Availability of hairy vetch (*Vicia villosa* Roth) as leguminous green manure crops for organic rice cultivation in reclaimed saline land

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Key words: Organic agriculture, hairy vetch, rice, green manure, salinity, seedling

Abstract

In this study we evaluated the availability of hairy vetch in reclaimed organic rice production systems. The response to increasing salinity was analyzed by means of the germination rate and seedling growth of hairy vetch. Results showed that seed germination of hairy vetch decreased insignificantly up to concentration of 0.6% NaCl. However, shoot and root growth of hairy vetch showed significant reduction at salinity concentrations higher than 0.1% NaCl level. In these results we were considered that hairy vetch can be use below concentration of 0.1% salinity as green manure crop in reclaimed saline rice production.

Introduction

Hairy vetch (*Vicia villosa* Roth) is playing an important role to improve soil physical properties and soil fertility for the supply of crop nutrients. A hairy vetch cover crop can supply especially nitrogen (Carrera et. al., 2007; Giacomo Tosti et. al., 2012) and also suppress weeds (Enio Campiglia et. al., 2012). Therefore, cover crops are well known for improving soil organic matter, soil structure, water holding capacity, reducing soil erosion, and increasing crop yield (Sainju et al., 2006). This crop is used as a representative legumes green manure for the production of organic agricultural food and grown from October to June as a winter cover crop in the upland and rice paddy fields of South Korea. However, a hairy vetch has not yet been utilized due to high salt accumulation in reclaimed rice production systems. Soil salinity is one of the major abiotic stresses affecting plant growth and crop production. The area of reclaimed saline land amounts to about 9% (135,100ha) of the total area of agricultural land in South Korea. We were conducted to investigate the impacts of the salt-resistance on seed germination and growth of hairy vetch under laboratory condition.

Material and methods

Although seedlings are vulnerable stage in the life cycle of plants, their assessment is very important. This experiment was conducted to investigate the salinity resistance on seed germination and seedling growth of hairy vetch and rice. Seed germination is affected by several environmental stresses such as drought, extreme temperatures, heavy metals and salinity. The trails were tested in a growth chamber controlled with 25 ± 0.5℃ under laboratory condition. Seeds were sown in three replications in 11 cm diameter Petri-dishes lined with two discs of Whatman No.2 filter paper. The seeds were surface sterilized with 2% sodium hypochlorite for 2 minutes then rinsed five times with distilled water. Each replication contained 100 seeds. Germination rate and seedling growth of rice (*Oryza sativa* L.) and hairy vetch in relation to salinity was examined with seawater, natural salts, sodium chloride and reclaimed saline soil. The concentrations of the salinity were from 0.05 to 1.0 percent. The obtained data was evaluated by the Duncan test.

Results

Germination of seeds kept in *in vitro* started within 1~2 days. *In vitro* conditions were found to quicken the process of seed germination. Results demonstrated clear differences in patterns of germination and seedling growth of rice between the different salinity concentrations. All treatment materials showed a decreased lag in germination with increased amounts of salts. Maximum rice seed germination occurred at the concentration of 0.05% salinity. However, no significant differences were detected with other salinity levels. In contrast, salinity appears to play an important role in seedling development. The length of the primary root and the maximum length of shoot of seedlings were significantly reduced with increased salinities.

Germination of hairy vetch was assessed under various salinity concentrations of seawater, natural salts, sodium chloride and reclaimed saline soil: 0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0%. Significant

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decreases in germination percentage were observed above the concentration of 0.6% salinity. Salt tolerance at the seedling stage was analyzed in 10 day old seedlings, grown in petri-dish. The high seedling survival percentage for the trial was observed in the treatment with seawater. Increasing salt concentration was delayed germination. Furthermore, seed germination was inhibited by natural salts and sodium chloride solution to a similar degree to seawater. These results are in agreement with those previously reported by WANG Zhou-fei *et.al*.

