**Results**

***Sporophytic Variables***

*Cell Membrane Stability*

The cell membrane stability (CMS) was measured by using conductivity as a proxy for cytoplasm leakage when the cell membrane is disturbed. We used the inverse ratio of conductivity before and after temperature treatments as a tolerance index. More tolerant plants will have a higher CMS ratio and vice versa. When *Solanum carolinence* plants from the north were compared to the south, we found no significant difference in the hot treatment, but there was a significant difference in the cold treatment. Conversely, we found a significant difference between genotypes in the hot treatment, but not in the cold treatment. For both the hot and cold treatments, there was a significant block effect, meaning that plants grown at different times in the greenhouse had different CMS ratios.

Chart, box and whisker chart

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Figure: Cell membrane stability across temporally independent blocks and colored by region. ANOVA results show that there is a significant difference between blocks (p = 0.022, n = 202, df = 1), but not between regions of origin (p = 0.059).

Chart, box and whisker chart

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Figure: Cell membrane stability by region. ANOVA results show that there is a significant difference between blocks (p = 0.022, n = 202, df = 1), but not between regions of origin (p = 0.059).

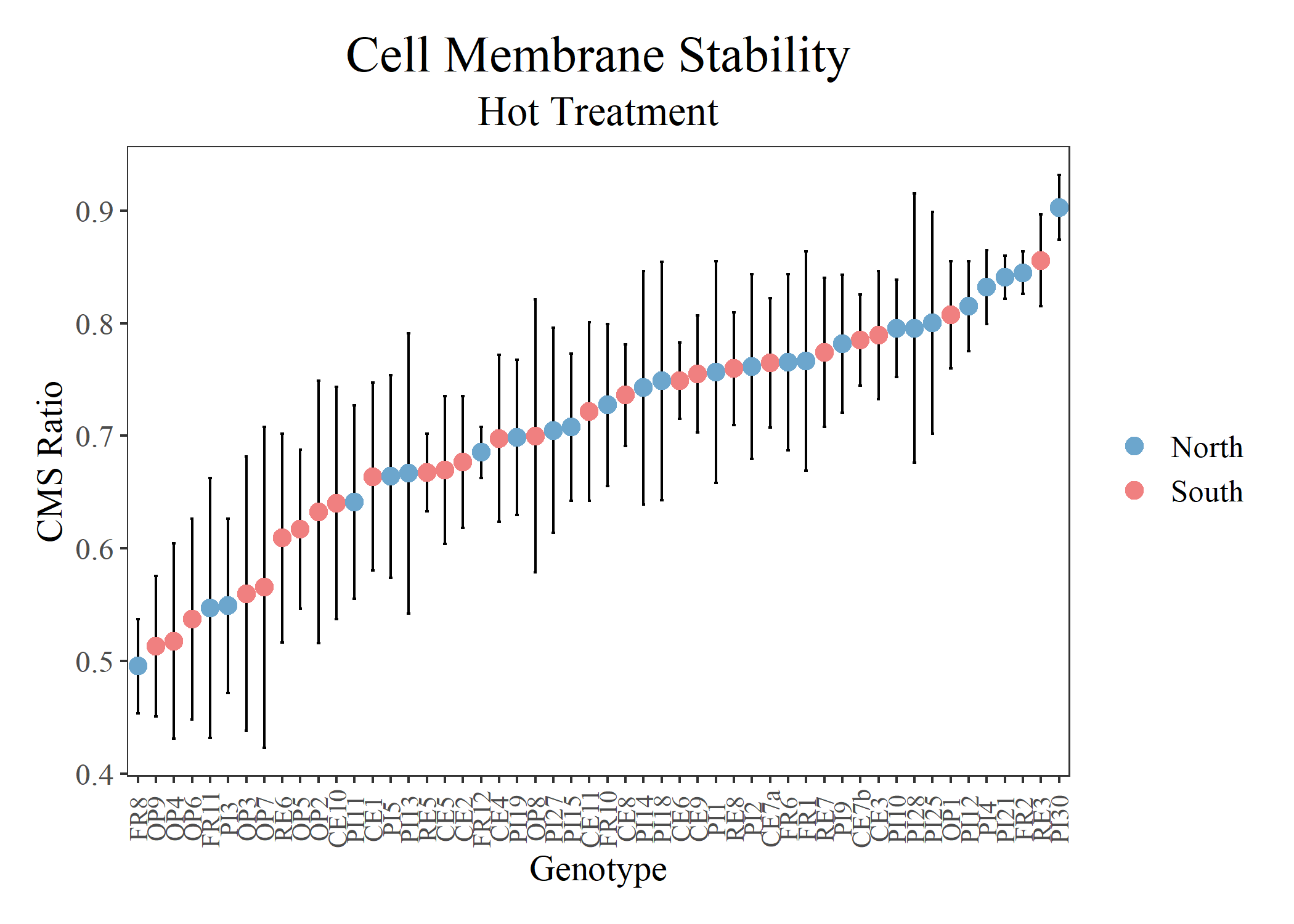


Figure: Cell membrane stability for all genotypes, colored by region. ANOVA results show that there is a significant difference between genotypes (df = 51, p = 0.032).

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Figure: Cell membrane stability across temporally independent blocks and colored by region. ANOVA results show that there is a significant difference between the regions (p = 0.006, n = 202, df = 1) and the blocks (p = 5.7e-5).

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Figure: Cell membrane stability by region. ANOVA results show that there is a significant difference between the regions (p = 0.006, n = 202, df = 1) and the blocks (p = 5.7e-5).

