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Salinity effects on germination and growth of Malaysian weedy rice biotypes and cultivated rice

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Abstract

Germination and seedling growth of plant species are reduced in saline due to an external osmotic potential. An experiment was conducted at the laboratory, Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, to compare the salt effect on seed germination and growth of weedy rice and cultivated rice. Seeds (10 in each) were placed in petri dishes. Five salinity levels 0 (distilled water), 4, 8, 12 and 16 dSm^{-1} (NaCl) were applied. The number of germinated seeds was recorded daily. The final germination percentage, germination index (GI), seedling vigour index (SVI) mean germination time (MGT), shoot and root dry weight were estimated. At highest salinity (16 dSm^{-1}) germination percentage was higher (100%) in weedy rice awn and weedy rice compact. Lowest germination percentage was in MR219 and TQR-8 (50-60%). Mean germination time (MGT) was found higher in all weedy rice biotypes compared to cultivated rice. At highest salinity (16dSm^{-1}) weedy rice open produced the highest MGT (9.92) followed by weedy rice compact (9.73) while lowest MGT was in MR219 (9.48). At highest salinity (16dSm^{-1}) germination index was higher in weedy rice awn (11.71) and compact type (9.62). Lowest germination index was in MR219 (5.90) and TQR-8 (8.94). At the highest salinity (16 dSm^{-1}), seedling vigor index was highest in weedy rice awn (6.06) followed by weedy rice compact (5.26); while lowest was in MR219 (2.11) followed by MR269 (3.82).On the basis of Germination index, seedling vigor index and growth related results it could be concluded that weedy rice awn, compact and open biotypes were more salt tolerant compared to other cultivated rice MR219, MR269 and TQR-8.

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Introduction

Rice is a staple food and world's most important crop for more than half of the world's population. Weedy rice, weedy forms of *Oryza sativa* L., is a serious problem in many rice growing areas in Asia, causing increased production costs and considerable yield losses in rice. In Malaysia, a rice yield loss due to weedy rice infestation has been reported to be 74% (Azmi *et al.* 2007). In Malaysia, weedy rice (*Oryza sativa* L) established itself in direct- seeded rice (DSR) fields in the Muda area in 1990.

The presence and subsequent emergence of several morphological variants similar to the common characteristics of wild rice, O. rufipogon, within weedy rice population over seasons in Muda have given some clues to the possibility of out crossing occurring between cultivated and wild rice. Weedy rice is closely related to cultivated rice and infests fields in all major rice-growing areas in the tropics. Weedy rice is an emerging weed problem in many rice-growing areas in Asia (Chauhan and Johnson 2011). Difficulties arise in the management of weedy rice due to its physiological, anatomical, and morphological similarities to cultivated rice.

The manipulation of the environment to improve cultivated rice production and suppress the emergence of weedy rice variants is important in the management of weedy rice, as well as other cultural practices and use of pesticides (Bashira *et al*, 2016).

Generally rice crop is sensitive to salinity. Predicted global climate changes will cause sea levels rising and it will not only increase the salinity level of the salt-affected lands, rather will also increase the total saline area. Germination and seedling growth of plant species are reduced in saline soils due to an external osmotic potential that prevents water uptake or due to the toxic effects of Na^+ and Cl^- ions or both on the germinating seed (Murrillo *et al.*, 2002). The objective of the study was to determine the effects of seed germination and growth on weedy rice biotypes and cultivated rice at different salinity levels.

Materials and methods

An experiment was conducted at the laboratory, Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, Sandakan campus to compare the salt effect on seed germination of weedy rice and cultivated rice. Seeds (10 in each) were placed in Petri dishes between layers of moist Whatman filter paper 1. Five salinity levels: 0 (distilled water), 4, 8, 12 and 16 dSm^{-1} (NaCl) were applied. Room temperature was 28±2°C with 12hr light. The completely randomized design with four replications was used. The number of germinated seeds was recorded daily. The final germination percentage, germination index (GI), seedling vigour index (SI) and mean germination time (MGT) were estimated. Data were analyzed using the ANOVA PROC with RCBD design available in SAS version 9.1. The treatment means were separated by protected Least Significance Differences (LSD) at the 5% probability level.

