CHAPTER III

RESULTS

3.1 DNA yield and quality

From one gram of rice leaves, the yield of DNA from each specimen was in the range of 800-1,000 μg/g fresh leaf. The contamination of proteins in genomic DNAs prepared by CTAB method were checked by determining the absorbance (A) ratio at 260/280 nm, and all DNAs used showed ratio A_{260}/A_{280} in the range of 1.8-2.0. The size of DNAs were determined by electrophoresis on a 0.7 % agarose gel. Figure 3.1 showed that DNA extracted from all 12 rice cultivars were larger than 23.1 kb and should be suitable for amplification by PCR.

3.2 Genetic variation by RAPD

3.2.1 Screening of primers

Twenty primers of arbitrary nucleotide sequence were used to amplify DNA segments from the genomic DNA of 6 rice cultivars. Pokkali is the standard salt tolerant cultivar and IR 28 is the standard salt sensitive cultivar. Other 4 native salt tolerant cultivars: Khao Dawk Mali 105, Khao Tah Haeng 17, Leuang Pratew 123, and Look Daeng Pattani were used in the screening experiment. At first, X6, X8, X9, X10 and C1, five out of 20 primers gave amplification products for Pokkali, Khao Dawk Mali 105, Khao Tah Haeng 17, Leuang Pratew 123, Look Daeng Pattani and IR 28 in which the 5 primers produced a total of 131 useful markers. Each primer produced between 16 (primer X10) and 31 (primer X9) amplification products, which ranged in size between 200 and 1517 bp. Figure 3.2 showed the RAPD patterns of Pokkali and IR 28 with 3-5 polymorphic amplification products with 3 primers: X6, X8 and X9, while X10 gave only one amplification product with IR 28 and C1 gave very faint bands with both IR 28 and Pokkali. Figure 3.3 showed the 3-5 RAPD patterns of Khao Dawk Mali 105 and Leuang

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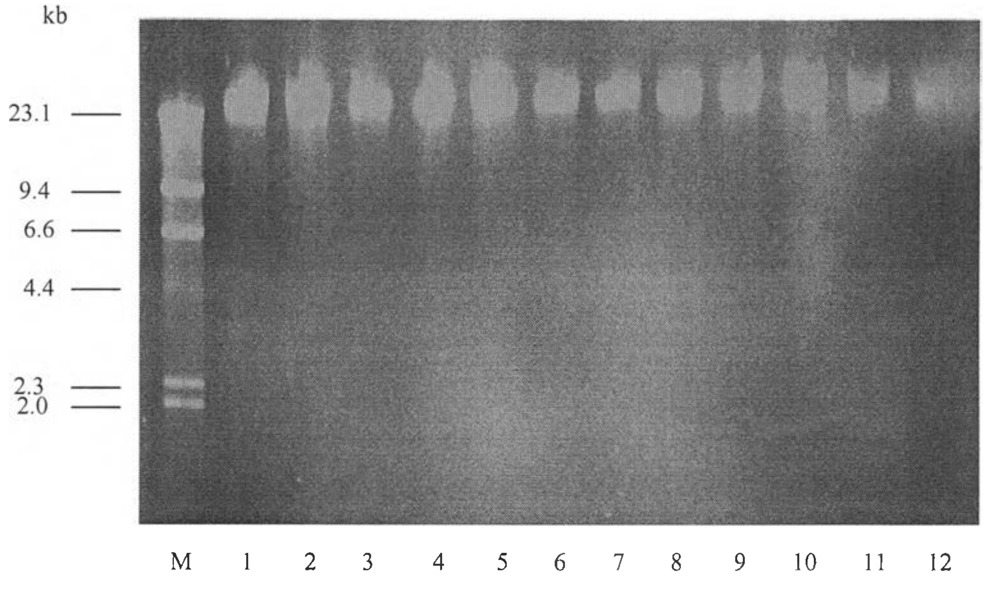


Figure 3.1 Agarose gel electrophorogram showing intact DNA from 12 rice cultivars

Each lane was loaded with 1 μg DNA, eletrophoresed on 0.7% agarose and stained with Ethidium bromide, using DNAs cut by λ/*Hind* III as standard molecular marker (M).

lane 1 = Pokkali	lane 7 = IR 28
lane 2 = Khao Dawk Mali 105	lane 8 = Muey Nawng 62 M
lane 3 = Khao Tah Haeng 17	lane 9 = Nahng Pa-yah 132
lane 4 = Leuang Pratew 123	lane 10 = Yah Yaw
lane 5 = Look Daeng Pattani	lane 11 = Foi Tawng
lane 6 = Gow Ruang 88	lane 12 = Leb Nok Pattani

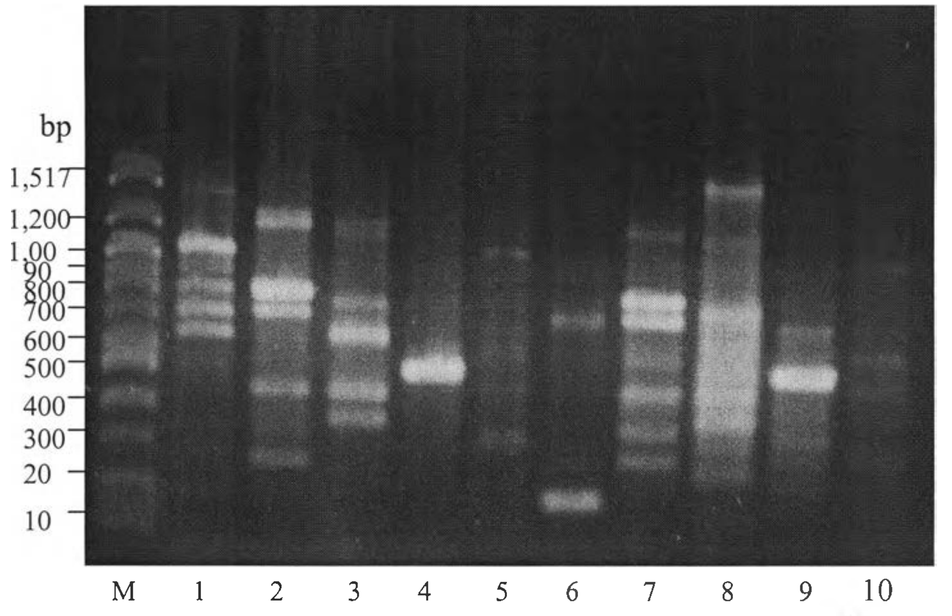


Figure 3.2 RAPD patterns of IR 28 and Pokkali using primer X6,X8,X9,X10 and C1

DNA marker(M)and polymorphic patterns detected in rice DNA from 2 rice cultivars: IR 28 (lane 1-5) and Pokkali (lane6-10) using RAPD. Amplification products obtained with primer X6, X8, X9, X10 and C1were resolved by a 1.5% agarose gel.

lane M = 100 bp DNA ladder

lane 1,6 = X6

lane 2,7 = X8

lane 3,8 = X9

lane 4,9 = X10

lane5,10 = C1

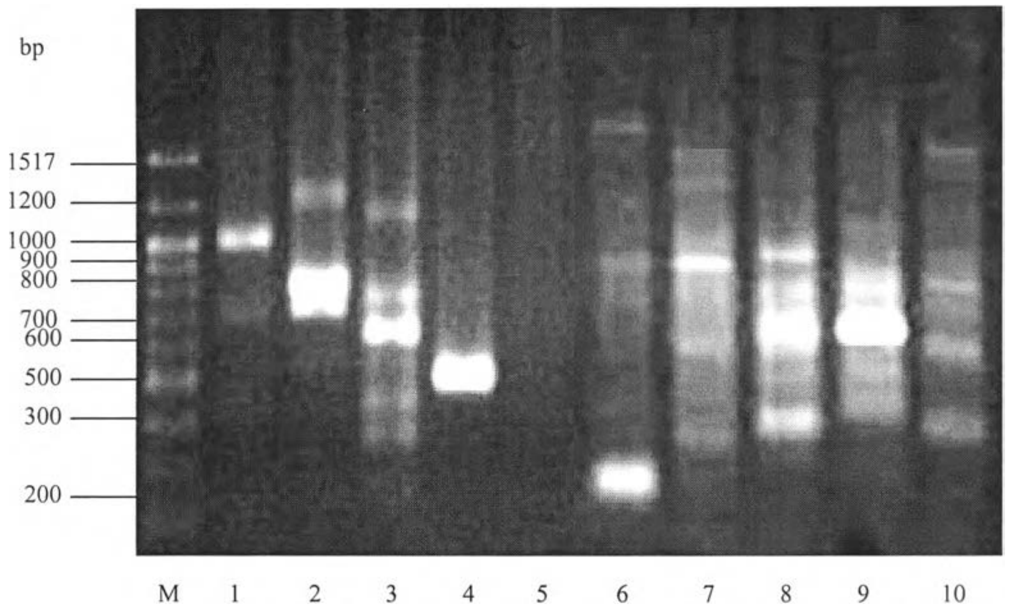


Figure 3.3 RAPD patterns of Khoa Dawk Mali 105 and Leuang Pratew 123 using primer X6,X8,X9,X10 and C1

DNA marker (M) and polymorphic patterns detected in rice DNA from 2 rice cultivars Khoa Dawk Mali 105 (lanes 1-5) and Leuang Pratew 123 (lanes 6-10) using RAPD. Amplification products obtained with primer X6,X8,X9,X10 and C1 were resolved by a 1.5% agarose gel.

lane M = DNA marker

lane 1,6 = X6

lane 2,7 = X8

lane 3,8 = X9

lane 4,6 = X10

lane 5,10 = C1

Pratew 123, where amplification products were observed only with X8 and X9, while X6 and X10 gave monomorphic products with Khao Dawk Mali 105 and Leuang Pratew 123 respectively and C1 gave faint bands for Khao Dawk Mali 105. Figure 3.4 showed the RAPD patterns of Look Daeng Pattani and Khao Tah Haeng 17, in which the polymorphic amplification products with X6, and X9 while X8 X10 gave low amplification products and C1 gave faint bands.