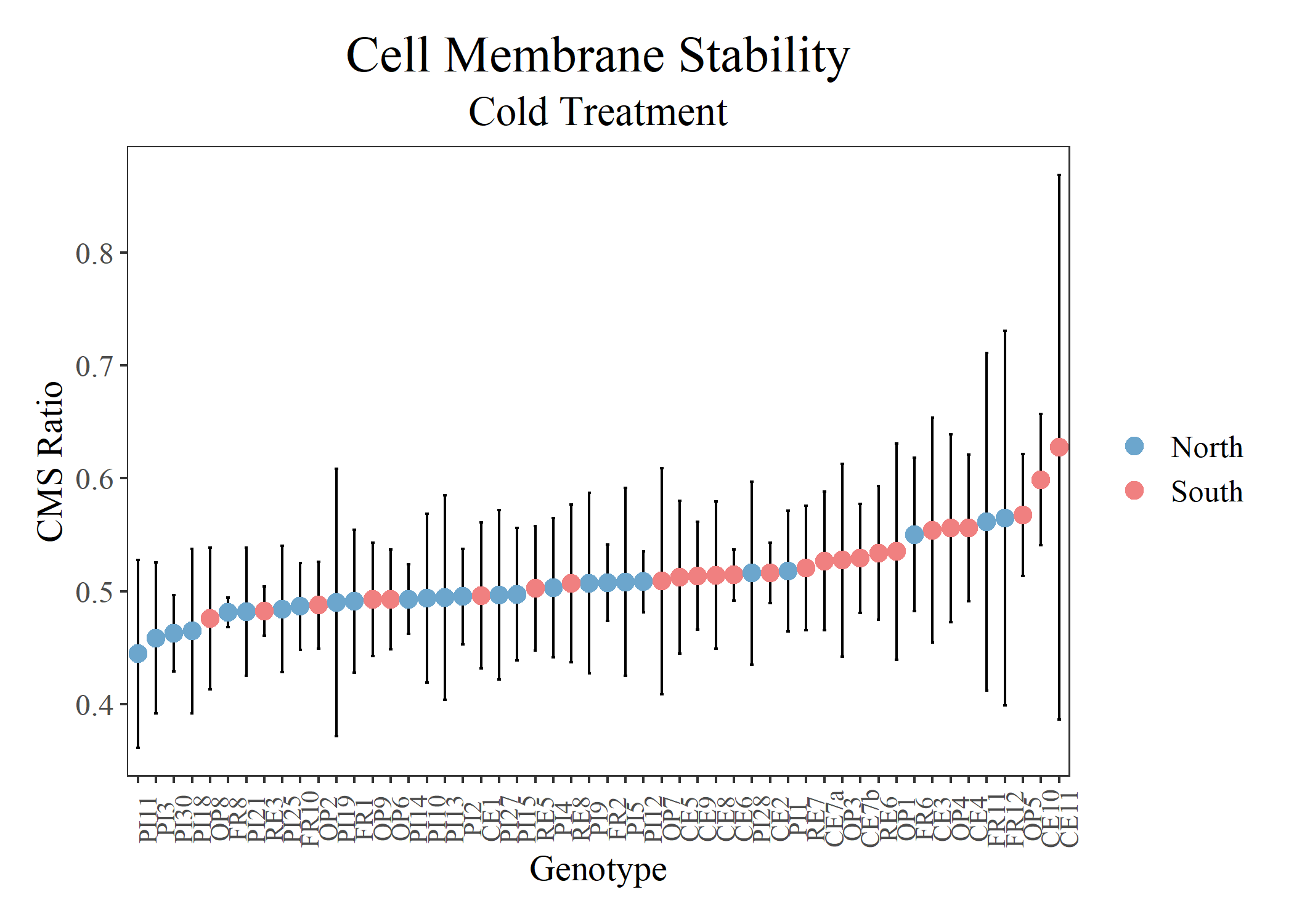


Figure: Cell membrane stability for all genotypes, colored by region. ANOVA results show that there is no significant difference between genotypes (df = 51, p = 0.86).

*Chlorophyll content*

We used chlorophyll content as another temperature tolerance index. Again, the chlorophyll content was measured before and after temperature treatments and the inverse ratio of the measurements were used as a proxy of temperature tolerance. As the chlorophyll ratio increases, the individual sporophyte is more tolerant of extreme temperatures. There was a significant difference between plants originating in the north and south for both the hot and cold treatments. We found a significant difference between individual genotypes for the cold treatment, but not for the hot treatment.

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Figure: Chlorophyll content by region. ANOVA results show that there is a significant difference between the region (p = 0.043, n = 202, df = 1).