Table 1. Comparison of the rice germination rate of rice after 10 days of treatment at different salinity concentration levels

Treatment materials	Concentration of salinity (%)											
	0	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
seawater	85^{a}	97^{a}	87^{a}	87^{a}	86^{a}	86^{a}	85^{a}	85^{a}	82^{a}	78^{a}	67^{a}	65^{a}
natural salts	86^{a}	88^{a}	84^{a}	83^{a}	78^{a}	78^{a}	75^{b}	71^{b}	76 ^{a}	54^{b}	23^{b}	22^{b}
sodium chloride	84^{a}	84^{a}	82^{a}	83^{a}	82^{a}	82^{a}	76^{b}	48^{c}	47^{b}	21^{c}	3^{c}	2^{c}
reclaimed soil	56^{b}	46^{b}	45^{b}	41^{b}	41^{b}	38^{b}	37^{c}	37^{c}	35^{bc}	31^{c}	31 ^{b}	31^{b}

* significant at P<0.05

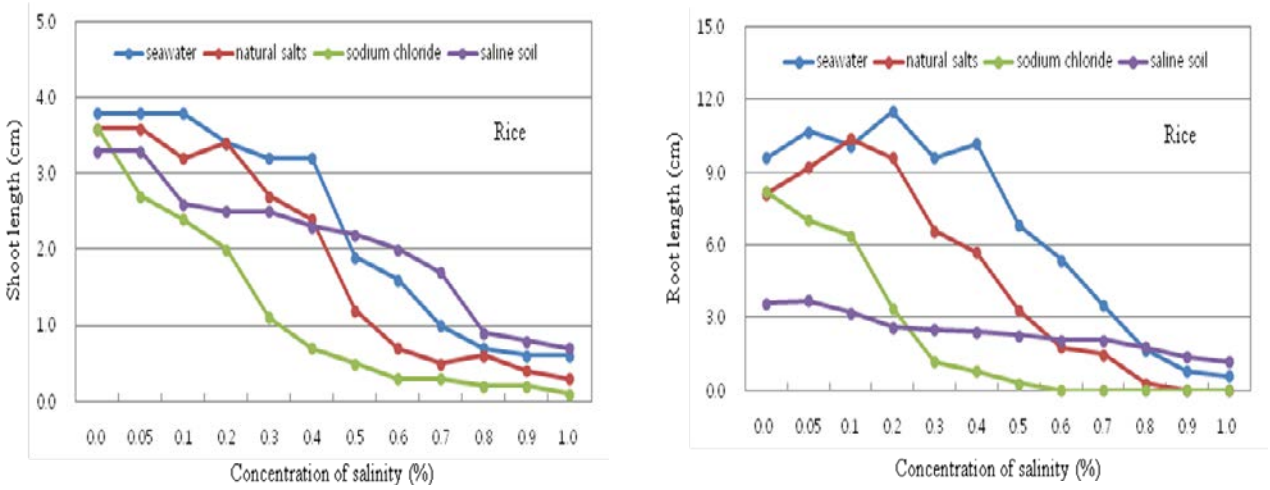


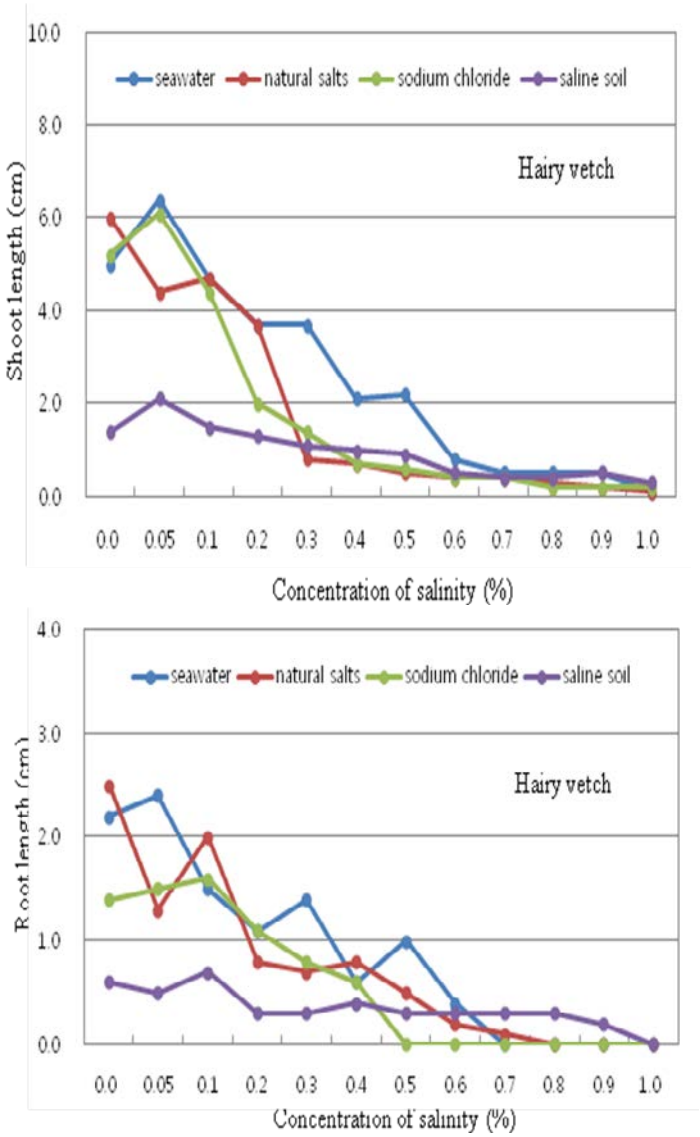
Figure 1. The seedling growth of rice after 10 days of treatment at different salinity concentration levels

Table 2. Comparison of the germination rate of hairy vetch after 7 days of treatment at different salinity concentration levels

Treatment materials	Concentration of salinity (%)											
	0	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
seawater	81^{a}	79^{a}	74^{a}	73^{a}	72^{a}	71^{a}	69^{a}	56^{a}	47^{a}	43^{a}	43^{a}	43^{a}
natural salts	84^{a}	78^{a}	77^{a}	71^{a}	70^{a}	70^{a}	69^{a}	68^{b}	55^{a}	40^{a}	18^{c}	15^{b}
sodium chloride	81^{a}	77^{a}	73^{a}	71^{a}	70^{a}	65^{a}	63^{a}	63^{b}	48^{a}	28^{b}	27^{b}	12^{b}
reclaimed soil	52^{b}	29^{b}	24^{b}	17^{b}	16^{b}	14^{b}	12^{b}	10^{c}	7^{b}	6^{c}	3^{d}	2^{d}

* significant at P<0.05

