co.), 3 g of casamino acids (DIFCO), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium.

[0087] DNA was extracted from calli derived from anthers in growth culture for 2 weeks (Kikuchi et al. (1998) Plant Biotechnology 15: 45-48). To amplify the DNA region containing the transposon DNA by PCR, we used the oligonucleotides comprising the sequences of Sequence Number 14 (88933rd-88962nd bases of AP004236) and Sequence Number 15 (95545th-95574th bases of AP004236) as PCR primers. Each reaction mixture (100 μ l) contained 200 ng of DNA, 2.5 units of TaKaRa LA Taq (Takara Co.), 10 μ l of 10×LA PCR buffer II, 6 μ l of 25 mM MgCl₂, 8 μ l of dNTP mixture (2.5 mM each dNTP) and 100 pmol of primers.

[0088] Each cycle of the polymerase reaction consisted of a denaturation step at 94° C. for 30 sec and an extension step at 68° C. for 12 min. This cycle was repeated 35 times. After the reaction, DNA was separated on 0.8% L03 agarose (Takara Co.) gel electrophoresis. The DNA band of approximately 6.6 kbp indicates the DNA band including the transposon gene (5341 bp) of this invention. Since the size of the transposon of this invention is approximately 5.4 kbp, the DNA band of approximately 1.2 kbp could be expected when this transposon gene is deleted. A DNA band of approximately 1.2 kbp was obtained in this example (FIG. 13). These results show that the transposon gene is mobile in anther-derived calli. The probability, that the DNA band of approximately 1.2 kbp was observed in calli, was three calli per 64 calli (4.7%). This example proved that the MITE of rice with the nucleotide sequence of Sequence Number 2 was mobile in anther-derived calli.

COMPARATIVE EXAMPLE 2

[0089] Seeds of Nihonbare, a rice cultivar, were sterilized in 3% sodium hypochlorite solution for 15-30 min, washed with sterilized water, inoculated on a 90×20 mm of Petri dish (Iwaki Co.) containing 20-30 ml of media at the rate of 9 seeds per dish and subjected to induction culture under light for 24 h at 30° C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 0.3 g of casamino acids (DIFCO), 0.1 g of myo-inositol (Sigma Co.), 2.878 g proline (Wako), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium. On the 10th day of inductive culture, the calli derived from induced seeds were transplanted to a 90×20 mm of Petri dish (Iwaki Co.) containing 20-30 ml of medium and subjected to growth culture under light for 24 h at 30° C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 0.3 g of casamino acids (DIFCO), 0.1 g of myo-inositol (Sigma Co.), 2.878 g proline (Wako), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium. DNA was extracted from calli derived from seeds in growth culture for two weeks (Kikuchi et al. (1998) Plant Biotechnology 15: 45-48). To amplify the DNA region containing the transposon DNA by PCR, we used the oligonucleotides comprising the sequences of Sequence Numbers 14 and 15 as PCR primers. Each reaction mixture (100 μ l) contained 200 ng of DNA, 2.5 units of TaKaRa LA Taq (Takara Co.), 10 μ l of 10×LA PCR buffer II, 6 μ l of 25 mM MgCl₂, 8 μ l of dNTP mixture (2.5 mM each dNTP) and 100pmol of primers. Each cycle of the polymerase reaction consisted of a denaturation step at 94° C. for 30 sec and an extension step at 68° C. for 12 min. This cycle was repeated 35 times. After the reaction, DNA was separated on 0.8% L03 agarose (Takara Co.) gel electrophoresis. A single DNA band of approximately 6.6 kbp, but not a band of approximately 1.2 kbp, was observed for all calli samples from seeds (FIG. 13). The result implied that transposon genes were not mobile in seed derived-calli. The probability that the DNA band of approximately 1.2 kbp was observed in seed-derived callus is 0 callus per 64 calli (0%).

EXAMPLE 7

[0090] In this example, to look for a cultivar, wherein the autonomous transposon gene (Sequence Number 2) is not

included and to clarify whether there is a difference in the efficiency of the transposition of a nonautonomous transposon gene between calli with the autonomous transposon gene (Sequence Number 2) and those without the gene, we induced anther-derived callus from cultivars not including autonomous transposon gene (Sequence Number 2) and checked the efficiency of the transposition of a nonautonomous transposon gene.