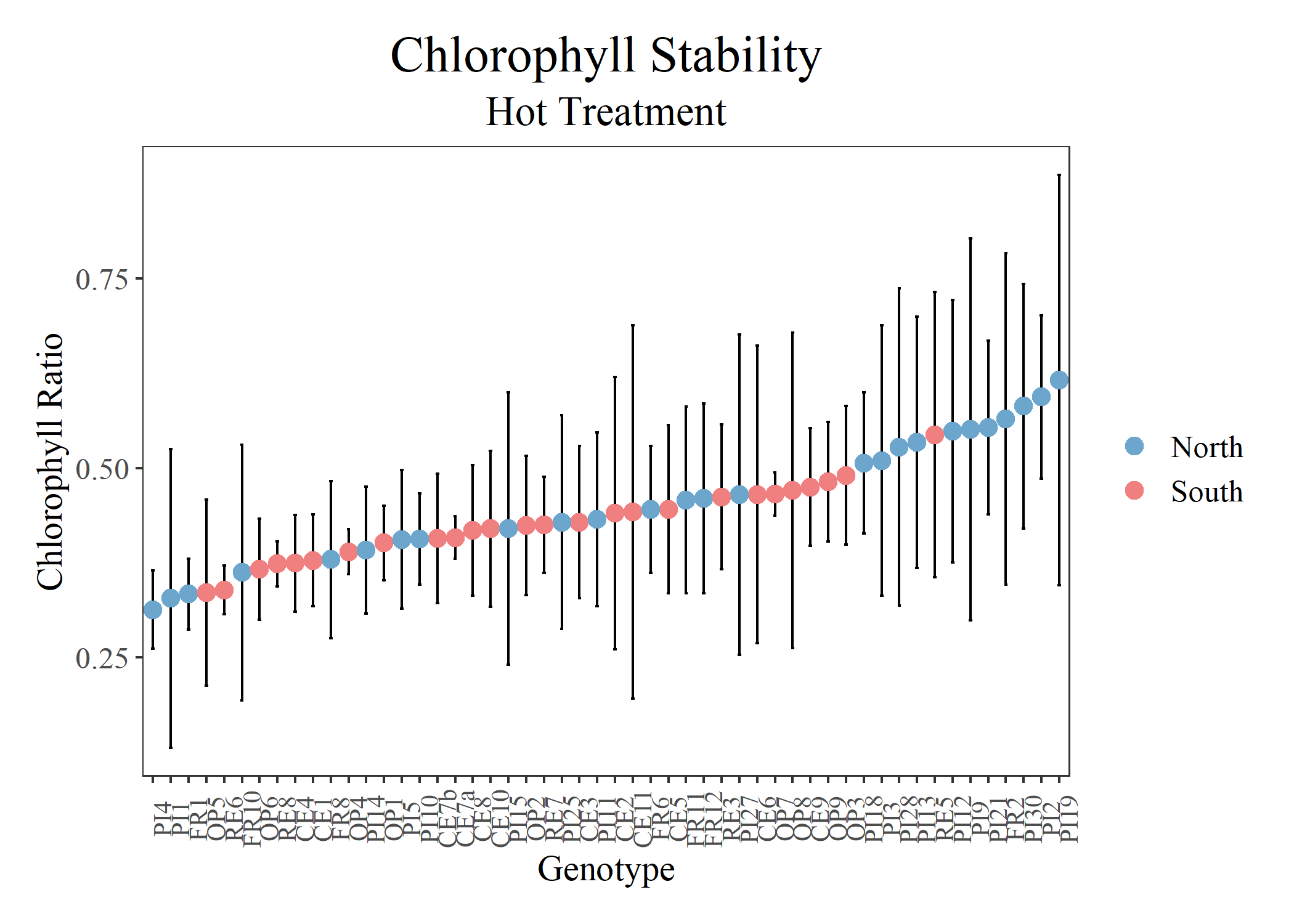


Figure: Chlorophyll stability for all genotypes, colored by region. ANOVA results show that there is no significant difference between genotypes (df = 51, p = 0.364).

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Figure: Chlorophyll content by region. ANOVA results show that there is a significant difference between the region (p = 1.6e-10, n = 202, df = 1).

