Physiological response of cloned Norway spruce seedlings to drought stress

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Abstract

Variability of signs and properties is an inherent component of each organism. Genetic diversity is the basis for adaptability, stability and evolution of species and forest tree population. A vessel experiment with clones of spruce (*Picea abies* (L.) Karst.) was established in order to specify knowledges about changes of physiological reaction in connection with the appearance, duration and intensity of drought. There are changes of some chlorophyll a parameters during progressive drought stress presented. Using of clone is interesting in term of intraspecific variability elimination and determination of eventual deviation of genetically homogenous material in response on stress factors. Chlorophyll fluorescence *a* measurements (Fo, Fm, Fv/Fm, Fm/Fo) were taken using the PEA chlorophyll fluorimeter (Plant Efficience Analyser, Hansatech Ltd., Kings Lynn, UK). This is a standard technique for stress indication. One way ANOVA indicated significant differences (and sensibility to drought) of various clones.

Key words: drought, *Picea abies*, chlorophyll a fluorescence, genotype variability

MATERIALS AND METHODS

• A main meteorological using the treatment characteristics were measured during the treatment: air temperature [℃], global radiation [kWh.m-2] and atmospheric humidity [%]. For measuring were used Min 32 (Environmental Measuring Systems, Brno, www.emsbrno.cz) with automatic data storage.

• They were used cloned seedlings of spruce for analysis. The cutting transplants were sampled from 20 years old parent stands during the year 2005. Those stands are growing in altitude from 800 m to 1000 m.

• 25 seedlings (5 clones x 5 individuals) were used for experiment.

• Response to progressive drought was observed during 49 days. Seedlings were not irrigated during this period.

• Chlorophyll fluorescence *a* measurements (parameters Fo, Fm, Fv/Fm, Fm/Fo, *Area*, Tm) were taken using the PEA chlorophyll fluorimeter (Plant Efficience Analyser, Hansatech Ltd., Kings Lynn, UK). The sample was irradiated by a saturated impulse following a 30-minute darkness adjustment.

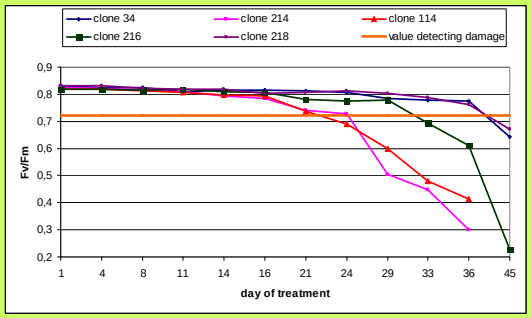

Fig. 3: Dynamics of Fv/Fm parameter measured on spruce clones during progressive drought stress

RESULTS

• Average daily air temperature was 20 ℃ during the treatment, average daily air humidity fluctuate between 50–70%. Seedlings were not exposure to direct radiation.
• Marked changes were observed among clones more tolerant to drought stress and sensitive to drought. Statistical significant decrease of Fv/Fm parameter was observed after 21 days of treatment for 214 and 114 clones. In this time were measured values near 0.725 for clones 214 and 114. It is a critical value for identification of assimilation organs damage, according of many authors. By contrast, values for resistant clones (34 and 218) were not decreased under critical value until the day 36.
• Earliest and most marked changes were found for parameters Fm/Fo, Fv/Fm. Less suitable for drought stress detection are Fm and Fo, utilization of parameters *Area* and Tm (non-listed)is strongly delimited.

Fig. 1: Measuring of global radiation (left), air temperature and atmospheric humidity (right)

Fig. 2: Fluorimeter PEA (Plant Efficience Analyser, Hansatech Ltd., Kings Lynn, UK)

Tab. 1: Average value of Fo parameter and similarity among clones, Different letter denote significant difference tested by ANOVA, Duncan's test, P < 0.05

Day of treatment	1	4	8	11	14	16	21	24	29	33	36	45	49
clone 34	0,196a	0,230ab	0,241a	0,260a	0,246a	0,259a	0,269a	0,274a	0,276a	0,296a	0,289a	0,324a	0,340a
clone 214	0,203a	0,239ab	0,223a	0,243a	0,246a	0,263a	0,275a	0,294a	0,308a	0,340a	0,341a	X	X
clone 114	0,203a	0,216a	0,233a	0,269a	0,266a	0,279a	0,302ab	0,309a	0,300a	0,323a	0,325a	x	X
clone 216	0,267b	0,250b	0,247a	0,257a	0,265a	0,276a	0,319b	0,311a	0,309a	0,340a	0,333a	0,447b	x
clone 218	0,218a	0,241ab	0,238a	0,269a	0,240a	0,265a	0,281a	0,278a	0,283a	0,308a	0,300a	0,338a	0,328ab
R^2 [%]	46,10	23,40	11,60	23,70	23,70	14,00	40,90	22,00	26,80	22,50	27,10	75,50	53,70
F	4,06	1,45	0,62	1,48	1,48	0,77	3,29	1,34	1,74	1,38	1,76	8,60	2,90
p	0,015*	0,26	0,65	0,25	0,25	0,56	0,033*	0,29	0,18	0,28	0,18	0,001*	0,08