[0091] DNA was isolated by CTAB method from leaves of 4 kinds of rice cultivars, Nihonbare, Koshihikari, Taichung No. 65 and Kasarasu. The isolated DNA was digested by a restriction enzyme, HindIII, separated by 1.0% L03 agarose gel electrophoresis, transferred to a Nylon membrane (HybondN+, Amersham Co.) by an alkaline blotting and detected by DIG luminescence DNA Detection kit (Roche Co.) using Southern hybridization. The PCR DIG probe synthesis kit (Roche Co.) was used for preparation of probes. To amplify the DNA region specific to the autonomous transposon gene by PCR, we used the oligonucleotides comprising the sequences of Sequence Number 16 and 17 as PCR primers. The result of Southern hybridization shows that one copy of autonomous transposon gene exists in both Nihonbare and Koshihikari, but not in Taichung No.65 and Kasarasu (**FIG. 14**).

[0092] Then, we induced callus derived from anthers of Taichung No.65 and examined whether nonautonomous transposon gene (Sequence Number 1) was transposed.

[0093] Spikes of Taichung No. 65 were harvested from the head spout before forming the spikes, kept in cold treatment for 10 days at 10° C., sterilized in 1% sodium hypochlorite solution for 1 min and washed with sterilized water. Then, anthers were picked out from the caryopsis, seeded in a 35×10 mm Petri dish (CORNING Co.) containing 3 ml of liquid medium at the rate of 50 anthers per dish and subjected to induction culture under light for 24 h at 30° C. We used a liquid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 30 g of sucrose (Wako) in 1 L of medium. After 3~4 weeks of inductive culture, the calli derived from induced anthers were transplanted to a 90×20 mm of Petri dish (Iwaki Co.) containing 20~30 ml of medium and subjected to growth culture under light for 24 h at 30° C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 ml of α -naphthalene acetic acid solution (Sigma Co.), 2 ml of kinetin solution (Sigma Co.), 3 g of casamino acids (DIFCO), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium.

[0094] DNA was extracted from calli derived from anthers in growth culture for 2 weeks according to the method described (Kikuchi et al. (1998) Plant Biotechnology 15: 45-48). To amplify the DNA region specific to the autonomous transposon gene by PCR, we used the oligonucleotides comprising the sequences of Sequence Numbers 18 and 19 (L02), Sequence Numbers 20 and 21 (L06) and Sequence Numbers 22 and 23 (L07) as PCR primers. Each reaction mixture (100 μ l) contained 200 ng of DNA, 2.5 units of AmpliTaq Gold (ABI Co.), 10 μ l of GeneAmp10×PCR buffer (contains 15 mM MgCl₂), 10 μ l of Gene Amp Mixture (2 mM each dNTP) and 200 pmol of primers. Each cycle of the polymerase reaction consisted of a denaturation step at

96° C. for 30 sec. an annealing step at 55° C. for 1 min and an extension step at 72° C. for 1 min. This cycle was repeated 35 times. After the reaction, DNA was separated on 2% L03 agarose (Takara Co.). The results show that there are no transpositions of the nonautonomous transposon gene, located in L02, L06 and L07 loci, in Taichung N.65, not carrying the autonomous transposon gene (Sequence Number 1) (Table 2, the first line). However the nonautonomous transposon gene transposed in high frequency at 10.9-31.3% in anther-derived callus of Nihonbare, which carries the autonomous transposon gene (Sequence Number 2), as shown in the following comparative example 3.

TABLE 2

	L02	L06	L07
Anther-derived callus	0/64	0/64	0/64
Gene-transduced anther-derived callus	2/38 5.3%	1/38 2.6%	0/38 0%