By comparing the RAPD patterns of these 5 primers with 6 rice cultivars, primer X9, X8 and X6 were considered more effective than X10 and C1 to study genetic variation among 6 lowland rice cultivars. Table 3.1 showed the pair-wise similarity coefficient (SC) analysis for 6 rice cultivars using primer X6. The highest genetic diversity (SC=0) between IR 28 and Pokkali seemed to be good for distinguishing salt sensitive IR 28 from salt tolerant Pokkali, but low similarity (SC=0) between Pokkali and Khao Dawk Mali 105, between Pokkali and Khao Tah Haeng 17 showed that primer X6 may not be suitable for comparison among salt tolerant cultivars. Table 3.2 showed similarity matrix of 6 rice cultivars using primer X8. The results of pair-wise comparisons indicated the high similarity of 0.71 between IR 28 and Pokkali, showing that primer X8 should not be suitable to monitor salt tolerant and salt sensitive characters. Table 3.3 showed the similarity matrix for 6 rice cultivars using primer X9. The highest genetic diversity between salt sensitive IR 28 and salt tolerant Pokkali was evident by SC=0, whereas variation of similarity coefficient was observed among salt tolerant cultivars Pokkali, Khao Dawk Mali 105, Khao Tah Haeng 17, Leuang Pratew 123 and Look Daeng Pattani showing that primer X9 could distinguish between salt tolerant and salt sensitive cultivars. Table 3.4 showed similarity matrix for 6 rice cultivars with primer X10. The zero similarity coefficient between Khao Tah Haeng 17 and Pokkali, and between Look Daeng Pattani and Pokkali eliminate the possibility of using X10 to study genetic variation among salt tolerant cultivars. Table 3.5 showed pair-wise similarity for 6 rice cultivars with C1. The highest genetic diversity between IR 28 and Pokkali, between Pokkali and Khao Dawk Mali 105, and between Pokkali and Look Daeng Pattani showing that primer C1 could not compare the similarity among these 6 salt tolerant, and salt sensitive cultivars. From all these results it is concluded that primer X9 could be a putative primer to study genetic variation between salt tolerant and salt sensitive

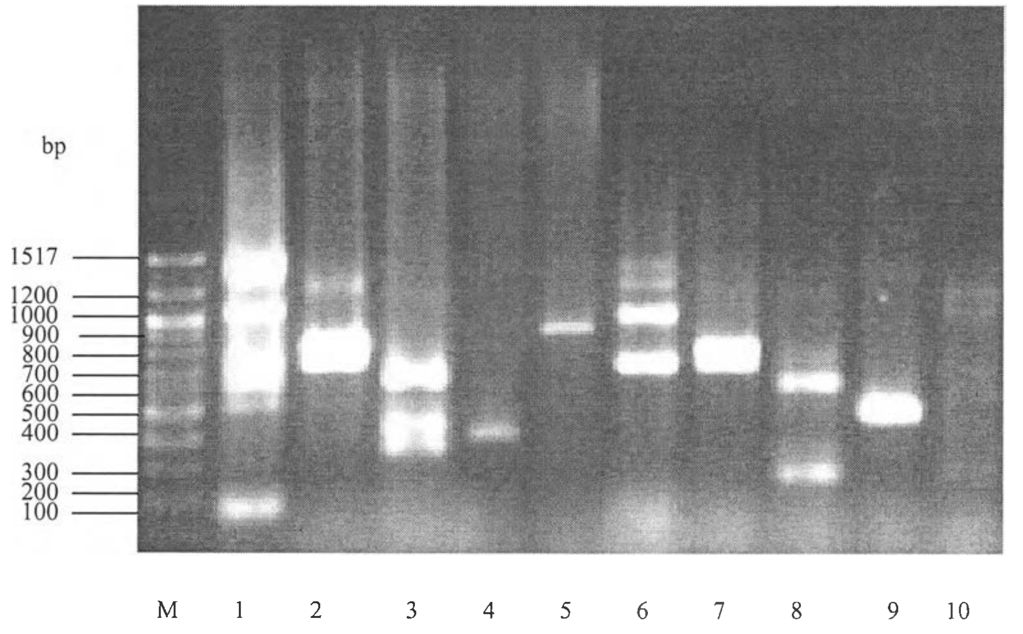


Figure 3.4 RAPD patterns of Look Daeng Pattani and Khao Tah Haeng 17 using primer X6,X8,X9,X10 and C1

DNA marker (M) and polymorphic patterns detected in rice DNA from 2 rice cultivars Look Daeng Pattani (lanes 1-5) and Khao Tah Haeng 17 (lanes 6-10) using RAPD. Amplification products obtained with primer X6,X8,X9,X10 and C1 were resolved by a 1.5% agarose gel.

lane 1,6 = X6

lane 2,7 = X8

lane 3,8 = X9

lane 4,9 = X10

lane 5,10 = C1

Table 3.1 Similarity matrix of 6 rice cultivars with primer X_6

	POK	KDML	KTH	LPT	LDP	IR
POK	1.00					
KDML	0	1.00				
KTH	0	0	1.00			
LPT	0.33	0.67	0.25	1.00		
LDP	0.22	0.22	0.73	0.55	1.00	
IR	0	0.50	0.40	0.60	0.46	1.00

Table 3.2 Similarity matrix of 6 rice cultivars with primer X_8

	POK	KDML	KTH	LPT	LDP	IR
POK	1.00					
KDML	0.2	1.00				
KTH	0	0.40	1.00			
LPT	0.71	0.40	0.22	1.00		
LDP	0.20	0.33	0.80	0.40	1.00	
IR	0.71	0.40	0.22	0.71	0.40	1.00

POK = Pokkali

KDML = Khao Dawk Mali 105

KTH = Khao Tah Haeng 17

LPT = Leuang Pratew 123

LDP = Look Daeng Pattani

IR = IR 28

Table 3.3 Similarity matrix of 6 rice cultivars with primer X_9

	POK	KDML	KTH	LPT	LDP	IR
POK	1.00					
KDML	0.46	1.00				
KTH	0.17	0.67	1.00			
LPT	0.31	0.60	0.89	1.00		
LDP	0.17	0.22	0.50	0.44	1.00	
IR	0	0.20	0.44	0.40	0.67	1.00

Table 3.4 Similarity matrix of 6 rice cultivars with primer X_{10}

	POK	KDML	KTH	LPT	LDP	IR
POK	1.00					
KDML	0.29	1.00				
KTH	0	0	1.00			
LPT	0.83	0.29	0	1.00		
LDP	0	0	0	0	1.00	
IR	0.29	1.00	0	0.29	0	1.00

POK = Pokkali

KDML = Khao Dawk Mali 105

KTH = Khao Tah Haeng 17

LPT = Leuang Pratew 123

LDP = Look Daeng Pattani

IR = IR 28

Table 3.5 Similarity matrix of 6 rice cultivars with primer C_1

	POK	KDML	KTH	LPT	LDP	IR
POK	1.00					
KDML	0	1.00				
KTH	0.20	0	1.00			
LPT	0.57	0	0.29	1.00		
LDP	0	0	0	0.20	1.00	
IR	0	0	0.36	0.40	0.29	1.00

Table 3.6 Similarity matrix of 6 rice cultivars with five primers: X6, X8, X9, X10 and C1

	POK	KDML	KTH	LPT	LDP	IR
POK	1.00					
KDML	0.23	1.00				
KTH	0.18	0.33	1.00			
LPT	0.58	0.30	0.34	1.00		
LDP	0.09	0.38	0.50	0.50	1.00	
IR	0.26	0.30	0.34	0.38	0.49	1.00

POK = Pokkali

KDML = Khao Dawk Mali 105

KTH = Khao Tah Haeng 17

LPT = Leuang Pratew 123

LDP = Look Daeng Pattani

IR = IR 28

cultivars, and for studying genetic diversity among indigenous lowland *indica* rice. The other 15 primers, although previously reported to produce polymorphic products in several *japonica and indica* cultivars did not show polymorphism DNA with Thai rices under PCR condition used.

