Effects of Salt and Nitrogen Stress on the Growth of Winter Rye

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Abstract: Winter Rye (Secale cereale L.) is an important food stock that are found on most part of the world that are coastal areas, which are now open to threats as global warming causes multiple issues that includes soil salination and high-concentration nitrogen run-off. As of right now, it's already clear that salt will place a growth stress on most plants in high concentrations and will prohibit critical organs for nutrient intake, yet a number of researches stated that high dose of nitrogen will restore the growth of most wild and commercial plants. We are interested to find out how the interaction between salt and nitrogen can interfere with the growth of winter rye. A standard comprehensive 2-variable greenhouse assay was set up, with different levels of salt and nitrogen. After a 3-week growth period, an ANOVA test was conducted. The plants performance was inhibited when they are exposed to the lowest salt concentration and medium to high levels of nitrogen. In high saline environments, however, the performance of the plant was improved as it's exposed to medium and particularly, high nitrogen levels. The finding of this study would be useful in ways that few previous studies had focused on the effect of salt and nitrogen stress on the grown of food species in case of global warming and population growth, and the subject should be studied on more food species in future researches.

1 Introduction

Native to Central and Eastern Europe, Winter Rye (Secale cereale L.) is a major food stock for baking and livestock feeding, and as a renewable energy source [1]. As if right now, this species is primarily grown in a belt stretching from northern Germany through Poland, Ukraine, Belarus, Lithuania and Latvia into central and northern Russia. It's also grown in eastern United States, part of Canada, in Oceania, and in Southeast China as well [2].

In the past 10 to 20 years, climate change had always been at the concern of those studying food scientists as well as ecologist given its potential for causing sea level rise and thus coastal soil salination. As predicted by IPCC in 2018, by the end of the century, a rise in sea level of 0.95 feet (0.29m) and 3.61 feet (1.1m) is highly likely [3]. Soil salinity largely affects plant growth in various regions of the world, limiting 20% of the cultivated areas as well as 50% of the irrigated areas worldwide [4, 5, 6]. The challenge became worse as new research with their data suggests the significant existence of over-the-land transport of nitrogen-rich dissolved urea fertilizer towards sensitive coastal areas and its waters [7] , concentrating and thus presenting challenges towards the plants that grow in such areas, which may result in costal region's further salination [8].

It pretty clear that salt places a large growth stress on a majority of plants through the halting of the development of important organs that are used for water and nutrition uptake. One of the researches concludes that an increased salinity resulted in a significant decrease in shoot and root biomass, as well as its relative water content and water potential [9]. Some other finds that *Medicago truncatula* depends on an abundant nodular system for nitrogen uptake, which can be negatively affected as the plant failed to protect its leaves against salt ion accumulation [10].

Yet, quite a few studies find the existence of the relationship between salt and nitrogen quite common among plants species when it comes to their comprehensive effects on the performance of plants as well as their biochemical indexes. According to Mansour (2000), nitrogen containing compounds is usually correlated with plant salt tolerance, even though this correlation is based on untested hypotheses [11]. A similar research in 2001 finds that the retarded growth of pearl millet due to salinity stress was partially restored in the presence of high nitrate concentration in the irrigation solution [12].

There is not a plethora of published information when it comes to the comprehensive effects of both salt and nitrogen stress on the growth of plants, especially when it comes to the food species, such as winter rye. A majority of the studies gives a huge focus on economical crops and wild species with regards to their tolerance towards stresses. Through this study, the mechanism of a winter, drought torrent food species' response to both stresses will be thoroughly examed and studied.

Given its special implications and applications, this study is vulnerable in ways that its findings are only useful in coastal areas that are exposed to both sea level rise and over-nitrification. In land plantations such as Russia, NE China, Central NA are exempted from the outcomings of this research. They are largely free from one of the stresses, whether it's salt or nitrogen.

This study seeks to determine the determine factors of the performance of winter rye, whether it's salt, nitrogen or combined. This study will operate under the hypothesis that there is an interaction between salt and nitrogen concentration in soil that impacts the growth of Winter Rye. Under the hypothesis, the study predicts that with a high salt stress, the individual that's exposed to the highest (higher-than-usual) Nitrogen concentration will display the best salt tolerance.

2 Methods

2.1 Materials

A bag of winter rye seeds was purchased from Walmart; Artificial sea mix and Blood Meal with a formula of 24-0-0 was used to prepare the 12 different exposure treatments for the Winter Rye. A total of 10 replicas were performed for each exposure treatment, resulting in a total of 120 cases. Cups are used for the germination and the growth of winter rye. 12 rye seeds were used per cup, and holes were cut on the bottom of each cup.

2.2 Preparation

Winter Rye (Secale cereale L.) was studied in this particular research. Salt and nitrogen are the two growth stress applied to the plants. Four different sea salt concentrations were applied: fresh water, 10 ppm, 20 ppm, and 30 ppm. The saltwater was diluted from a standardized stock of artificial sea water at a concentration of 35ppm. Three different nitrogen levels were applied: 0 tsp, 1/2tsp, and 1/4 tsp of nitrogen fertilizer in 1/4 gal of fresh water. The different concentration of salt and nitrogen fertilizer was crossed and results in 12 different treatments with varying levels of the two growth stress. Winter Rye seeds were freshly purchased from local grocery store and was germinated by freshwater at the first week of the study. After germination, the plants were exposed to the 12 different treatments in forms of watering once a week for a period of 4 weeks.

