Necrotic disease of beech in individual growth stages

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ABSTRACT: The paper deals with the present state of necrotic disease of beech in the growth stages of self-seeding, advance growth, thicket, small pole stage, pole stage and maturing stand from four localities of Central and Eastern Slovakia. We found out that the self-seeding was affected by the necrotic disease to the least extent. The strongest negative changes in the necrotic disease measured in terms of its frequency were recorded in the stage of advance growth. In later stages the trend of negative changes in necrotic disease became more moderate and was accompanied by small fluctuations. The lowest degree of necrotic disease expressed by means of stem necrotisation index (I_{NK}) was in the small pole stage, it moderately increased in the pole stage and in maturing stands. The frequency of stem necrotisation in maturing stands ranged from 89% to 96%. The results confirm the fact that the necrotic disease belongs to significant phytopathological problems influencing development of beech stands.

Keywords: *Fagus sylvatica* L.; bark necrotic disease; growth stages of beech; Slovakia

In the last decades the bark necrotic disease of beeches has spread in Slovakia and in other parts of Europe. This phytopathological phenomenon is an object of increased attention of researchers. In Slovakia this problem was dealt with by many authors, e.g. Štefančík and Leontovyč (1966), Surovec (1990, 1992), Leontovyč and Gáper (1997), Kunca et al. (2000). These authors studied the problem of necrotic disease of beech partially and very specifically. There are only few papers studying this problem from a wider aspect (Cicák, Mihál 1997, 2002; Kunca, Leontovyč 1999; Mihál, Cicák 2003; Mihál et al. 1997, 1998).

This problem was also studied abroad – in the Czech Republic by Jančařík (1992, 2000), in Germany by Metzler and Erffa (2000), Metzler et al. (2002), in France by Perrin (1981), in Romania by Chira and Chira (1998), in Ukraine by Gajevaja et al. (1995) and in the USA by Houston (1997).

The aim of this paper is to quantify the present state of the beech bark necrotic disease in individual growth stages, from self-seeding to maturing stand. The results should answer the question how the necrotic disease changes in relation to the beech ontogenesis? It is to be noted that we do not know any published works studying the dynamics of necrotic disease from this aspect. Most papers studied the necrotic disease only within one growth stage (Kunca et al. 2000; Surovec 1990, 1992; Metzler et al. 2002; Houston 1975), few papers (Jančařík 2000; Schütt, Summerer 1983; Mihál, Cicák 2003) evaluated it during two or three growth stages. In the literature, most attention was paid to the small pole stage, pole stage and mature stands (Kunca et al. 2000; Štefančík, Leontovyč 1966; Leontovyč, Gáper 1997; Štefančík, Štefančík 1999; Houston 1997; Metzler, Erffa 2000; Mihál et al. 1998; Cicák, Mihál 2002; Cicák et al. 2003). In addition, these papers differed from each other by evaluation methods, which makes the comparison of results difficult.

MATERIAL AND METHODS

The evaluation is based on description and classification of growth stages presented by Greguš (1968) and Korpeľ (1991). Description and definition of growth stages of woody plants that represent differently long parts of their lives are given in Table 1.

Evaluation of beech necrotic disease was carried out in spring and autumn 2002 and 2003 in four selected localities of Eastern and Central Slovakia (Table 2). In each locality, we evaluated 100 individuals in all stages, from self-seeding to maturing stand. The quantitative markers characterising individual stages were obtained by measuring the height of advance growth and stem diameter $d_{1.3}$ in thicket, small pole stage, pole stage and maturing stands. Up to 50 cm, the average height in the stage of self-seeding was estimated visually.

Evaluation of self-seeding and advance growth was carried out according to the method of Mihál et al. (1997). In this method, the presence of necroses on stems and branches is evaluated. Because of limited accessibility of tree crowns in the growth stage of thicket, we evaluated the frequency of necrosis occurrence only on the stems.

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Table 1. Quantitative and qualitative characters of growth stages of woody plants according to GREGUŠ (1968) and KORPEĽ (1991)

Growth stage	External quantitative characters	Qualitative characters
Self-seeding (plantation)	– up to reaching the average height of 50 cm	– survival
Advance growth (secured canopy)	– growth stage defined by a height between 50 and 150 cm	– adaptation
Thicket	– growth stage defined by a height exceeding 150 cm and average diameter up to 5 cm	– forming of perfect or even excessive canopy closure
Small pole stage	– average diameter of 6–12 cm	– height increment culminates, – culmination of diameter increment
Pole stage	– average diameter of 13–19 cm	– intensive diameter increment continues and volume increment culminates
Maturing (thinner) stand	– up to reaching the average diameter of 20 cm	– systematic fructification, – form differentiation strongly slows down

When evaluating necrotic disease in small pole stage, pole stage and maturing stand we used the method proposed by Cicák and Mihál (1997). In this method, a 5-degree semi-quantitative scale of necrotic damage of stems is used. Results obtained by this method can be interpreted by means of the necrotisation index (I_{NK}) or, in a simplified way, only as the frequency of stem necrotisation (Cicák, Mihál 1998). The use of two different methods of evaluation is given by a large difference in external quantitative characters of beeches in individual growth stages (Table 1).