COMPARATIVE EXAMPLE 3

[0095] Spikes of Nihonbare were harvested at pre-emergence, kept in cold treatment for 10 days at 10° C., sterilized in 1% sodium hypochlorite solution for 1 min and washed with sterilized water. Then, anthers were picked out from the floret, seeded in a 35×10 mm Petri dish (CORNING Co.) containing 3 ml of liquid medium at the rate of 50 anthers per dish and subjected to induction culture under light for 24 h at 30° C. We used a liquid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 30 g of sucrose (Wako) in 1 L of medium. After 3~4 weeks of inductive culture, the calli derived from induced anthers were transplanted to a 90×20mm of Petri dish (Iwaki Co.) containing 20~30 ml of medium and subjected to growth culture under light for 24 h at 30° C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 ml of α -naphthalene acetic acid solution (Sigma Co.), 2 ml of kinetin solution (Sigma Co.), 3 g of casamino acids (DIFCO), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium. DNA was extracted from calli derived from anthers in growth culture for 2 weeks. To amplify the DNA region containing the transposon DNA by PCR, we used the oligonucleotides comprising the sequences of Sequence Numbers 5 and 1 as PCR primers as described in example 7. Each reaction mixture (100 μ l) contained 200 ng of DNA, 2.5 units of AmpliTaq Gold (ABI Co.), 10 μ l of GeneAmp10×PCR buffer (contains 15 mM MgCl₂), 10 μ l of Gene Amp Mixture (2 mM each dNTP) and 200 pmol of primers. Each cycle of the polymerase reaction consisted of a denaturation step at 96° C. for 30 sec, an annealing step at 55° C. for 1 min and an extension step at 72° C. for 1 min. This cycle was repeated 35 times. After the reaction, DNA was separated using 2% L03 agarose (Takara Co.). We obtained the result that there are two DNA bands of approximately 850 bp and 420 bp. The DNA band of approximately 850 bp indicates the DNA band including a transposon gene. While, the band of approximately 420bp indicates that transposon genes were deleted. The probability, that the DNA band of approximately 420 bp is observed, was 11 calli per 64 calli (17.2%).

EXAMPLE 8

[0096] In this example, we isolated the DNA region including the autonomous transposon gene (Sequence Number 2), transduced to a cultivar (Taichung No.65), which does not include the autonomous transposon gene (Sequence Number 2), and examined the possibility of transposition of nonautonomous transposon gene (Sequence Number 1) in this cultivar.

[0097] To amplify the DNA region including the autonomous transposon gene (Sequence Number 2) from Nihonbare, a cultivar of rice, we designed two primer nucleotide sequences, Sequence Numbers 24 and 25, whose sequences are located at the adjacent upstream and downstream, respectively, of the target DNA region (Sequence Number 2) for the PCR reaction. We synthesized the oligonucleotides of the sequences of Sequence Number 24 and 25 and used them as primers. DNA was isolated from leaves of Nihonbare by CTAB method. Each reaction mixture (100 μ l) contained 200 ng of DNA, 2.5 units of TaKaRa LA Taq (Takara Co.), 10 μ l of 10 \times LA PCR buffer II, 6 μ l of 25 mM MgCl₂, 8 μ l of dNTP mixture (2.5 mM each dNTP) and 100 pmol of primers. Each cycle of the polymerase reaction consisted of a denaturation step at 94° C. for 30 sec and an extension step at 68° C. for 12 min. This cycle was repeated 35 times. After the reaction, DNA was separated on 0.8% L03 agarose (Takara Co.) gel electrophoresis. We obtained the DNA band of approximately 6.6 kbp, including the autonomous transposon gene. The DNA fragment (approximately 6.6 kbp) was recovered from gel slices, subcloned into plasmid pCRII-TOPO using TA cloning kit (In Vitrogen), cut out using the multicloning sites (ApaI and KpnI) in pCRII-TOPO, subcloned to a binary vector, which contains a selectable marker gene, hygromycin resistant gene, and could be used for plant infection, and transduced to Agrobacteria EHA101 by electroporation. On three days before the infection of the Agrobacteria to anther-derived callus, the Agrobacteria were streaked onto AB medium containing kanamycin (Wako) and hygromycin (Wako).

[0098] Then, mediated by the Agrobacterium, the DNA fragments (approximately 6.6 kbp), wherein the autonomous transposon gene (Sequence Number 2) was included, were transduced to the anther-derived calli of Taichung No.65, a rice cultivar.

[0099] Spikes of Taichung No.65 were harvested at pre-emergence, kept in cold treatment for 10 days at 10° C., sterilized in 1% sodium hypochlorite solution for 1 min and washed with sterilized water. Then, anthers were picked out from the floret, seeded in a 35 \times 10 mm Petri dish (CORNING Co.) containing 3 ml of liquid medium at the rate of 50 anthers per dish and subjected to induction culture under light for 24 h at 30° C. We used a liquid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 mg of 2,4-dichlorophenoxyacetic acid (Sigma Co.), 30 g of sucrose (Wako) in 1 L of medium. After 3–4 weeks of inductive culture, the calli derived from induced anthers were transplanted to a 90 \times 20 mm of Petri dish (Iwaki Co.) containing 20–30 ml of medium and subjected to growth culture under light for 24 h at 30° C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 ml of α -naphthalene acetic acid solution (Sigma Co.), 2 ml of kinetin solution (Sigma Co.),

3 g of casamino acids (DIFCO), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium.