Germination pattern and seedling vigor of weedy rice and cultivated rice were evaluated at different salinity levels. Final germination percentages (GP), mean germination times (MGT) and germination index (GI) were calculated using the following formula:

$$GP = \frac{\text{Number of germinated seeds at final count}}{\text{Total number of seeds tested}} \times 100$$

(AOSA, 1983).

$$MGT = \frac{\sum Dn}{\sum n}$$

(Ellis and Robert, 1981).

Where, n is the number of seeds germinated on day D and D is the number of day counted from beginning of germination.

$$GI = \frac{\text{Number of germinated seeds}}{\text{Day of first count}} + \ldots + \frac{\text{Number of germinated seeds}}{\text{Day of final count}}$$

(AOSA, 1983).

At 14 days after seeding (DAS), 3 seedlings from each replicate were randomly selected. Seedling length were measured and then oven dried at 70°C for 72 hours to record root and shoot dry weight of seedlings. Relative shoot dry weight and root dry weight was calculated by Ashraf and Waheed, 1990.

$$\text{Relative dry weight (\%)} = \frac{\text{Dry weight of salinized treatment value of a species}}{\text{Dry wight of control treatment value of that species}} \times 100$$

Seedling vigor index (SVI) was calculated using the following formula:

$$\text{Seedling Vigor Index (SVI)} = \frac{\text{Seedling length (cm)} \times \text{Germination percentage}}{100}$$

(AOSA, 1983).

Where, Seedling length= Root length + Shoot length.

Result and discussion

Germination pattern

Different salinity treatments exhibited a significant effect on germination percentage of rice and weedy rice biotypes. At 8 dSm^{-1} germination (%) was almost similar in all species except TQR-8. All the salinity treatments resulted in lower germination percentage (GP) than compared to control except 4 dSm^{-1} which gave GP similar to control.

Table 1. Effect of salinity on germination percentage of rice and weedy rice biotypes.

EC_w (dS m^{-1})	MR269	MR219	TQR-8	Weedy rice (awn)	Weedy rice (compact)	Weedy rice (open)
0	100a	100a	90a	100a	100a	100a
4	100a	100a	80b	100a	100a	100a
8	100a	100a	70c	100a	100a	100a
12	90b	80b	60d	100a	100a	100a
16	70c	50c	60d	100a	90a	90b
LSD (0.05)	0	0	0	0	0	0

Means within columns followed by the same letter are not significantly different at P =0.05 (LSD test).

Table 2. Effect of salinity on mean germination time of rice and weedy rice biotypes.

EC_w (dS m^{-1})	MR269	MR219	TQR-8	Weedy rice (awn)	Weedy rice (compact)	Weedy rice (open)
0	8.36b	8.19b	9.14ab	8.14b	8.09c	8.28b
4	8.54b	8.31b	8.96b	8.14b	8.14c	8.37b
8	8.91ab	8.27b	9.53a	8.86a	9.03b	9.40a
12	9.14ab	9.25a	9.63a	9.04a	9.30b	9.44a
16	9.52a	9.46a	9.56a	9.48a	9.73a	9.92a
LSD (0.05)	0.77	0.56	0.54	0.66	0.42	0.67

Means within columns followed by the same letter are not significantly different at P =0.05 (LSD test).

At highest salinity (16 dSm^{-1}) germination percentage was higher (100%) in Weedy rice awn and weedy rice compact. Lowest germination percentage was in MR219 and TQR-8 (50-60%) (Table 1). Chauhan *et al.* (2006) observed that the germination percentage of rice seeds was significantly decreased with increasing the salinity level and germination completely inhibited at 28 dSm^{-1} NaCl concentration.

Mean germination time (MGT) increased with increasing salinity in all species (Table 2). MGT was found higher in all weedy rice biotypes compared to cultivated rice. At highest salinity (16dSm^{-1}) weedy rice open produced the highest MGT (9.92) followed by weedy rice compact (9.73) while lowest MGT was in MR219 (9.46).

Table 3. Effect of salinity on germination index of rice and weedy rice biotypes.

EC_w (dS m^{-1})	MR269	MR219	TQR-8	Weedy rice (awn)	Weedy rice (compact)	Weedy rice (open)
0	19.05a	20.47a	8.04a	21.06a	21.47a	19.64a
4	16.64b	18.89b	8.78a	21.06a	20.97a	18.80a
8	14.12c	14.03c	7.99a	16.56b	13.86b	12.09b
12	12.21d	9.28d	8.79a	15.19b	12.76b	10.93bc
16	9.06e	5.90e	8.94a	11.71c	9.62c	8.92c
LSD (0.05)	1.81	2.04	1.81	2.04	2.07	2.04

Means within columns followed by the same letter are not significantly different at P =0.05 (LSD test).