When all amplified polymorphic DNA fragments with 5 primers were scored (0,1) as described in Material and Methods 2.8.1 for computer analysis. Table 3.6 showed pair-wise similarity for 6 rice cultivars. The similarity coefficient (SC) ranged from 0.09 to 0.58. The pair-wise comparisons indicated the highest genetic diversity between Pokkali and Look Daeng Pattani (SC=0.09) whereas the highest genetic similarity of 0.58 was observed between Pokkali and Leuang Pratew 123. Genetic variation among the 6 lowland rice cultivars revealed by UPGMA cluster analysis are presented in Figure 3.5 showing that the RAPD method using combination of several primers can be a useful tool for breeders to identify each cultivar from each other among 6 lowland rice cultivars, however the grouping according to geographic distribution could not be observed. To study more specific character like salt tolerance / sensitivity, primer X9 has the highest potential among these 5 primers, because it provided consistently polymorphic bands with all the 6 cultivars tested and it provided the highest genetic diversity between standard salt tolerant cultivars: Pokkali and salt sensitive : IR 28.

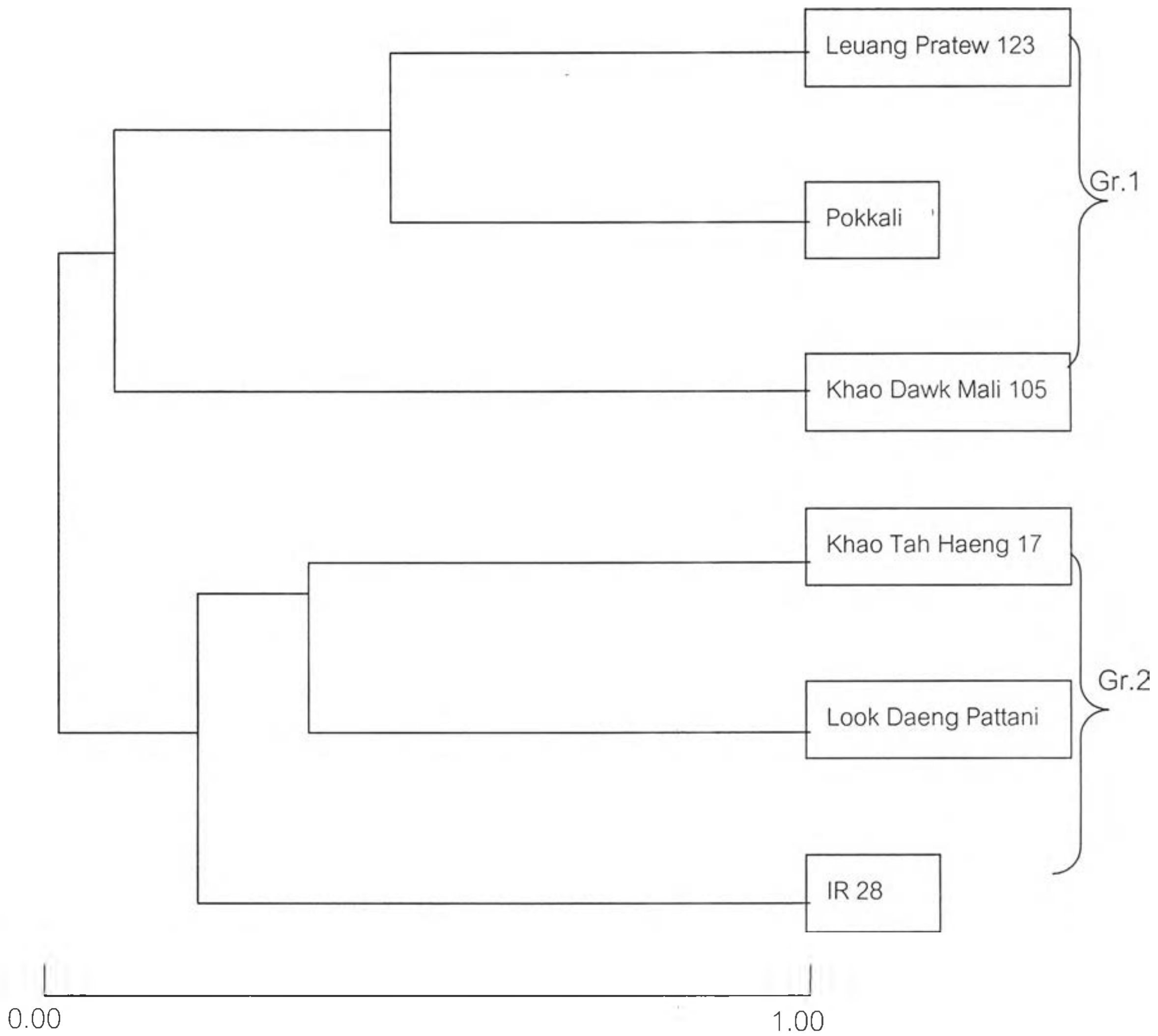


Figure 3.5 Dendrogram for 6 cultivars with X6,X8,X9,X10 and C1 constructed using UPGMA based on similarity coefficient.

3.2.2 Analysis of genetic variation among 6 salt tolerant and 6 salt sensitive cultivars by primer X9

RAPD analysis using primer X9 with 12 rice cultivars, including one more salt tolerant cultivars Gow Ruang 88, and 5 salt sensitive cultivars : Muey Nawng 62 M, Nahng Pa-yah 132, Foi Tawng, Yah Yaw, Leb Nok Pattani in addition to the former 6 cultivars used in the previous experiment.

By comparing the polymorphic DNA bands generated by primer X9 in 12 lowland rice cultivars, the 450 bp RAPD markers might be associated with salt tolerance phenology, since Khao Dawk Mali 105, Khao Tah Haeng 17, Leuang Pratew 123, Look Daeng Pattani and Gow Ruang 88 all showed faint band at this position (Figure 3.6, lane 2-6), while IR 28, Nahng Pa-yah 132, Yah Yaw and Foi Tawng showed smaller band (Figure 3.6, lane 7-12) Pokkali, although showed very faint band (Figure 3.6, lane 1) in this analysis, the 450 bp had been observed in the scanning experiment (Figure 3.2, lane 8).

Comparison of RAPD pattern of the 6 rice cultivars used in Figure 3.2, 3.3, 3.4 and the same 6 rice cultivars in Figure 3.6 revealed the inconsistency of the RAPD analysis. The variation in polymorphic pattern can be observed especially for faint bands although the major bands were more reproducible. The difference might occur from variation in seed population, quality of DNA prepared and subtle difference in PCR condition.

According to the dominant RAPD makers, the 600 bp band is common for all 10 Thai lowland rice cultivars (Figure 3.6, lane 2-6 and lane 8-12). It is noticeable that the 2 exotic cultivars, Pokkali and IR 28 differ from indigenous cultivars at this position.

By comparing the RAPD patterns of 12 cultivars using primers X9, gave amplification products of Pokkali, Khao Dawk Mali 105, Khao Tah Haeng 17, Leuang Pratew 123, Look Daeng Pattani, Gow Ruang 88, IR 28, Muey Nawng 62 M, Nahng Pa-yah 132, Foi Tawng, Yah Yaw and Leb Nok Pattani. The amplified polymorphic DNA fragments were scored as described in Materials and Method 2.8.1 for computer analysis. Table 3.7 showed the pair-wise similarity for 12 cultivars. The similarity coefficient (SC) ranged from 0.00 to 0.93. The results of pair-wise comparison indicated

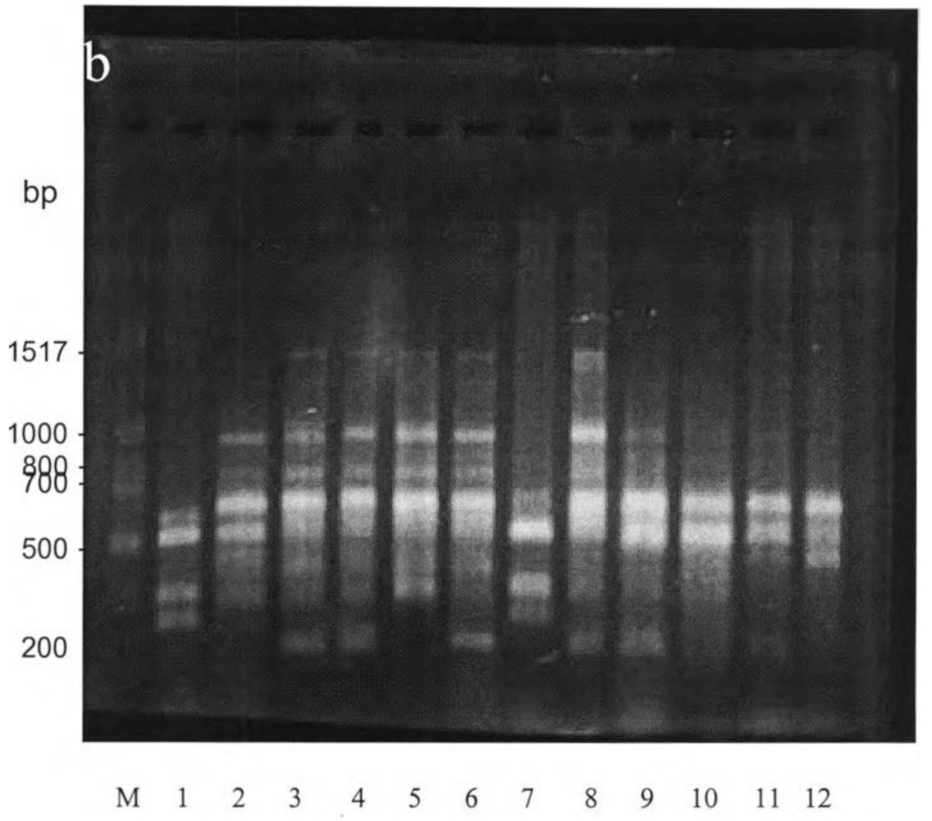


Figure 3.6 RAPD patterns of 6 salt tolerant and 6 salt sensitive cultivars using primer X9

DNA marker(M),Pokkali(lane1),Khao Dawk Mali 105(lane2),Khao Tah Haeng 17(lane3),Leuang Pratew 123(lane4),Look Daeng Pattani(lane5), Gow Ruang 88(lane6),IR 28(lane7),Muey Nawng 62 M(lane8),Nahng Pa-yah 132(lane9),Yah Yaw(lane10),Foi Tawng(lane11) and Leb Nok Pattani(lane12) using RAPD.Amplification products obtained with primerX9 were resolved by a 1.5% agarose gel.