[0100] The Agrobacteria were infected to anther-derived calli originated from Taichung No.65, at 2 weeks of growth culture in growth medium. The Agrobacteria, streaked onto the surface of AB medium and kept for three days, were scraped by a spatula, mixed with AAM medium (25 ml) supplemented with 10 mg/L acetosyringone. The mixed medium with the Agrobacterium for infection was kept in a Petri dish (IWAKI). The calli, in wire cage, derived from anther in growth culture for 2 weeks was immersed into the mixed medium for infection for 2 min. After the immersion, the mesh cage was put on a sterilized paper towel and removed the excess medium. The callus was put on a filter paper on a symbiotic medium by a forceps and cultured at 28° C. for 3 days under dark, sealed by a surgical tape. The symbiotic medium, we used, was a solid medium containing 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin Solution (Sigma Co.), 30 g of Sucrose (Wako), 10 g of Glucose (Wako), 2 mg of 2, 4-dichloro-phenoxyacetic acid (Sigma Co.), 2 g of gelrite (Wako) and 10 mg of acetosyringone in 1 L of medium. After symbiotic culture for 3 days, the callus was added to an Erlenmeyer flask with 100 ml of sterilized water, shaken well and the water was discarded. After washing with sterilized water several times and with washing solution supplemented with 500 mg/ml of carbenicillin, the callus was transplanted on Petri dish at the rate of 9 calli/dish, sealed by a surgical tape and was cultured under light at 25° C. for a month. As a selection medium, we used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS Vitamine Solution (Sigma Co.), 30 g of sucrose (Wako), 0.3 g of casamino acids (DIFCO), 2.878 g of proline (ICN), 0.1 g of mioinositol (Sigma Co.), 2 mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 500 mg of hygromycin (Wako), 50 mg of carbenicillin (Wako), 2 g of gelrite (Wako) in 1 L of medium.

[0101] Then, we examined the possible transduction of the autonomous transposon gene of Nihonbare and the possible transposition of the nonautonomous transposon gene (Sequence Number 1) in hygromycin-resistant calli, grown in a selection medium for 3–4 weeks after seeded on the medium.

[0102] DNA was isolated from the resistant calli according to the method described (Kikuchi et al. (1998) Plant Biotechnology 15: 45-48). To amplify the DNA region including the autonomous transposon gene (Sequence Number 2), we used the oligonucleotides comprising the sequences of Sequence Numbers 24 and 25, located at the adjacent upstream and down stream, respectively, of the target DNA region (Sequence Number 2), as primers.

[0103] Each reaction mixture (100 μ l) contained 200 ng of DNA, 2.5 units of TaKaRa LA Taq (Takara Co.), 10 μ l of 10 \times LA PCR buffer II, 6 μ l of 25 mM MgCl₂, 8 μ l of dNTP mixture (2.5 mM each dNTP) and 100 pmol of primers. Each cycle of the polymerase reaction consisted of a denaturation step at 94° C. for 30 sec and an extension step at 68° C. for 12 min. This cycle was repeated 35 times. After the reaction the PCR products were separated on 0.8% L03 agarose (Takara Co.) gel electrophoresis. As shown the results in FIG. 15, we confirmed the transduction of the autonomous transposon gene of Nihonbare in hygromycin-resistant calli from Taichung No.65.

[0104] Then to amplify the DNA region including the nonautonomous transposon gene by PCR, we used the oligonucleotides comprising the sequences of Sequence Numbers 18 and 19 (L02), Sequence Numbers 20 and 21 (L06) and Sequence Numbers 22 and 23 (L07) as primers. As PCR reaction mixture, we used HotStarTaq Master Mix kit (QIAGEN) Each cycle of the polymerase reaction consisted of a denaturation step at 96° C. for 30 sec, an annealing step at 55° C. for 1 min and an extension step at 72° C. for 2 min. This cycle was repeated 45 times. After the reaction, DNA was separated on 2% L03 agarose (Takara Co.). We examined the possibility of deletion of the nonautonomous transposon gene for 38 calli, wherein the autonomous transposon gene was transduced, and obtained a DNA band (shown by an arrow), suggestive of deletion of the nonautonomous transposon gene in L06 gene locus (FIG. 16). The frequency of deletion of the nonautonomous transposon gene in L02, L06 and L07 gene loci was around 0~5.3% (Table 2, the 2nd line).