Germination Index

The results showed that germination index (GI) significantly decreased with increasing salinity levels with increasing salinity in all species (Table 3).At highest salinity (16dSm^{-1}) germination index was higher in weedy rice awn (11.71) followed by compact type (9.62) and open type (9.25). Lowest germination index was found in MR219 (5.90) followed by TQR-8 (8.94) and MR269 (9.06).

Table 4. Effect of salinity on seedling vigor index of rice and weedy rice biotypes.

EC_w (dS m^{-1})	MR269	MR219	TQR-8	Weedy rice (awn)	Weedy rice (compact)	Weedy rice (open)
0	13.20a	11.66a	6.84b	12.63b	11.80a	12.33a
4	12.36a	10.63a	7.62a	13.56a	11.63a	10.99ab
8	8.36b	8.80b	5.83c	8.10c	8.83b	10.39b
12	6.93c	5.09c	4.85d	7.10d	6.40c	8.53c
16	3.82d	2.11d	2.65e	6.06e	5.26c	4.25d
LSD (0.05)	1.24	1.06	0.53	0.84	1.70	1.74

Means within columns followed by the same letter are not significantly different at *P* =0.05 (LSD test).

The results of our study supported by Carpici *et al.* (2009) and observed that increasing salinity levels linearly decreased germination index in all of the cultivars of maize (*Zea mays* L.). Khan *et al.* (1997) found that the decreasing trend of GI value with the increase in salinity. Rejili *et al.* (2009) also reported that the germination index of *Lotus creticus* (L.) decreased significantly due to increase in salinity levels. Small seeds of all cultivars of chickpea showed the highest GI values at all NaCl concentrations, while GI gradually decreased by the increasing of NaCl concentration (Kaya *et al.*, 2008). Seedling vigour.

Table 5. Effect of salinity on shoot length (mm) of rice and weedy rice biotypes.

EC_w (dS m^{-1})	MR269	MR219	TQR-8	Weedy rice (awn)	Weedy rice (compact)	Weedy rice (open)
0	7.83a	7.40a	7.43b	10.50a	8.30a	8.70a
4	6.96a	7.23a	9.23a	9.06b	8.26a	7.96a
8	5.23b	5.83b	5.76c	5.56c	6.86b	7.83a
12	5.06bc	3.73c	3.73d	4.50d	4.70c	6.43b
16	4.20c	2.70c	3.10d	4.30d	3.86c	3.56c
LSD (0.05)	0.88	1.23	1.23	0.78	0.95	1.17

Means within columns followed by the same letter are not significantly different at *P* =0.05 (LSD test).

A significant effect of salinity treatments was observed on seedling vigour of rice and weedy rice biotpes (Table 4). At the highest salinity (16 dSm^{-1}), seedling vigor index was highest in weedy rice awn (6.06) followed by weedy rice compact (5.26); while lowest in MR219 (2.11) followed by MR269 (3.82). The reduction in seedling height and seedling vigor increased of many crop plants grown under saline environment is a common phenomenon (Atak *et al.* 2008).

Shoot length

Shoot length of all the species declined in general at all the salt treatments as compared to control (Table 5).

However, at 4dS m^{-1} there was no significant differences among cultivated rice and *Oryza sativa* L. (weedy rice). At salinity 8 dS m^{-1} cultivated rice and *Oryza sativa* L. (weedy rice) had produced significantly higher shoot length compared to control treatments At the salinity level of 16 dS m^{-1} cultivated rice and *Oryza sativa* L. (weedy rice) showed drastic reduction in shoot length. The percent reduction of shoot length of MR269, MR219, TQR8, awn weedy rice, compact weedy rice and open weedy rice were 46, 64, 58, 59, 53 and 58 respectively. The reduction in seedling height of many crop plants grown under saline environment is a common phenomenon (Javed and Khan, 1995).