Table 3.7 Similarity matrix of 12 rice cultivars with primer X9.

	POK	KDML	KTH	LPT	LDP	GR	IR	MN	NP	YY	FT	LNP
POK	1.00											
KDML	0.55	1.00										
KTH	0.17	0.53	1.00									
LPT	0.33	0.80	0.75	1.00								
LDP	0.36	0.57	0.67	0.80	1.00							
GR	0.33	0.67	0.63	0.88	0.93	1.00						
IR	0.00	0.00	0.33	0.17	0.36	0.33	1.00					
MN	0.15	0.50	0.71	0.71	0.63	0.71	0.31	1.00				
NP	0.44	0.67	0.46	0.77	0.67	0.77	0.22	0.57	1.00			
YY	0.57	0.40	0.37	0.55	0.60	0.55	0.29	0.33	0.75	1.00		
FT	0.22	0.67	0.46	0.77	0.50	0.62	0.22	0.43	0.80	0.50	1.00	
LNP	0.29	0.40	0.37	0.55	0.40	0.36	0.29	0.17	0.50	0.67	0.75	1.00

POK = Pokkali
KDML = Khao Dawk Mali 105
KTH = Khao Tah Haeng 17
LPT = Leuang Pratew 123
LDP = Look Daeng Pattani
GR = Gow Ruang 88
IR = IR 28
MN = Muey Nawng 62 M
NP = Nahng Pa-yah 132
YY = Yah Yaw
FT = Foi Tawng
LNP = Leb Nok Pattani

the highest genetic diversity between 2 pairs: IR 28 and Pokkali, IR 28 and Khao Dawk Mali 105, whereas the highest similarity of 0.93 was observed between the two local cultivars : Look Daeng Pattani and Gow Ruang 88. Correlation among the 12 cultivars revealed by UPGMA cluster analysis are presented in Figure 3.7. The ten Thai cultivars were classified into 3 closely related groups. Group 1 consisted of 4 salt tolerant cultivars Look Daeng Pattani, Gow Ruang 88, Leuang Pratew 123 and Khao Dawk Mali 105 with the similarity coefficient higher than 0.80, and another 2 salt sensitive cultivars Nahng Pa-yah 132 and Foi Tawng. Group 2 consisted of Yah Yaw and Leb Nok Pattani. Group 3 consisted of Muey Nawng 62 M and Khao Tah Haeng 17. Separation of Pokkali and IR 28 from the main cluster of Thai cultivars may be due to geographical distribution.

The genetic variation among Group 1,2 and 3 are about 50% and cover all the 10 Thai cultivars. Pokkali with Sri Lanka origin showed 55-57% similarity with Group 1 and Group 2 (Khao Dawk Mali 105 and Yah Yaw), whereas IR 28, the other exotic cultivars and the only semi-dwarf non photosensitive cultivar was clearly distinguished from the 10 Thai cultivars by about 60-70% genetic diversity, and showing the highest genetic variation (SC=0) from Pokkali, which is the tallest cultivar.

The result indicated that RAPD analysis using a single primer X9 may be an RAPD marker which linked to geographical distribution, by classifying the 2 exotic cultivars out of the main cluster of local cultivars, and placed the 4 southern cultivars in a closely associated genetic similarity grcups. Muey Nawng 62 M and Khao Tah Haeng 17 which were grown in the North and Northeast regions were classified as closely related to each other. Look Daeng Pattani is an exception because it is the only southern cultivar classified as closely related to the other 2 cultivars of the central origin.

Although primer X9 showed that the 4 salt tolerant cultivars: Gow Ruang 88, Look Daeng Pattani, Leuang Pratew 123 and Khao Dawk Mali 105 are less diverse by this genetic index, it failed to explain the different saline vulnerability between Muey Nawng 62 M and Khao Tah Haeng 17, and failed to distinguish salt sensitive Nahng Pa-yah 132 and Foi Tawng from the 4 salt tolerant cultivars (Gow Ruang 88, Look Daeng Pattani, Leuang Pratew 123 and Khao Dawk Mali 105).

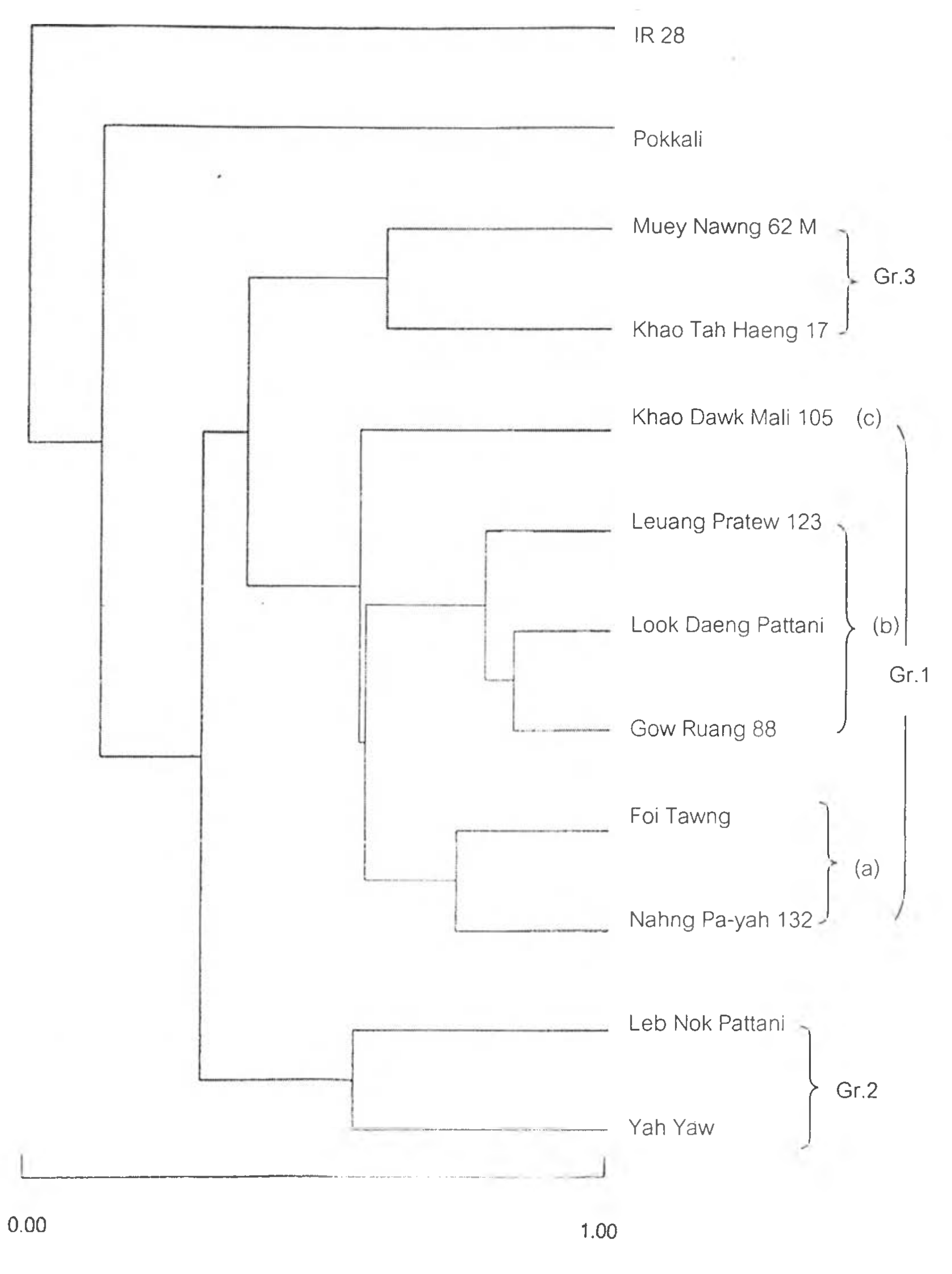


Figure 3.7 Dendrogram for 12 rice cultivars with X9 constructed using UPGMA based on similarity coefficient.