[0105] The DNA fragments suggestive of the deletion of nonautonomous transposon gene in L02 and L06 gene loci were recovered from the gel and subcloned into plasmids PCRII-TOPO using a TA cloning kit (In Vitrogen). The nucleotide sequences of the clones obtained were determined by 310 DNA sequencer (ABI Co.). There was nonautonomous transposon gene in these clones (FIG. 17 and 18).

[0106] These result show that transposition of the nonautonomous transposon gene was induced in anther-derived calli originated from Taichung No.65, wherein the autonomous transposon gene of Nihonbare was transduced.

[0107] On the basis of these results, we can conclude that the transposon gene expressed by sequence Number 2 not only transposes autonomously in anther-derived calli but also regulates the transposition of the nonautonomous transposon gene.

EXAMPLE 9

[0108] In this example, we examined the transposition activity of the nucleotide sequence of Sequence Number 3 in anther-derived calli and in scutellum-derived calli treated with 5-azacytidine.

[0109] Spikes of Nihonbare were harvested at pre-emergence, kept in cold treatment for 10 days at 10° C., sterilized in 1% sodium hypochlorite solution for 1 min and washed with sterilized water. Then, anthers were picked out from the floret, seeded in a 35×10 mm Petri dish (CORNING Co.) containing 3 ml of liquid medium at the rate of 50 anthers per dish and subjected to induction culture under light for 24 h at 30° C. We used a liquid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 30 g of sucrose (Wako) in 1 L of medium. After 3~4 weeks of inductive culture, the calli derived from induced anthers were transplanted to a 90×20 mm of Petri dish (Iwaki Co.) containing 20~30 ml of medium and subjected to growth culture under light for 24 h at 30° C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 ml of α -naphthalene acetic acid solution (Sigma Co.), 2 ml of kinetin solution (Sigma Co.), 3 g of casamino acids (DIFCO), 30 g of sucrose (Wako), 2

g of gelrite (Wako) in 1 L of medium. DNA was extracted from calli derived from anthers in growth culture for 2 weeks according to the method described (Kikuchi et al. (1998) Plant Biotechnology 15: 45-48).

[0110] Seeds of Nihonbare, a rice cultivar, were sterilized in 3% sodium hypochlorite solution for 15~30 min, washed with sterilized water, inoculated on a 90×20 mm of Petri dish (Iwaki Co.) with 20~30 ml of media at the rate of 9 seeds per dish and subjected to induction culture under light for 24 h at 30° C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 0.3g of casamino acids (DIFCO), 0.1 g of myo-inositol (Sigma Co.), 2.878 g proline (Wako), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium. On the 10th day of inductive culture, the calli derived from induced seeds were transferred to a growth medium supplemented with 5-azacytidine (Sigma) at 0 mM, 0.1 mM or 0.5 mM and were subjected to growth culture under light for 24 h at 30° C. We used a solid medium consisting of 4 g of CHU (N6) Basal Salt Mixture (Sigma Co.), 1 ml of MS vitamin solution (Sigma Co.), 2 mg of 2,4-dichloro-phenoxyacetic acid (Sigma Co.), 0.3 g of casamino acids (DIFCO), 0.1 g of myo-inositol (Sigma Co.), 2.878 g proline (Wako), 30 g of sucrose (Wako), 2 g of gelrite (Wako) in 1 L of medium. DNA was extracted from calli derived from seeds in growth culture for two weeks by Dneasy plant mini kit (Qiagen).

[0111] To amplify the DNA region containing the transposon DNA by PCR, we used the oligonucleotides comprising the sequences of Sequence Numbers 26 and 27 as PCR primers. Each reaction mixture (100 μ l) contained 200 ng of DNA, 2.5 units of TaKaRa LA Taq (Takara Co.), 10 μ l of 10×LA PCR bufferII, 6 μ l of 25 MM MgCl₂, 8 μ l of dNTP Mixture (2.5 mM each dNTP) and 100 pmol of primers. Each cycle of the polymerase reaction consisted of a denaturation step at 94° C. for 30 sec and an extension step at 68° C. for 12 min. This cycle was repeated 35 times. After the reaction, PCR products were separated on 0.8% L03 agarose (Takara Co.) gel electrophoresis.