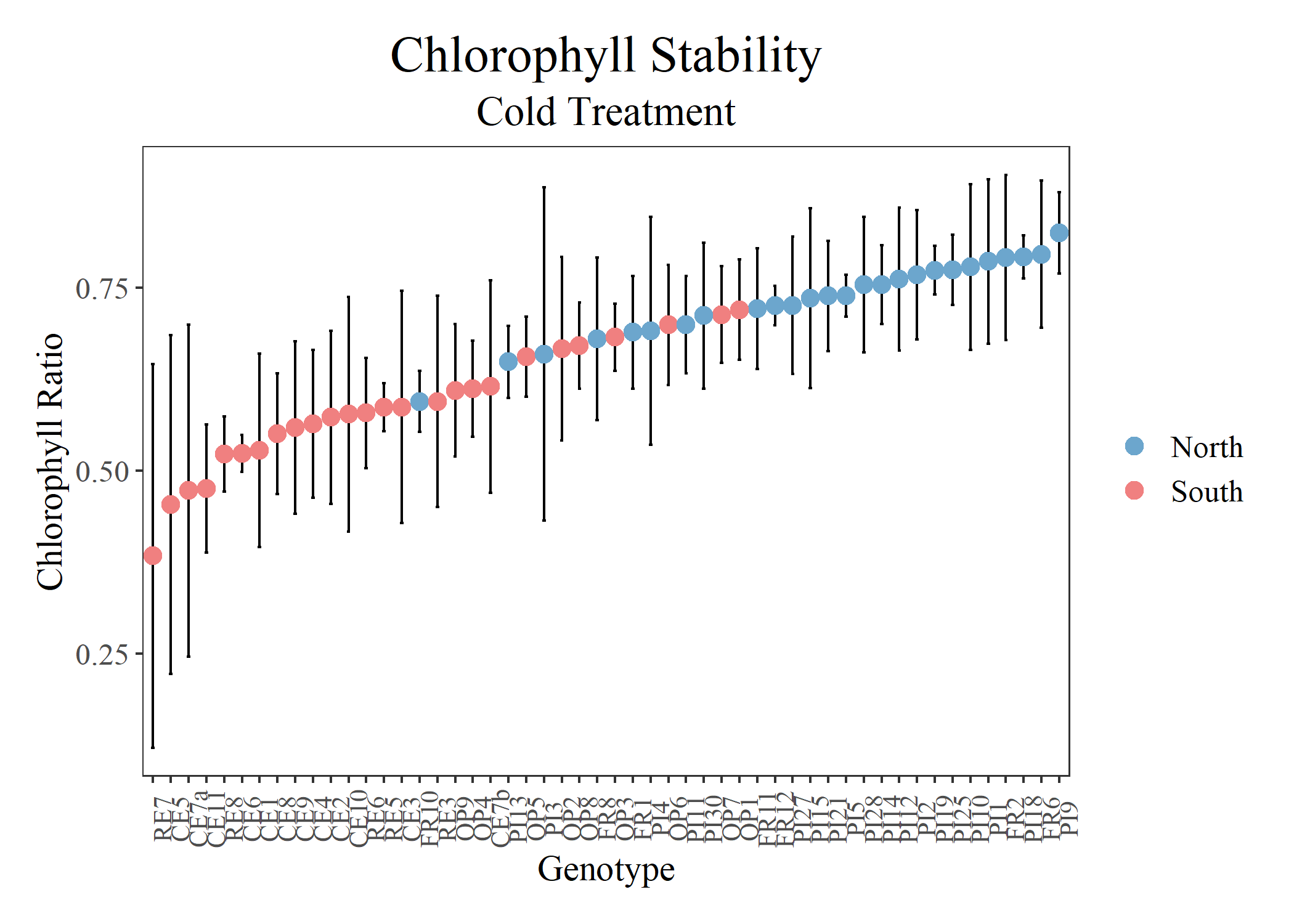


Figure: Chlorophyll stability for all genotypes, colored by region. ANOVA results show that there is a significant difference between genotypes (df = 51, p = 6.1e-9).

*Net Photosynthesis*

We used photosynthesis as a physiological indicator of temperature tolerance. Both previous variables mentioned could directly influence temperature tolerance through their involvement in photosynthesis. Photosynthesis was measured using a LI-6400 infrared gas analyzer before and after a temperature treatment. The results are presented as a proportion of the net photosynthesis after the treatment to the net photosynthesis before the treatment. For both the cold and hot treatments, there was no significant difference between north and south. There was a significant difference between genotypes for both the hot and cold treatments.

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Figure: Photosynthesis by region. ANOVA results show that there is no significant difference between the regions (p = 0.87, n = 134, df = 1).