Seedlings of hairy vetch were tested for their tolerance to combined salinity. Salinity at 0.05% concentration of seawater enhanced seedling growth in this crop. Reductions in seedling establishment showed from 0.3% levels with increases of salinity. Significant negative correlations were identified between salinity treatment materials. Salinity may be one of the possible reasons for decreased seedling growth of hairy vetch plants under saline conditions. We suggested that the negative effects of salinity in this crop were mainly due to Na^+ and/or Cl^- toxicity. Salt-induced inhibition of seed germination could be attributed to osmotic stress or to specific ion toxicity (Bajji et al., 2002; Zhang et al., 2010).



Discussion

Hairy vetch (*Vicia villosa* Roth) is an important cover crop world-wide for weed management and improving nitrogen fertilization. The objective of this research was the evaluation of the response of hairy vetch to conditions of high salinity. Hairy vetch has demonstrated the lower tolerance to salinity variability than rice. The current study suggested that the germination percentage of hairy vetch (*Vicia villosa* Roth) seeds was strongly reduced when 0.6% concentration of salinity was treated. We also observed the differences in salinity resistance to salt sources. Hairy vetch may be able to utilize below the concentration of 0.1% salinity in reclaimed saline land. Therefore, we could be determined the degree of salt resistance in hairy vetch and rice plants. Rice and hairy vetch were decreased in germination rate and seedling growth with increasing salinity.

Figure 2. The seedling growth of hairy vetch after 10 days of treatment at different salinity concentration levels

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