[0112] It was found that the transposon gene with the nucleotide sequence of Sequence Number 3 was not transposed in anther-derived calli and in scutellum-derived calli, but high frequency of transposition was taken place in scutellum-derived calli treated with 5-azacytidine (Table 3).

TABLE 3

The frequency of deletion	
Anther-derived callus (Nihonbare)	0/64 (0%)
Scutellum-derived callus (Nihonbare)	0/64 (0%)
0 mM 5-azacytidine	0/8 (0%)
0.1 mM 5-azacytidine	2/8 (25%)
0.5 mM 5-azacytidine	7/8 (87.5%)

[0113] The transposon gene with the nucleotide sequence of Sequence Number 3 has the structure of an autonomous transposon gene with a coding sequence of a transposase, can be activated by the treatment with 5-azacytidine and may control the transposition of nonautonomous transposon gene (Sequence Number 1).

EXAMPLE 10

[0114] DNA was extracted from mature leaves of Kasarasi, a cultivar of rice, by Dneasy plant mini kit (QIAGEN). To amplify the DNA region adjacent to the inserted transposon gene by PCR, we used an inverse PCR method. We used the oligonucleotide comprising the sequence (5'-CCAT-TGTGACTGGCC-3') of 15 bases from the 5'-end of Sequence Number 1 as a primer for inverse PCR. GeneAmp9600 system (ABI Co.) was used for PCR. HotStarTaq Master Mix kit (QIAGEN) was used for PCR reaction

solution. Each cycle of the polymerase reaction consisted of a denaturation step at 96° C. for 30 sec, an annealing step at 44-58° C. for 1 min and an extension step at 72° C. for 1 min. This cycle was repeated 45 times. After the reaction, PCR products were separated on 2% L03 agarose (Takara Co.) gel electrophoresis. The amplified DNA fragments were subcloned into a plasmid pCRII-TOPO using TA cloning kit (In Vitrogen). The nucleotide sequence of the obtained clone was determined by 310 DNA sequencer (ABI Co.).

SEQUENCE LISTING

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<210> SEQ ID NO 4

<211> LENGTH: 455

<212> TYPE: PRT

<213> ORGANISM: *Oryza sativa*

<400> SEQUENCE: 4

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35          40          45
Ala Ala Asp His Arg Leu His Pro Arg Lys His Ile Lys Arg Pro Arg
50          55          60
Glu Glu Ala His Gln Asn Leu Val Asn Asp Tyr Phe Ser Glu Asn Pro
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85          90          95
Leu Phe Leu Arg Ile Val Asp Ala Leu Gly Gln Trp Ser Asp Tyr Phe
100         105         110
Thr Gln Arg Val Asp Ala Ala Gly Arg Gln Gly Leu Ser Pro Leu Gln
115         120         125
Lys Cys Thr Ala Ala Ile Arg Gln Leu Ala Thr Gly Ser Gly Ala Asp
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Glu Leu Asp Glu Tyr Leu Lys Ile Gly Glu Thr Thr Ala Met Asp Ala
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 Tyr Phe Thr Gln Arg Val Asp Ala Val Asn Arg Lys Gly Leu Ser Pro
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 Glu Ala Met Lys Asn Phe Val Lys Gly Leu Gln Asp Val Phe Gly Glu
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 Arg Tyr Leu Arg Arg Pro Thr Met Glu Asp Thr Glu Arg Leu Leu Gln
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 225 230 235 240
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 Ser His Asp Leu Trp Ile Trp His Ala Phe Phe Gly Ala Ala Gly Ser
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 Tyr Asp Arg Gly Val Leu Arg Asp Val Val Leu Ala Cys Ile Ile Leu
 385 390 395 400
 His Asn Met Ile Val Glu Asp Glu Lys Glu Thr Arg Ile Ile Glu Glu
 405 410 415
 Asp Leu Asp Leu Asn Val Pro Pro Ser Ser Ser Thr Val Gln Glu Pro
 420 425 430
 Glu Phe Ser Pro Glu Gln Asn Thr Pro Phe Asp Arg Val Leu Glu Lys
 435 440 445
 Asp Ile Ser Ile Arg Asp Arg Ala Ala His Asn Arg Leu Lys Lys Asp
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 Gly Asn