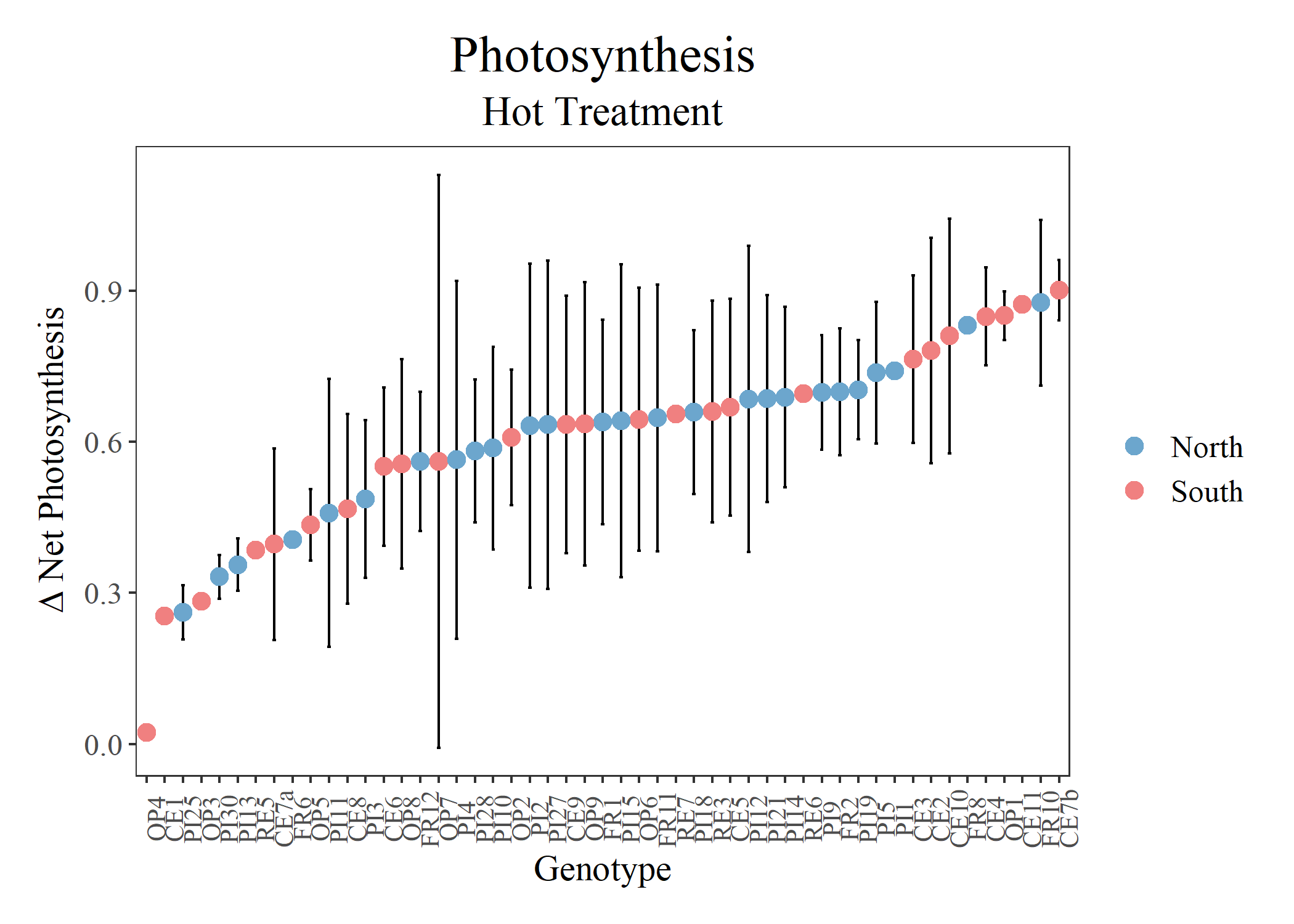


Figure: Net photosynthesis for all genotypes, colored by region. ANOVA results show that there is a significant difference between genotypes (df = 49, p = 0.097).

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Figure: Net photosynthesis by region. ANOVA results show that there is no significant difference between the regions (p = 0.11, n = 147, df = 1).