Tab. 2: Average value of Fm parameter and similarity among clones, Different letter denote significant difference tested by ANOVA, Duncan's test, P < 0.05

Day of treatment	1	4	8	11	14	16	21	24	29	33	36	45	49
clone 34	1,152a	1,316ab	1,366a	1,381a	1,340a	1,395a	1,424a	1,424ab	1,309a	1,364bc	1,313b	1,061b	0,915a
clone 214	1,147a	1,349ab	1,222a	1,297a	1,223a	1,258a	1,133b	1,162ac	0,743b	0,730a	0,628a	x	x
clone 114	1,116a	1,184b	1,245a	1,392a	1,320a	1,357a	1,158b	1,082c	0,995bc	0,922ab	0,770a	x	x
clone 216	1,468b	1,394a	1,337a	1,424a	1,391a	1,425a	1,482a	1,413ab	1,411a	1,169abc	0,935ab	0,645a	x
clone 218	1,302b	1,441a	1,337a	1,505a	1,333a	1,358a	1,463a	1,482b	1,444a	1,475c	1,316b	1,164b	0,983a
R^2 [%]	43,90	35,10	17,80	23,20	19,00	23,90	62,80	44,80	61,10	49,00	53,30	54,20	43,60
F	3,72	2,57	1,03	1,44	1,12	1,49	8,03	3,85	7,46	4,57	5,47	5,33	1,93
p	0,021*	0,07	0,42	0,26	0,38	0,24	0,001*	0,019*	0,0009*	0,009*	0,004*	0,008*	0,18

Tab. 2: Average value of Fv/Fm parameter and similarity among clones, Different letter denote significant difference tested by ANOVA, Duncan's test, P < 0.05

Day of treatment	1	4	8	11	14	16	21	24	29	33	36	45	49
clone 34	0,831b	0,824ab	0,824a	0,808a	0,814a	0,814a	0,811b	0,807a	0,784a	0,778b	0,773a	0,642b	0,522a
clone 214	0,823ab	0,822ab	0,816a	0,809a	0,794a	0,783a	0,739a	0,728ab	0,505b	0,447a	0,302b	x	x
clone 114	0,818a	0,817a	0,812a	0,806a	0,798a	0,794a	0,736a	0,691b	0,597ab	0,478a	0,415bc	x	x
clone 216	0,817a	0,819ab	0,814a	0,818a	0,808a	0,805a	0,781ab	0,776a	0,778a	0,693ab	0,610ac	0,229a	x
clone 218	0,832b	0,832b	0,821a	0,820a	0,819a	0,802a	0,807b	0,811a	0,803a	0,788b	0,763a	0,670b	0,596a
R^2 [%]	44,30	27,60	21,50	16,10	24,50	16,30	49,30	42,00	47,80	44,80	52,70	63,50	43,80
F	3,78	1,81	1,30	0,91	1,54	0,93	4,63	3,45	4,34	3,85	5,29	5,07	1,95
p	0,020*	0,17	0,30	0,48	0,23	0,47	0,009*	0,028*	0,012*	0,019*	0,005*	0,010*	0,18

Tab. 2: Average value of Fm/Fo parameter and similarity among clones, Different letter denote significant difference tested by ANOVA, Duncan's test, P < 0.05

Day of treatment	1	4	8	11	14	16	21	24	29	33	36	45	49
clone 34	5,875b	5,730ab	5,675a	5,307a	5,446ab	5,393a	5,295b	5,202b	4,751a	4,606b	4,536b	3,272b	2,692a
clone 214	5,659ab	5,656ab	5,476a	5,339a	4,961ab	4,784a	4,117a	3,956a	2,410b	2,149a	1,843a	x	x
clone 114	5,495a	5,492a	5,343a	5,176a	4,963a	4,871a	3,841a	3,505a	3,313bc	2,854a	2,371a	x	x
clone 216	5,495a	5,573ab	5,411a	5,536a	5,253ab	5,169a	4,650ab	4,537ab	4,567ac	3,444ab	2,806a	1,442a	x
clone 218	5,972b	5,976b	5,627a	5,591a	5,548b	5,118a	5,204b	5,329b	5,101a	4,786b	4,393b	3,440b	2,996a
R^2 [%]	44,50	29,40	23,50	19,40	30,00	17,20	53,20	50,10	57,60	50,60	53,10	58,90	39,40
F	3,81	1,98	1,46	1,15	2,04	0,99	5,40	4,78	6,44	4,87	5,38	5,62	1,62
p	0,019*	0,14	0,25	0,37	0,13	0,44	0,004*	0,008*	0,002*	0,007*	0,005*	0,007*	0,24

CONCLUSION

As results from presented datas, it is possible to use some chlorophyll fluorescence *a* parameters for screening of drought resistant genotypes. The results could be used by breeder, in order to obtain a new, higher quality of seed, with accent on physiological and morphological assessment.

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