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<210> SEQ ID NO 6
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<212> TYPE: DNA
<213> ORGANISM: *Oryza sativa*

<400> SEQUENCE: 6

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<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: PCR primer

<400> SEQUENCE: 7

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<210> SEQ ID NO 8
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<213> ORGANISM: Artificial Sequence
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<400> SEQUENCE: 8

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<210> SEQ ID NO 9
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<210> SEQ ID NO 10
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<212> TYPE: DNA
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<400> SEQUENCE: 10

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28

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<213> ORGANISM: Artificial Sequence
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26

<210> SEQ ID NO 12
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<212> TYPE: DNA
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<220> FEATURE:
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23

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<211> LENGTH: 23
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
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<400> SEQUENCE: 13

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23

<210> SEQ ID NO 14
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<220> FEATURE:
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<400> SEQUENCE: 14

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30

<210> SEQ ID NO 15
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30

<210> SEQ ID NO 16
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<220> FEATURE:
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<210> SEQ ID NO 17
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<210> SEQ ID NO 18
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<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
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<400> SEQUENCE: 18
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<210> SEQ ID NO 19
<211> LENGTH: 24
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: PCR primer

<400> SEQUENCE: 19
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<210> SEQ ID NO 20
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<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
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<400> SEQUENCE: 20
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<210> SEQ ID NO 21
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<212> TYPE: DNA
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<220> FEATURE:
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<400> SEQUENCE: 21
cccaaagata cagagcacct acaca 25

<210> SEQ ID NO 22
<211> LENGTH: 21
<212> TYPE: DNA
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<220> FEATURE:
<223> OTHER INFORMATION: PCR primer

<400> SEQUENCE: 22
tgatccagat acaacctcca t 21

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<210> SEQ ID NO 23
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<212> TYPE: DNA
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<220> FEATURE:
<223> OTHER INFORMATION: PCR primer

<400> SEQUENCE: 23

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<210> SEQ ID NO 24
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<212> TYPE: DNA
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<400> SEQUENCE: 24

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<210> SEQ ID NO 25
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<212> TYPE: DNA
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<220> FEATURE:
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<210> SEQ ID NO 26
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<212> TYPE: DNA
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<220> FEATURE:
<223> OTHER INFORMATION: PCR primer

<400> SEQUENCE: 26

cctcacaacc aatccctacc a                               21

<210> SEQ ID NO 27
<211> LENGTH: 21
<212> TYPE: DNA
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<220> FEATURE:
<223> OTHER INFORMATION: PCR primer

<400> SEQUENCE: 27

agccaccaca ataaccaaag t                               21

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1. A transposon gene of rice consisting of a nucleotide sequence which is at least 95% homological to SEQ ID NO: 1.

2. The transposon gene of claim 1, wherein enhancers or promoters are inserted.

3. A transposon gene of rice consisting of a nucleotide sequence which is at least 90% homological to SEQ ID NO: 2 or 3.

4. A transposase gene of rice consisting of a nucleotide sequence which is at least 75% homological to bases 3190-4557 of SEQ ID NO.: 2.

5. A transposase gene encoding a protein consisting of an amino acid sequence of SEQ ID NO: 4 or 5 or an amino acid sequence wherein one or several amino acids are deleted, substituted or added in said amino acid sequence.

6. A transposase consisting of a protein with an amino acid sequence of SEQ ID NO: 4 or an amino acid sequence wherein one or several amino acids are deleted, substituted or added in said amino acid sequence.

7. A plasmid containing the transposon gene of claim 1.

8. A plasmid containing a promoter and transposase gene of claim 4.

9. A transformant, wherein the transposon gene of claim 1 is transduced.

10. The transformant of claim 9, wherein the host is a plant.

11. The transformant of claim 10, wherein said plant is rice, barley, wheat or maize.

12. A transformant, wherein a promoter and the transposase gene of claim 4 is transduced.

13. The transformant of claim 12, wherein the host is a plant.

14. The transformant of claim 13, wherein said plant is barley, wheat or maize.

15. A method for transposing the transposon gene of claim 1, comprising subjecting any one of the transformants to anther culture or treating one of them with a chemical agent.