3.3 Effect of salinity on rice development

3.3.1 Vegetative phase

3.3.1.1 Germination stage

Percent germination of 12 cultivars were evaluated at 5 levels of salt stress (3,6,8,10 and 12 dS/m) plus control (Table 3.8 and Figure 3.8). In the salt tolerant cultivar group, all the cultivars displayed a high germination rate at 3,6 and 8 dS/m. At 10 dS/m, germination rate of Khao Tah Haeng 17 and Look Daeng Pattani was significantly suppressed where Khao Dawk Mali 105, Leuang Pratew 123 and Gow Ruang 88 were slightly affected. At a salinity level of 12 dS/m, only Pokkali and Leuang Pratew 123 retained more than 70 % of their germination rate compared with the control.

In the salt sensitive cultivar group, all the cultivars displayed a high germination rate at 6 dS/m. At 8 and 10 dS/m, germination rate of IR 28 and Nahng Pa-yah 132 was significantly suppressed. At a salinity level of 12 dS/m, Yah Yaw and Leb Nok Pattani retained more than 60% of their germination rate compared with the control. The salinity level of 8 dS/m where all the salt tolerant cultivars germinate normally and most salt sensitive cultivars were slightly depressed, was therefore selected to compare for damage under salt stress in the seedling stage.

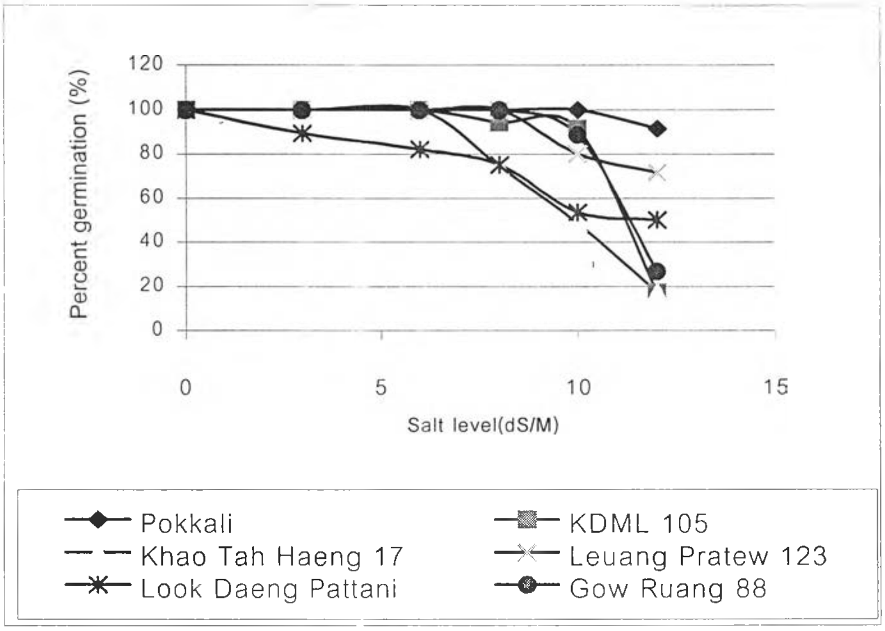
3.3.1.2 Leaf damage

Symptoms of damaged leaf of 12 rice cultivars evaluated at a salinity level of 8 dS/m versus control (no NaCl) include fade leaves, brown color starting at the margin of older leaf blades, gradually moving toward the leaf base and finally led to died seedling. From the experiment, symptoms of damaged leaves of 6 salt sensitive cultivars were more serious than 6 salt tolerant cultivars.

<u>1st week</u> After 17 day old seedlings of each rice cultivar were transplanted into plastic pot containing with mixture of clay and sand. Seedlings of each cultivar were treated with the modified Limpinuntana's nutrient solution which were adjusted with NaCl

Table 3.8 Percent germination of salt tolerant and sensitive rice cultivars under salt stress

cultivar	Control	Salinity level(dS/m)				
		3	6	8	10	12
Salt tolerant rice cultivar						
Pokkali	100	100	100	100	100	91.43
Khao Dawk Mali 105	100	100	100	94.29	91.43	17.14
Khao Tah Haeng 17	100	100	100	74.29	48.57	17.14
Leuang Pratew 123	100	100	100	100	80.00	71.43
Look Daeng Pattani	100	89.29	82.14	75.00	53.57	50.00
Gow Ruang 88	100	100	100	100	88.57	26.86
Salt sensitive rice cultivar						
IR 28	100	100	71.43	57.14	42.86	0.00
Muey Nawng 62 M	100	100	100	91.43	74.29	20.00
Nahng Pa-yah 132	100	71.43	71.43	57.14	35.71	28.57
Yah Yaw	100	100	100	91.43	77.14	62.86
Foi Tawng	100	100	94.29	94.29	88.57	48.57
Leb Nok Pattani	100	100	100	100	100	82.86



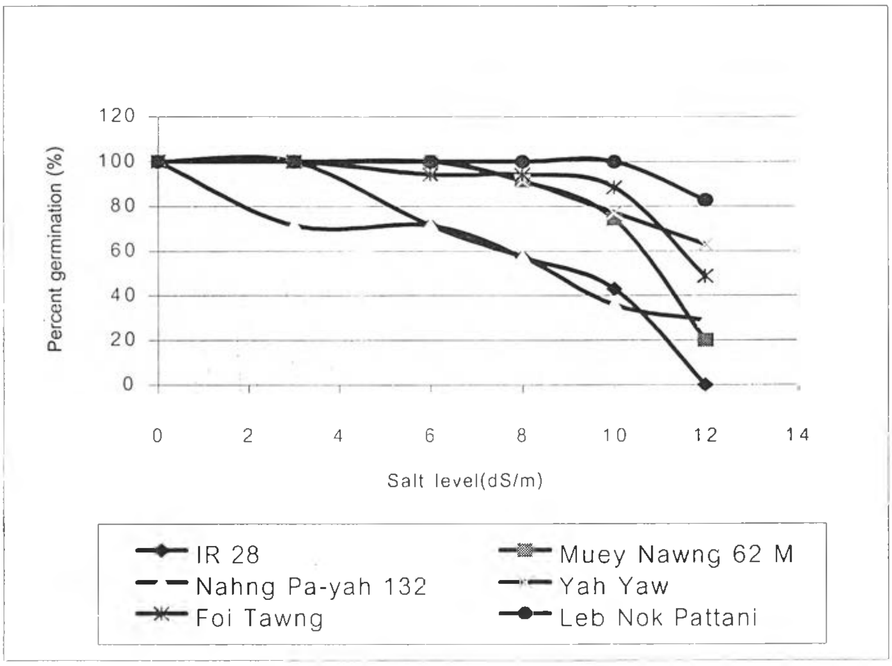


Figure 3.8 Percent germination (%) of (A) salt tolerant cultivars and (B) salt sensitive cultivars under salt stress.

for EC at 8 dS/m, and standard Limpinuntana's nutrient solution as control. No damaged leaves appeared at this week.

2 nd week Fade older leaves of 6 salt sensitive cultivars were higher than 6 salt tolerant cultivars.

3 rd week Brown color starting at the margin of older leaf blades and gradually moving toward the leaf base appeared. These symptoms of 6 salt sensitive cultivars were higher than 6 salt tolerant cultivars (Figure3.9).

4 th-5 th week Fade younger leaves and dried older leaves appeared. These symptoms of 6 salt sensitive cultivars were significantly higher level than 6 salt tolerant cultivars as shown in Table 3.9 and Figure 3.10 and 3.11.

6 th week 6 salt sensitive cultivars died while 6 salt tolerant cultivars still survived.

3.3.1.3 Plant height

Plant height of 12 cultivars was evaluated at a salinity level of 8 dS/m comparing to control without salt treatrment. According to the Table 3.9,plant height of 6 salt tolerant cultivars were significantly taller than 6 salt tolerant cultivars at 5 th week. In addition, Figure 3.12 showed average plant height of 6 salt tolerant cultivars between untreated and treated with NaCl and average plant height of 6 salt sensitive cultivars between untreated and treated with NaCl from 0 to 5 th week.

0-2nd week Average plant height of 6 salt tolerant cultivars between untreated and treated with NaCl and average plant height of 6 salt sensitive cultivars between untreated and treated with NaCl were not significantly difference.

3rd–5th week Average plant height of 6 salt sensitive cultivars between untreated and treated with NaCl was more significantly different than average plant height of 6 salt tolerant cultivars between untreated and treated with NaCl.