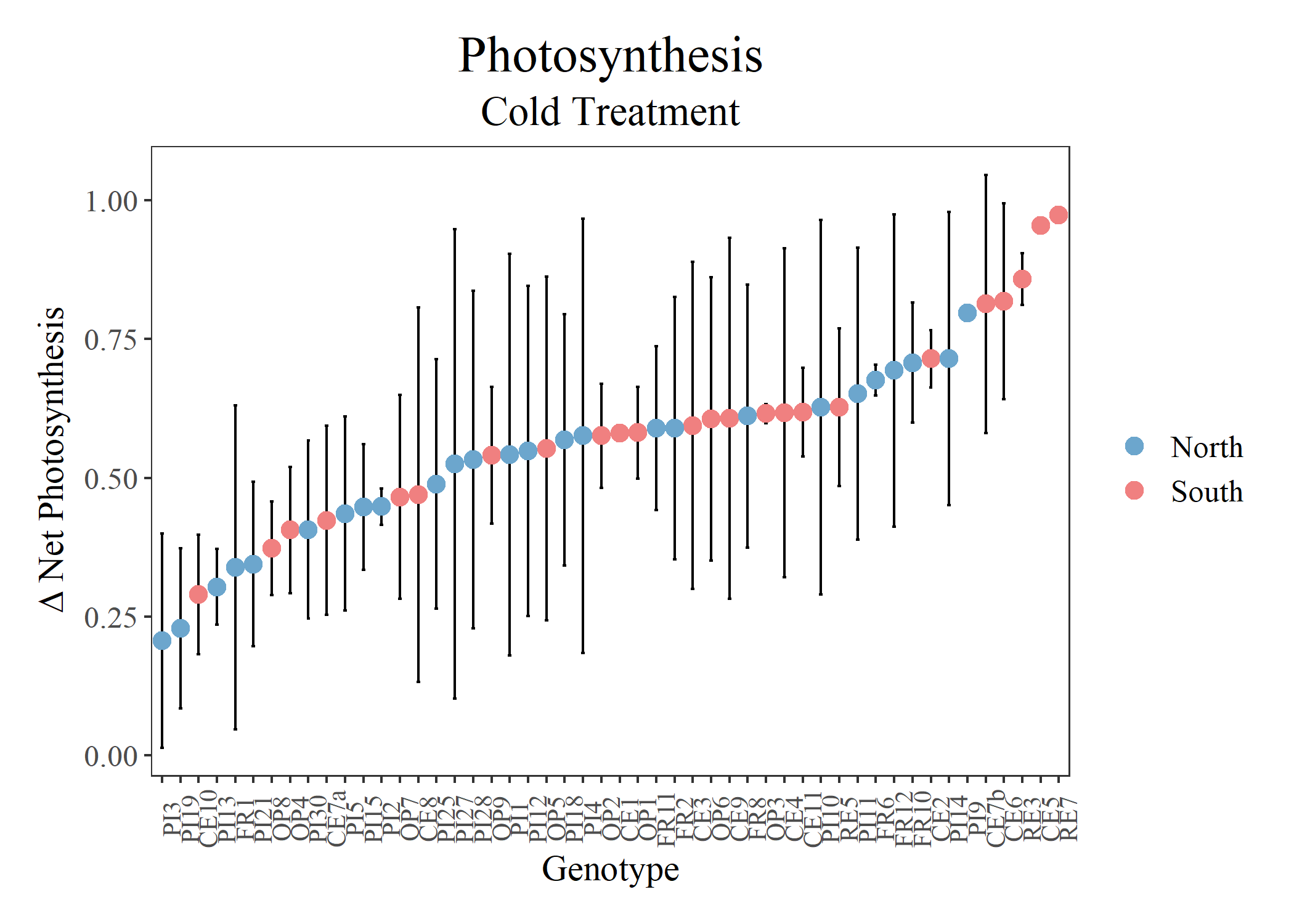


Figure: Net photosynthesis for all genotypes, colored by region. ANOVA results show that there is a significant difference between genotypes (df = 49, p = 0.089).

*Correlations and Principal Component Analysis*

We used correlations and principal component analysis to identify relationships between the 6 sporophytic variables. Pearson’s correlations were determined for all variables. Only four correlations were significant, and the strongest correlation was 0.21 between hot cell membrane stability and cold photosynthesis. There was one negative correlation between cold and hot cell membrane stability (-0.14).

The first three principal components explained 60.34% of the variance. PC1 primarily loaded on hot photosynthesis (HPS) and hot cell membrane stability (HCMS). The other variables were, for the most part, evenly loaded on PC2 and PC3.Chart, bubble chart

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Figure: Correlation matrix of sporophytic variables with significant Pearson’s correlations.

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Figure: PC1 and PC2 from principal component analysis for all sporophytic variables with 95% confidence ellipse. PC1 explains 22.04% of the variance and PC2 explains 21.45% of the variance.

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Figure: PC2 and PC3 from principal component analysis for all sporophytic variables with 95% confidence ellipse. PC2 explains 21.45% of the variance and PC3 explains 16.86% of the variance.

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Figure: PC1 and PC3 from principal component analysis for all sporophytic variables with 95% confidence ellipse. PC1 explains 22.04% of the variance and PC3 explains 16.86% of the variance.

***Gametophytic Variables***

*Pollen Viability*

Pollen viability was determined by the percentage of the number of pollen grains that produced pollen tubes or germinated out of the total number of grains. We measured pollen viability for all individuals that flowered at five different temperatures.

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Figure: Percent germination for *Solanum carolinense* pollen grains from the north (blue) and south (red) across a temperature gradient. Thick lines indicate the mean value for the region at each temperature.

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Figure: Estimates for the maximum (Tmax), optimal (Topt), and minimum (Tmin) germination temperatures attained using bilinear fits of the germination data for each individual. There is a significant difference between north and south for Tmax (Mann-Whitney, p = 0.003), but not for Topt and Tmin.