Our result supported by Rahman and Ungar (1990) and noted that the seedling length of *Echinochloa crusgalli* significantly decreased due to increased salt concentration of NaCl. Okcu *et al.* (2005) reported that the shoot and root lengths of pea decreased with the increased salt concentrations. Similar results were also observed and noted by Atak *et al.* (2008) that shoot length of dry green pea declined with the increase of NaCl. Kaya *et al.* (2008) observed the similar result that the shoot length of chickpea (*Cicer arietinum* L.) was significantly influenced by NaCl and severely affected by with complete inhibition of shoots at 16.3 dS m^{-1} NaCl stress in all cultivars. Root Length.

Table 6. Effect of salinity on root length (mm) of rice and weedy rice biotypes.

EC_w (dS m^{-1})	MR269	MR219	TQR-8	Weedy rice (awn)	Weedy rice (compact)	Weedy rice (open)
0	5.40a	4.26a	3.96a	3.56a	3.50a	3.63a
4	5.36a	3.40b	3.46a	3.06ab	3.36a	3.03ab
8	3.13b	2.96bc	2.56b	2.60b	1.96b	2.56bc
12	2.63bc	2.63c	2.33b	2.53b	1.70b	2.10c
16	1.26c	1.53d	1.33c	1.76c	1.40b	1.16d
LSD (0.05)	1.03	0.75	0.58	0.69	1.12	0.75

Means within columns followed by the same letter are not significantly different at *P* =0.05 (LSD test).

Table 7. Effect of salinity on shoot dry weight (mg) of rice and weedy rice biotypes.

EC_w (dS m^{-1})	MR269	MR219	TQR-8	Weedy rice (awn)	Weedy rice (compact)	Weedy rice (open)
0	7.79a	6.72a	6.11a	7.95a	6.53a	7.25a
4	7.21b	6.48a	5.90ab	7.84a	6.30a	6.85a
8	5.87c	4.75b	5.51bc	7.63a	5.84a	6.08b
12	4.47d	4.23b	5.33bc	5.27b	4.35b	4.85c
16	3.45c	3.00c	5.28c	4.18c	4.13b	4.52c
LSD (0.05)	0.46	0.83	0.57	0.55	0.76	0.68

Means within columns followed by the same letter are not significantly different at *P* =0.05 (LSD test).

Root lengths were more affected with increased salinity levels compared to shoot and salt effects on root were more prominent than shoot at each specific salinity level (Table 6). At 16 dS m-1, showed serious reduction in root length. The percent reduction of root length of MR269, MR219, TQR8, awn weedy rice, compact weedy rice and open weedy rice were 77, 64, 66, 51, 60 and 68 respectively. Soltani *et al.* (2002) observed that root length was diminished by increasing NaCl concentration. The gradual decrease in root length with the increase in salinity might probably be due to more inhibitory effect of NaCl to root growth compared to that of shoot growth (Rahman *et al.*, 2001). Salt concentration caused corresponding decrease in root length in all cultivars of chickpea and the longest roots were obtained from small seeds in each cultivar under all salt stress conditions (Kaya *et al.*, 2008). Similar result was observed and noted by Momayezi *et al.* (2009) that the root length of all rice genotypes was reduced with increasing salt concentration.

Shoot dry weight

The shoot dry weight (SDW) of rice and weedy rice biotypes decreased as the level of salinity increased (Table 7). Results showed that weedy rice awn and compact was the most salt tolerant species, showing complete tolerance to salinity levels upto 8dS m-1. At highest salinity (16 dSm^{-1}) shoot dry weight (SDW) reduction was greater in MR269 (56%) followed by MR219 (55%) while lower reduction was in weedy rice compact (37%) followed by weedy rice open (38%). The gradual decrease in root length with the increase in salinity might probably be due to more inhibitory effect of NaCl to root growth compared to that of shoot growth (Rahman *et al.*, 2001).

Table 8. Effect of salinity on root dry weight (mg) of rice and weedy rice biotypes.

EC_w (dS m^{-1})	MR269	MR219	TQR-8	Weedy rice (awn)	Weedy rice (compact)	Weedy rice (open)
0	2.65a	2.16a	2.62a	2.85a	2.14a	2.68a
4	2.45a	1.93a	2.47ab	2.54b	2.12a	2.56a
8	1.60b	1.46b	2.22bc	2.44b	1.25b	2.04b
12	1.20c	1.16c	2.02c	1.69c	1.02c	1.52c
16	1.02c	0.70d	1.65d	1.25c	0.91c	1.37c
	38	32	63	44	43	51
LSD (0.05)	0.25	0.27	0.34	0.23	0.16	0.15

Means within columns followed by the same letter are not significantly different at *P* =0.05 (LSD test).