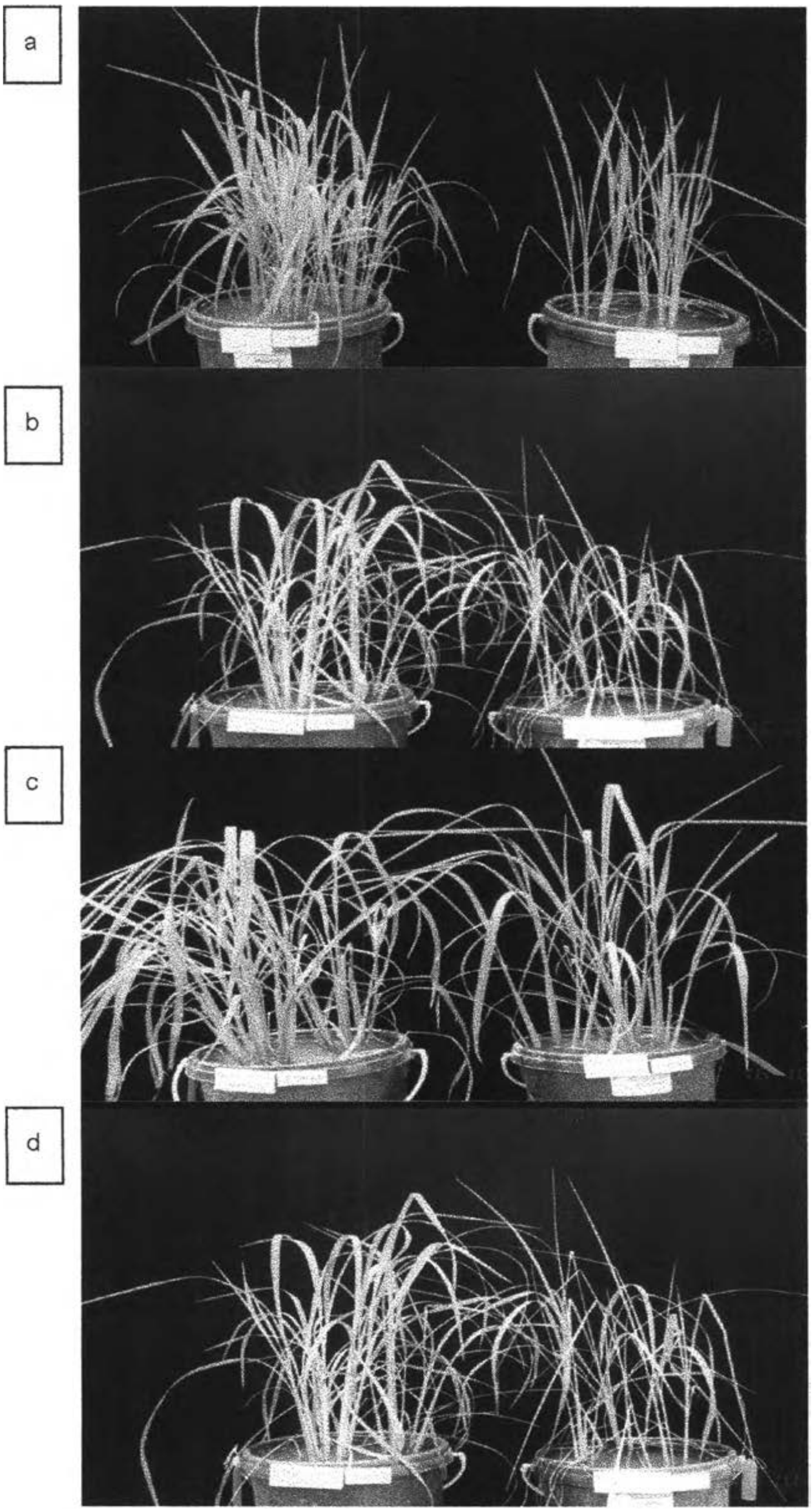


Figure 3.9 Leaf damage at 3 weeks under salt stress

a. Pokkali., b. IR28., c. Gow Ruang 88 and d. Nahng Pa-yah 132

(Left : control ; Right : + salt)

Table 3.9 Rice plants injury due to NaCl 8 dS/m at vegetative growth state(17 day-old) under greenhouse conditions at the 5 th week

Cultivar	Damaged leaf(%)	Plant height(cm) -NaCl	Plant height(cm) +NaCl	Change (%)	Tillers/hill -NaCl	Tillers/hill +NaCl	Change (%)
POK(T)	21.87^{b}	125.19^{g}	119.71^{f}	-4.38	8.48^{ab}	6.76^{cd}	-20.28
KDML(T)	15.27^{ab}	99.00^{bcd}	93.67^{d}	-5.38	12.24^{de}	7.71^{de}	-37.01
KTH(T)	10.74^{a}	105.90^{def}	100.76^{e}	-4.85	9.71^{abc}	8.52^{e}	-12.26
LPT(T)	13.49^{ab}	107.81^{ef}	99.14^{de}	-8.04	9.33^{abc}	8.81^{e}	-5.57
LDP(T)	15.30^{ab}	$103.71^{c\text{-}f}$	98.24^{de}	-5.27	11.14^{cde}	8.19^{de}	-26.48
GR(T)	15.87^{ab}	$103.67^{c\text{-}f}$	97.90^{de}	-5.57	9.10^{abc}	7.76^{de}	-14.73
IR(S)	49.11^{d}	69.38^{a}	55.76^{a}	-16.63	15.24^{f}	5.81^{bc}	-61.88
MN(S)	49.43^{d}	109.52^{f}	81.62^{c}	-25.48	7.72^{a}	3.45^{a}	-55.3
NP(S)	48.22^{cd}	95.76^{b}	67.24^{b}	-29.78	12.48^{e}	3.05^{a}	-75.56
YY(S)	43.33^{cd}	$101.95^{b\text{-}e}$	85.48^{c}	-16.15	10.10^{bcd}	4.43^{ab}	-56.14
FT(S)	39.37^{c}	$104.71^{c\text{-}f}$	82.29^{c}	-21.41	10.85^{cd}	5.62^{bc}	-48.20
LNP(S)	43.37^{cd}	98.05^{bc}	68.86^{b}	-29.77	13.14^{e}	4.52^{ab}	-65.60
Mean	30.45	102.06	87.56		10.79	6.22	
F-test	28.43*	33.02 *	66.35*		8.63*	17.19*	
CV(%)	26.3	5.7	6.6		18.1	20.8	

*Significant at 1% level

$$\text{change}(\%) = \frac{\text{treated NaCl mean} - \text{untreaded NaCl mean}}{\text{untreated NaCl mean}} \times 100$$

POK = Pokkali KDML = Khao Dawk Mali 105 KTH = Khao Tah Haeng 17

LPT = Leuang Pratew 123 LDP = Look Daeng Pattani GR = Gow Ruang 88

IR = IR 28 MN = Muey Nawng 62 M NP = Nahng Pa-yah 132

YY = Yah Yaw FT = Foi Tawng LNP = Leb Nok Pattani

T = salt tolerant rice cultivar S = salt sensitive rice cultivar

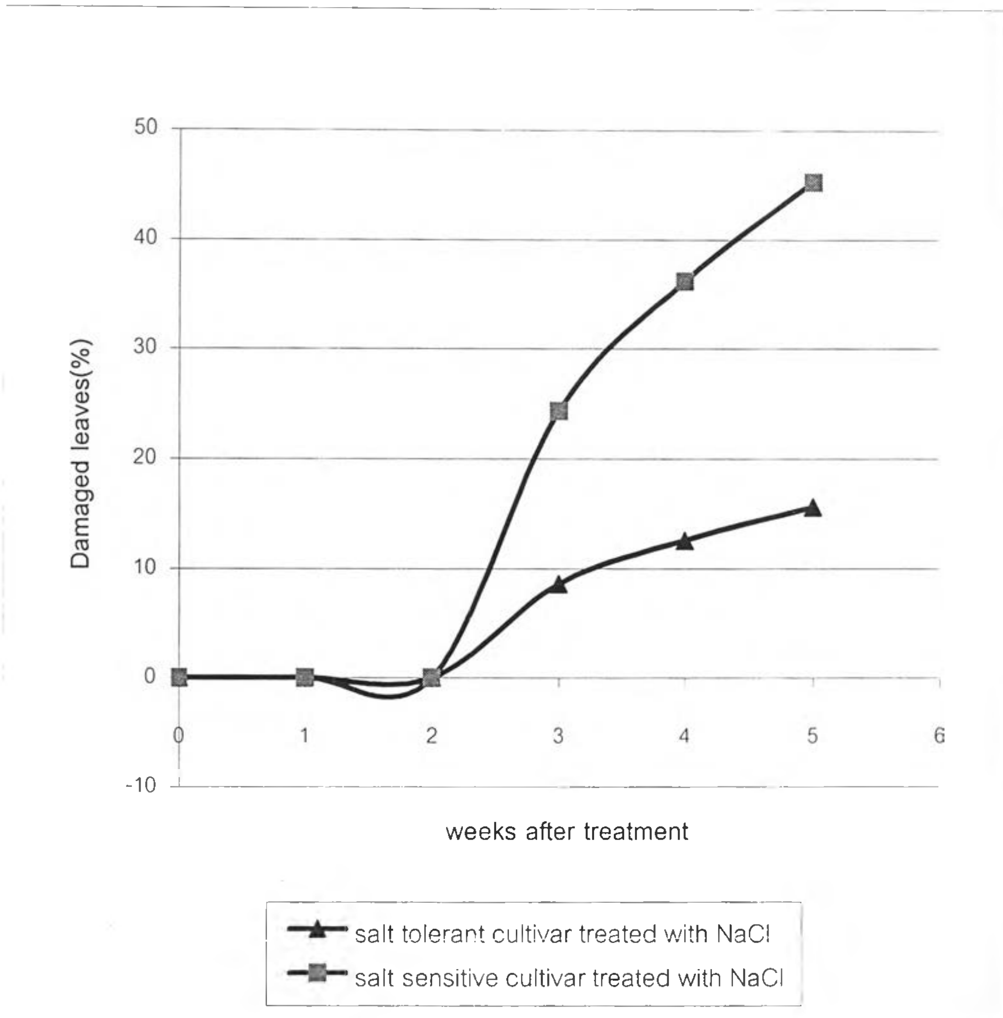


Figure 3.10 Damaged leaves(%) of salt tolerant and sensitive cultivar under salt stress