2.3 Harvest

The plants in the 120 cups were cut, dried, weighted, measured after 5 weeks of the growth period. 500-mL beakers were used to transfer and weighting the harvested plants

3 Results

3.1 ANOVA

From the raw data we acclaimed, an ANOVA statistic test was conducted on an application called Prime. Three sources of variation were calculated from their effectiveness in affecting the growth of winter rye: interaction between salt and nitrogen, salt and, nitrogen. Both the interaction of the two variables and salt itself efficiently and significant
ly influences the outcome of the growth period by either retarding or helping the winter rye. Salt was a strong variation source compared to the interaction between the two sources as it has a much higher % of variation (73.3%) compared to that of the interaction between the two sources, which is 10.6%. Surprisingly, change in nitrogen levels failed to significantly influence the growth of winter rye, which has a rather low percent of total variation of only 0.0506 %.

Table 1. The percentage of total variation of the three sources in this study, indicating their relative significance

Source of Variation	% of total variation	P value
Interaction	10.6	< 0.0001
Salt	73.3	< 0.0001
Nitrogen	0.0506	0.8437

3.2 Interpretation

From the raw data captured in this study, two histograms with error bars were constructed, both displaying the combined effect of salt and nitrogen on the growth of winter rye (as height) after 3 weeks of growth period. There is a total of 12 different treatments. The histogram on the left was grouped by the same salt concentration, while the histogram on the right was grouped by the same nitrogen levels. (fig.1 a & b)

In fig 1a, as the salt concertation increased, an increasing level of nitrogen had different effects on the growth of winter rye. At a low salt concentration, normal nitrogen fertilizer level (1/4 tsp) negatively affected the growth of the plant while the pots with no nitrogen added displayed the best growth. At a high salt concentration, increased nitrogen level significantly helped the growth of the winter rye. With no fertilizer added, the winter rye's growth is the worst, while the pots with 1/2 or 1/4 tsp added showed a significant increasing in height, with the highest performance at 30 ppm salt and overdosage of nitrogen.

In fig 1b, as the nitrogen level increased, as increasing of salt concentration significantly suppressed the growth of the winter rye. At a level of either 0 tsp nitrogen or 1/2 nitrogen, which is higher than the suggested level, the performance of the plant degraded rapidly and significantly when the salt concentration increased from 20 ppm to 30 ppm, which is lower than sea water salt concentration. At a level of 1/4 tsp nitrogen, which is the suggested level, the ryes performed the best at a salt concentration of 10 ppm of salt; the performance levels when the salt concentration is either 0 ppm or 20 ppm. The growth was the worst when the salt concentration reached 30 ppm.

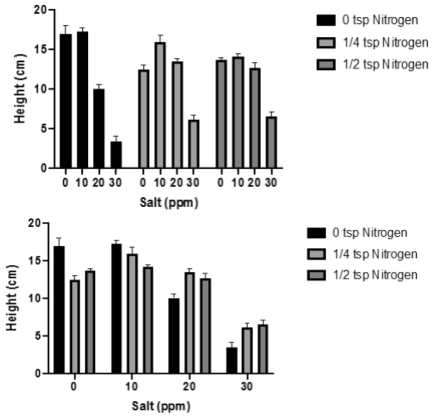

Fig 1a & 1b: average length of Winter Rye after growth period under different treatments

4 Discussion

Our hypothesis that the interaction between salt and nitrogen content in soil creates an impact on the growth of winter rye is supported accordingly in this study. The prediction that exposed to a high salt stress, the individuals that are exposed to the highest (higher-than-usual) nitrogen content have the best performance, compared to the other individuals that are given a lower nitrogen content is mildly supported.

General trends in the study strongly suggests that given same nitrogen content, the performance of the individuals peaks when exposed to 10 ppm of salt and gradually decreases as the salt concentration continues to rise towards 30 ppm, with the lowest at 30 ppm @ 0 tsp nitrogen. The data also suggests that at low salt levels (0 & 10 ppm), individual's performances drops as soon as any nitrogen was added to the pot; however, as the salt concentration raise to medium and high (20 – 30 ppm), the performance of winter rye is strongly improved with the presence of nitrogen. When exposed to the highest possible salt content, individual's performance levels off at medium and high nitrogen levels, a trend that is not seen in individuals with other different treatments, which might lead to the conclusion that, when it comes to winter rye (Secale cereale L.), high nitrogen content in a high salt environment helps instead of inhibits the growth of the plant through mechanisms such as osmosis, which is different from what a number of studies had suggested.

As far as this study and many other similar ones go, it seems that the effect of salt and nitrogen on the growth plants varies in a case by case situation. Despite the fact that this study leaves so many questions unanswered, this experiment is highly valuable. The food portion of the question of the effect of salt and nitrogen on the plants is a relative new question that can be explored with further experiments and researches. There are thousands of food species that inhibit and planted on the costal soils of worldwide, of which many are still unknown to the developed world, and we have only covered one of them. Thus I find this particular topic more profound and meaningful that what it sounds, by exploring the interaction between salt and nitrogen and its effects on various food species, it not only saving a village, a city, a country in the rise of climate change, global warming, industrialization and sea level rise: it's about saving a culture, a nation, and what's founding the making of it.

5. Conclusion

Our hypothesis and prediction are both supported according to our data, and the results are really interesting and deviates from normal understandings: growth doesn't necessarily worsen with increased amount of Nitrogen and salt. Despite some imperfections such as the limited implications and applications of the results, our findings have rather important implications on such unique topic of world food safety under the condition of climate change. I strongly suggest that more food species need to be tested with regards to similar subjects.

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