Root dry weight

The results showed that root dry weight (RDW) significantly decreased with increasing salinity levels (Table 8). At 4 dS m^{-1} there were no significant differences between species due to the effect of salinity, except for *weedy rice awn* were found to be tolerant in terms of RDW up to 8 dS m^{-1} salinity. At highest salinity (16 dSm^{-1}) root dry weight (RDW) reduction was greater in MR219 (68%) followed by MR269 (62%) while lower was in weedy rice open (49%) followed by weedy rice compact (47%).

Conclusion

On the basis of Germination index, seedling vigor index and growth related results it could be concluded that weedy rice awn, compact and open biotypes were more salt tolerant compared to other cultivated rice MR219, MR269 and TQR-8. Salinity study may provide important information on the tolerance ability of weedy rice to salinity. Most importantly, breeders can utilize the traits of such weedy rice and able to breed salt-tolerant rice cultivars.

References

AOSA (Association of Official Seed Analysis). 1983. Seed vigour testing handbook, Contribution No. 32 to the handbook on seed testing, Springfield, IL, USA.

Ashraf M, Waheed A. 1990. Screening of local/exotic accessions of lentil (*Lens culinaris* Medic.) for salt tolerance at two growth stages. Plant Soil **128,** 167–176.
http://dx.doi.org/10.1007/BF00011106.

Atak M, Kaya MD, Kaya G, Kaya M, Khawar KM. 2008. Dark green colored seeds increase the seed vigor and germination ability in dry green pea (*Pisum sativum* L.). Pakistan Journal Botany **40,** 2345-2354.
http://dx.doi.org/10.1007/s10531-010-9833.

Azmi M, Abdullah MZ, Muhammad H. 2009. Weedy rice: A real threat to rice industry and farmers. Proc. 4th national seed symposium, p.109-112.

Azmi M, Juraimi AS, Mohammad Najib MY. 2007. Critical period of weedy rice control in direct seeded rice. Journal of Tropical Agriculture and Food Science **35(2),** 319-332.
http://dx.doi.org/10.1100/2012/603043.

Bashira O, Juraimi AS, Uddin MK, Husni A, Amirul A. 2016. Completive ability cultivated rice against weedy rice biotypes. Chiliean Journal of Agricultural research **2,** 243-252.
http://dx.doi.org/10.4067/S07185839201600020001 5.

Chauhan BS, Johnson DE. 2011. Competitive interactions between weedy rice and cultivated rice as a function of added nitrogen and the level of competition. Weed Biology Management **11,** 202-209.
http://dx.doi.org/10.1111/j.1445-6664.2011.00421.

Ellis R, Roberts A. 1981. The qualification of ageing and survival in orthodox seeds. Seed Science Technology **9,** 373-409.

Khan MS, Hamid A, Karim MA. 1997. Effect of sodium chloride on germination and seedling characters of different types of rice (*Oryza sativa* L.). Journal Agronomy Crop Science **179,** 163-169. http://dx.doi.org/10.1111/j.1439-037X.1997.tb00512.

Murillo-Amador B, Lopez-Aguila R, Kaya C, Larrinaga-Mayoral J, Flores-Hernandez A. 2002.Comparative effects of NaCl and polyethylene glycol on germination, emergence and seedling growth of cowpea. Journal Agronomy Crop Science **188**, 235-247. http://dx.doi.org/10.1046/j.1439037X.2002.00563.

Rahman MS, Miyake H, Taheoka Y. 2001. Effect of sodium chloride salinity on seed germination and early seedling growth of rice (*Oryza sativa* L.). Pakistan Journal Biological Science **4,** 351-355. http://dx.doi.org/10.3923/pjbs.2001.351.355.

Rejili M, Ahmedou M, Guetet VA, Mahdhi M, Lachiheb B. 2009. Ferchichi and M. Mars: Influence of temperature and salinity on the germination of *Lotus creticus* (L.) from the arid land of Tunisia. African J. Ecol., **48,** 329-337. http://dx.doi.org/10.1111/j.1365-2028.2009.01111.