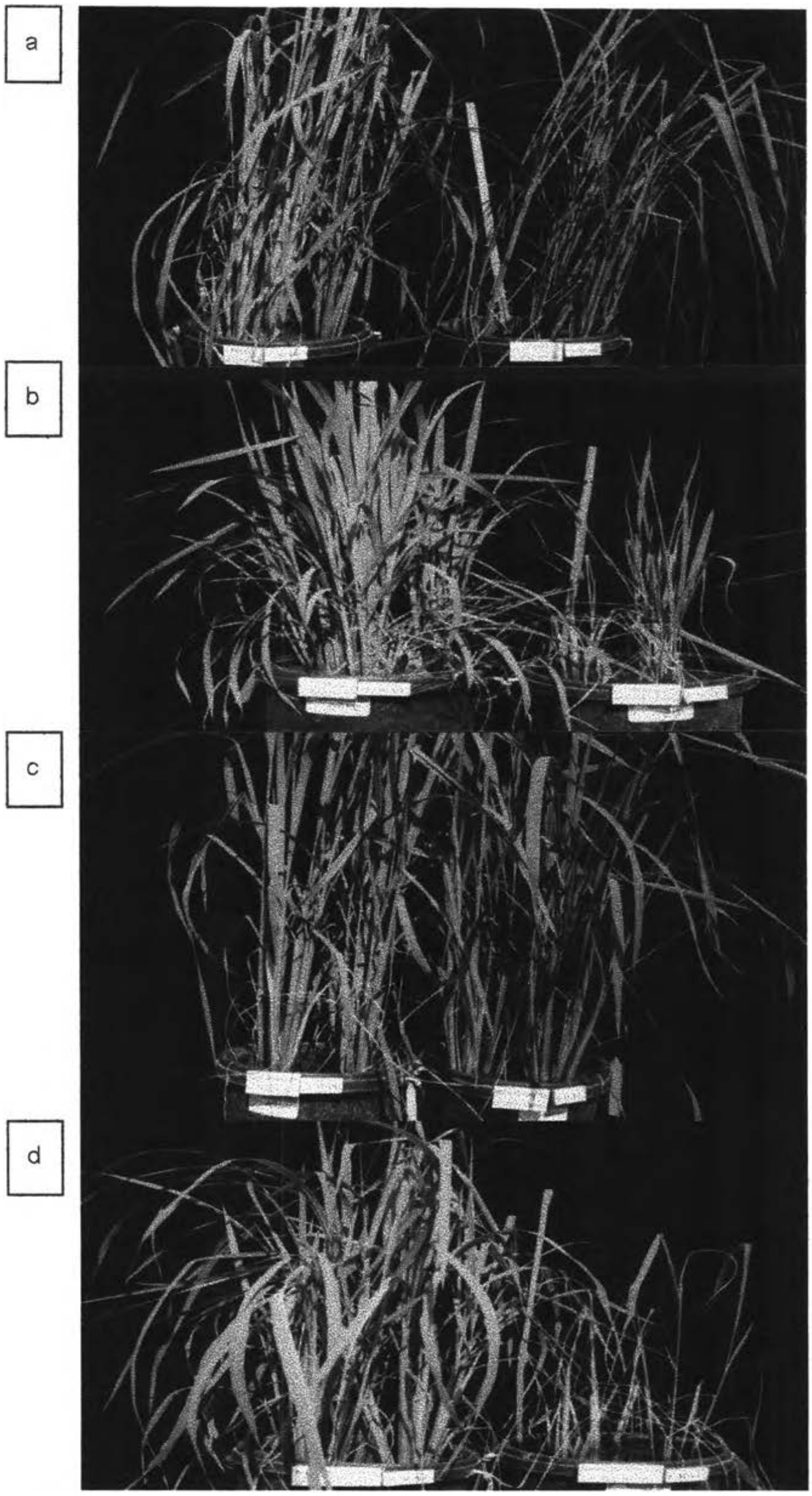


Figure 3.11 Leaf damage at 5 weeks under salt stress

a. Pokkali., b. IR28., c. Gow Ruang 88 and d. Nahng Pa-yah 132

(Left : control ; Right : + salt)

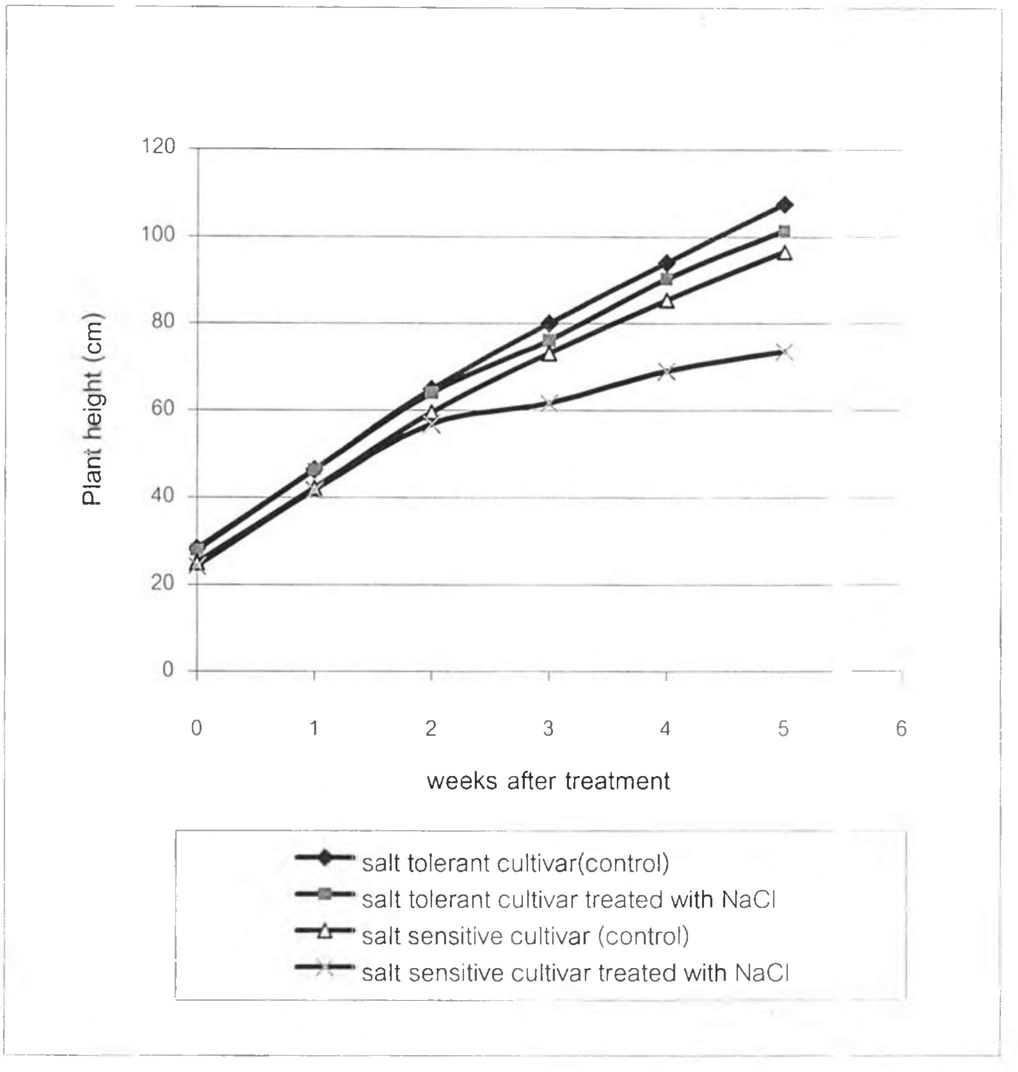


Figure 3.12 Plant height of salt tolerant and sensitive rice cultivars under salt stress

3.3.1.4 Tillering

The tillering of 12 rice cultivars starting from 3 rd to 5 th week after transplantation was evaluated at a salinity level of 8 dS/m plus control. According to the Table 3.9, maximum number of tillers/hill of salt sensitive cultivars was significantly reduced by salinity than maximum number of tillers/hill of salt tolerant cultivars at 5 th week. In addition, Figure 3.13 showed average number of tillers/hill of 6 salt tolerant cultivars between untreated and treated with NaCl and average number of tillers/hill of 6 salt sensitive cultivars between untreated and treated with NaCl from 3 th to 5 th week.

3 th–5 th week Average number of tillers/hill of 6 salt sensitive cultivars between untreated and treated with NaCl(11:4) was significantly difference by salinity than average number of tillers/hill of 6 salt tolerant cultivars between untreated and treated with NaCl(10:8).

3.3.2 Reproductive phase

3.3.2.1 Ratio of shoot to root dry weight (S/R ratio)

The ratio of shoot to root dry weight (S/R ratio) after harvesting arranged between 3.18-5.43,2.95-4.75,3.01-6.01 and 2.69-5.00 among 6 salt tolerant cultivars untreated and treated with NaCl and 6 salt sensitive cultivars untreated and treated with NaCl respectively (Table 3.10). The S/R ratio was reduced by salinity but the decrease was not significant only in Gow Ruang 88.