16. The method of claim 15, wherein said chemical agent is 5-azacytidine or 5-azadeoxycytidine.

17. A method for transposing the transposon gene of claim 1, comprising culturing anthers of rice or treating seeds, leaves or stems of axillary buds of rice or callus derived from them with 5-azacytidine or 5-azadeoxycytidine.

18. A transformed plant or its seed, wherein a transposon gene is transposed by the method of claim 15.

19. The plant or its seed of claim 18, wherein said plant is rice, barley, wheat or maize.

20. A method for determining the integrated region of transposon genes, which comprises the steps of transposing said transposon gene of claim 1, extracting DNA from the plant obtained by the previous step, digesting said DNA by a restriction enzyme with no cutting sites inside the transposon gene, ligating said DNA fragments obtained by the previous step, conducting PCR for said DNA fragments obtained by the previous step, and determining the nucleotide sequence of said PCR products obtained by the previous step, wherein an oligonucleotide comprising the sequence of at least consecutive 10 bases from the 5'-end of SEQ ID NO: 1, and an oligonucleotide comprising the sequence of at least consecutive 10 bases from the 3'-end of SEQ ID NO: 1 or the oligonucleotides comprising the sequence complementary to said oligonucleotides are used as the primer set when conducting PCR reaction.

21. A transposon gene of rice consisting of a nucleotide sequence which is at least 90% homological to SEQ ID NO: 3.

22. A transposase gene of rice consisting of a nucleotide sequence which is at least 75% homological to bases 2959-4407 of SEQ ID NO: 3.

23. A transposase gene encoding a protein consisting of an amino acid sequence of SEQ ID NO: 5 or an amino acid sequence wherein one or several amino acids are deleted, substituted or added in said amino acid sequence.

24. A transposase consisting of a protein with an amino acid sequence of SEQ ID NO: 5 or an amino acid sequence wherein one or several amino acids are deleted, substituted or added in said amino acid sequence.

25. A plasmid containing the transposon gene of claim 2.

26. A plasmid containing the transposon gene of claim 3.

27. A plasmid containing a promoter and transposase gene of claim 5.

28. A transformant, wherein any one of transposon genes of claim 2 is transduced.

29. A transformant, wherein the transposon gene of claim 3 is transduced.

30. A transformant, wherein a promoter and the transposase gene of claim 5 are transduced.

31. A method for transposing the transposon gene of claim 2, comprising subjecting any one of the transformants to anther culture or treating one of them with a chemical agent.

32. A method for transposing the transposon gene of claim 3, comprising subjecting any one of the transformants to anther culture or treating one of them with a chemical agent.

33. A transformed plant or its seed, wherein a transposon gene is transposed by the method of claim 16.

34. A transformed plant or its seed, wherein a transposon gene is transposed by the method of claim 17.

35. A method for determining the integrated region of transposon genes, which comprises the steps of transposing the transposon gene of claim 2, extracting DNA from the plant obtained by the previous step, digesting said DNA by a restriction enzyme with no cutting sites inside the transposon gene, ligating said DNA fragments obtained by the previous step, conducting PCR for said DNA fragments obtained by the previous step, and determining the nucleotide sequence of said PCR products obtained by the previous step, wherein an oligonucleotide comprising the sequence of at least consecutive 10 bases from the 5'-end of SEQ ID NO: 1, and an oligonucleotide comprising the sequence of at least consecutive 10 bases from the 3'-end of SEQ ID NO: 1 or the oligonucleotides comprising the sequence complementary to said oligonucleotides are used as the primer set when conducting PCR reaction.

36. A method for determining the integrated region of transposon genes, which comprises the steps of transposing the transposon gene of claim 3, extracting DNA from the plant obtained by the previous step, digesting said DNA by a restriction enzyme with no cutting sites inside the transposon gene, ligating said DNA fragments obtained by the previous step, conducting PCR for said DNA fragments obtained by the previous step, and determining the nucleotide sequence of said PCR products obtained by the previous step, wherein an oligonucleotide comprising the sequence of at least consecutive 10 bases from the 5'-end of SEQ ID NO: 1, and an oligonucleotide comprising the sequence of at least consecutive 10 bases from the 3'-end of SEQ ID NO: 1 or the oligonucleotides comprising the sequence complementary to said oligonucleotides are used as the primer set when conducting PCR reaction.

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