Determining the adaptability to abiotic conditions and potential establishment success of tree species needs to be conducted before attempting to use a species in large-scale afforestation programs. In this study, the chemical and physiological performance of four Turkish red pine (*Pinus brutia* Ten.) provenances was investigated after exposure to artificial cold temperature treatments to determine their adaptability to cold environment for potential use in afforestation programs. Seeds were sown and raised for 24, 28, and 32 weeks and exposed to decreasing temperatures in an artificial freezer. Relative electrolyte leakage, chlorophyll fluorescence, and carbohydrate concentrations were measured to determine the variability between provenances. Results showed that diameter and height growth did not vary with origin for each of the three growth stages measured. Root electrolyte leakage values differed between provenances, confirming that cold stress was effectively causing physiological damages when plants were exposed to temperature at −15 °C and below. The variability observed in the relationship between provenances and cold hardness responses can be attributed to tree-to-tree variability within provenances and microsites conditions. There was generally no significant difference in chlorophyll fluorescence between provenances, also attributed to low genetic variation between provenances. Carbohydrate concentrations were also very variable and varied significantly among growth stages and provenances. High-altitude provenances had higher soluble carbohydrates concentrations in several cases, suggesting a relationship between altitude, soluble sugars, and cold hardiness. However, these trends were not consistent; therefore, we suggest that such hypotheses be confirmed through more comprehensive further studies.