3.3.2.2 Panicles/plant of 12rice cultivars under salt stress

Panicles/plant ranged between 6.67-11.62, 4.81-5.67, 5.71-10.74 and 4.90-6.62 among 6 salt tolerant cultivars untreated and treated with NaCl and 6 salt sensitive cultivars untreated and treated with NaCl respectively. (Table3.10). Panicles/plant was reduced by salinity but the decrease was not significant only in Khao Tah Haeng 17 and Look Daeng Pattani.

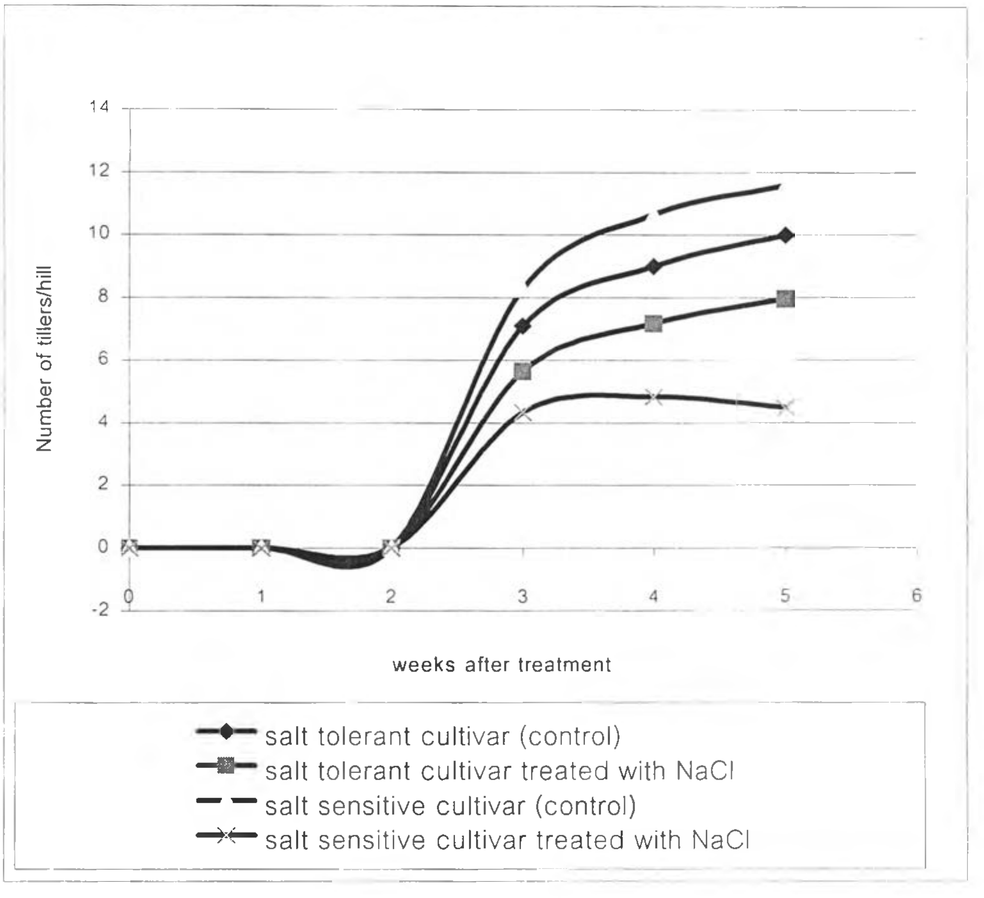


Figure 3.13 Number of tillers/hill under salt stress

Table 3.10 Effect of salt stress in reproductive phase on yield of biomass, panicle and grain

cultivars	Shoot/Root Ratio		change	Panicles/plant		change	Filled grains/Panicle		change
	- NaCl	+NaCl	(%)	-NaCl	+NaCl	(%)	-NaCl	+NaCl	(%)
POK	4.92^{abc}	4.09^{cd}	-16.87	7.00^{a}	5.33^{abc}	-23.86	59.28^{cd}	52.70^{e}	-11.10
KDML	5.43^{bc}	4.75^{de}	-12.52	11.62^{b}	4.95^{ab}	-57.40	24.17^{a}	16.87^{abc}	-30.20
KTH	4.21^{abc}	3.70^{bc}	-12.11	7.19^{a}	4.81^{a}	–33.10	48.99^{c}	40.32^{de}	-17.70
LPT	4.36^{abc}	2.95^{ab}	-32.34	7.29^{a}	5.67^{abc}	–22.22	50.69^{c}	28.78^{cd}	-43.22
LDP	3.18^{a}	2.98^{ab}	-6.29	6.67^{a}	4.86^{a}	-27.14	45.29^{bc}	38.30^{de}	-15.43
GR	4.38^{abc}	3.62^{a}	–17.35	7.00^{a}	4.95^{ab}	-29.29	54.78^{cd}	26.82^{bc}	–51.04
IR	6.01^{c}	5.00^{e}	-16.81	10.74^{b}	6.29^{bc}	-41.43	29.57^{ab}	10.31^{ab}	-65.13
MN	4.63^{abc}	4.61^{de}	-0.43	5.71^{a}	4.93^{ab}	-13.66	48.64^{c}	6.65^{a}	-86.33
NP	4.02^{ab}	3.61^{abc}	-10.20	7.76^{a}	5.48^{abc}	-29.38	42.53^{bc}	26.84^{bcd}	-36.89
YY	3.01^{a}	2.78^{ab}	-7.64	6.76^{a}	5.59^{abc}	-17.31	68.52^{d}	47.23^{e}	-31.07
FT	4.69^{abc}	2.69^{a}	-42.64	6.62^{a}	4.90^{ab}	-25.98	57.72^{cd}	51.69^{e}	-10.45
LNB	4.06^{ab}	3.65^{abc}	–10.10	7.43^{a}	6.62^{c}	-10.90	70.93^{d}	55.25^{e}	-22.11
Mean	4.41	3.70		7.65	5.36		50.09	33.48	
F-test	2.11**	6.93*		7.53*	1.94**		6.44*	9.47*	
CV(%)	34.7	21.2		21.9	21.0		28.9	42.9	

Means followed by a common letter are not significantly different at 5 % level by DMRT

POK	=	Pokkali	KDML	=	Khao Dawk Mali 105	KTH	=	Khao Tah Haeng 17
LPT	=	Leuang Pratew 123	LDP	=	Look Daeng Pattani	GR	=	Gow Ruang 88
IR	=	IR 28	MN	=	Muey Nawng 62 M	NP	=	Nahng Pa-yah 132
YY	=	Yah Yaw	FT	=	Foi Tawng	LNP	=	Leb Nok Pattani

3.3.2.3 Filled grains/panicle of12rice cultivars under salt stress

Filled grains/panicle between 24.17-59.28,16.87-52.70,29.57-70.93 and 6.65-55.25 among 6 salt tolerant cultivars untreated and treated with NaCl and 6 salt sensitive cultivars untreated and treated with NaCl respectively (Table3.10). Filled grains/panicle was reduced by salinity but the decrease was not significant only in IR 28.

3.3.3.2.4 100-grain weight(gram) of 12rice cultivars under salt stress

100-grain weight (gram) between 1.61-2.67,1.60-2.56,1.23-3.04and 1.21-2.62 among 6 salt tolerant cultivars untreated and treated with NaCl and 6 salt sensitive cultivars untreated and treated with NaCl respectively.(Table 3.11). 100-grain weight (gram) was significant only in Pokkali, Khao Tah Haeng 17,Leuang Pratew 123, Look Daeng Pattani, Gow Ruang 88,IR 28 and Yah Yaw.

Table3.11 100-grain weight (gram) of 12 rice cultivars under salt stress

cultivar	100-grain weight(gram)		change
	-NaCl	+NaCl	(%)
POK	2.67[b]	2.56[a]	-4.12
KDML	2.06[d]	1.92[d]	-6.80
KTH	2.18[d]	2.05[c]	-5.96
LPT	2.17[d]	2.20[b]	+1.38
LDP	1.61[f]	1.60[ef]	-0.62
GR	2.37[c]	2.22[b]	-6.33
IR	1.64[ef]	1.68[e]	+2.4
MN	3.04[a]	2.62[a]	-13.82
NP	1.75[e]	1.67[e]	-4.57
YY	1.66[ef]	1.53[f]	-7.83
FT	1.57[f]	1.53[f]	-2.55
LNB	1.23[g]	1.21[g]	-1.63
Mean	2.00	1.90	
F-test	135.67*	160.54*	
CV(%)	5.9	4.8	

* significant at 1% level

** significant at 5% level

Means followed by a common letter are not significantly different at 5% level by DMRT (Duncan's Multiple Range Test)

$$\text{Change (\%)} = \frac{\text{NaCl treated means - NaCl untreated control means}}{\text{NaCl untreated control means}} \times 100$$

POK	= Pokkali	KDML	= Khao Dawk Mali 105	KTH	= Khao Tah Haeng 17
LPT	= Leuang Pratew 123	LDP	= Look Daeng Pattani	GR	= Gow Ruang 88
IR	= IR 28	MN	= Muey Nawng 62 M	NP	= Nahng Pa-yah 132
YY	= Yah Yaw	FT	= Foi Tawng	LNP	= Leb Nok