In consequence of using two evaluation methods, only between-the-locality comparisons are possible. However,

Table 2. Basic characteristics of localities and parameters of external quantitative characters (mean ± standard error of average height and average diameter) of beech growth stages

Orographic complex	Locality	Growth stage	Altitude (m a.s.l.)	Exposition	Geological substrate	External quantitative characters	
						average height h (cm)	average diameter $d_{1,3}$ (cm)
Bukovské vrchy	Havešová	self-seeding	520	SE	flysch	–	–
		advance growth	520	W	flysch	117.69 ± 2.40	–
		thicket	520	E	flysch	–	2.46 ± 0.08
		small pole stage	520	E	flysch	–	8.90 ± 0.26
		pole stage	520	W	flysch	–	16.77 ± 0.43
		maturing stand	520	W	flysch	–	23.35 ± 0.45
Slánske vrchy	Dargov	self-seeding	500	SE	andesite	–	–
		advance growth	500	SE	andesite	107.62 ± 5.23	–
		thicket	500	SE	andesite	–	4.19 ± 0.17
		small pole stage	500	SE	andesite	–	8.89 ± 0.27
		pole stage	500	SE	andesite	–	15.13 ± 0.49
		maturing stand	500	E	andesite	–	21.80 ± 0.56
Spišsko-gemerský kras (Muránska planina)	Nemecké lúčky	self-seeding	950	SE	limestone	–	–
		advance growth	950	SE	limestone	105.84 ± 3.23	–
		thicket	950	NW	limestone	–	3.66 ± 0.16
		small pole stage	950	NW	limestone	–	8.05 ± 0.16
		pole stage	950	NW	limestone	–	13.75 ± 0.46
		maturing stand	950	NW	limestone	–	21.99 ± 0.47
Kremnické vrchy	Štagiar	self-seeding	675	W	andesite	–	–
		advance growth	650	W	andesite	126.58 ± 4.00	–
		thicket	680	E	andesite	–	3.67 ± 0.11
		small pole stage	680	E	andesite	–	12.49 ± 1.40
		pole stage	675	W	andesite	–	14.46 ± 0.56
		maturing stand	675	W	andesite	–	23.47 ± 0.98

Table 3. Frequency of beech necrotisation in the stages of self-seeding, advance growth and thicket

Locality	Growth stage	Frequency of necrotisation (%)			
		stem	branch	stem and branch	total
Havešová	self-seeding	11	1	0	12
	advance growth	26	20	12	58
	thicket	60	–	–	–
Dargov	self-seeding	11	–	0	11
	advance growth	44	8	40	92
	thicket	84	–	–	–
Nemecké lúčky	self-seeding	16	10	2	28
	advance growth	33	7	50	90
	thicket	59	–	–	–
Štagiar	self-seeding	15	1	0	16
	advance growth	21	23	46	90
	thicket	85	–	–	–

the evaluation of frequency of necrotic damage to stems makes it possible to compare results both within one locality and between individual localities. In such cases, the branches (in the stage of self-seeding and advance growth) are excluded from the evaluation. In the case of small pole stage, pole stage and maturing stands, we also excluded the extent of necrotic damage to stem expressed by I_{NK}.

Differences in the values of necrotisation indices between individual localities were tested by Mann-Whitney's *U* test at the probability level $P = 0.05$. This test was chosen in regard to the non-parametric character of data and discrete values used in the semi-quantitative evaluation scale.

RESULTS AND DISCUSSION

The results of evaluation of necrotic disease of beech bark in the growth stages of self-seeding, advance growth and thicket are given in Table 3, whereas those for the stages of small pole, pole and maturing stand are in Table 4.

The frequency of necrotic damage of self-seeding in individual localities ranges from 11% to 28%. Higher values and larger differences were recorded in the advance growth from 58% to 92% and in the thicket from 59% to 85% (Table 3). After Mihál and Cicák (2003) evaluated the necrotic damage of beech self-seeding in 44 localities in Slovakia, they found out that the frequency of necrotic

Table 4. Frequency of necrotisation in individual necrotisation degrees and index of beech bark necrotisation (I_{NK}) in the stages of small pole, pole and maturing stand

Locality	Growth stage	Frequency of necrotisation in individual necrotisation degrees (%)								I_{NK} (mean ± standard error)
		0	1	2	3	4	1–4	2–4	3–4	
Havešová	small pole stage	9	67	17	2	5	91	24	7	1.27 ± 0.09^{a}
	pole stage	0	48	23	13	16	100	52	29	1.97 ± 0.11^{B}
	maturing stand	4	71	20	2	3	96	25	5	1.29 ± 0.07
Dargov	small pole stage	20	52	22	4	2	80	28	6	1.16 ± 0.09^{a}
	pole stage	12	51	22	11	4	88	37	15	1.44 ± 0.10^{A}
	maturing stand	8	55	24	7	6	92	37	13	1.48 ± 0.10
Nemecké lúčky	small pole stage	40	38	11	7	4	60	22	11	0.97 ± 0.11^{b}
	pole stage stand	9	63	13	6	9	81	28	15	1.43 ± 0.10^{A}
	maturing stand	11	54	24	6	5	89	35	11	1.41 ± 0.09
Štagiar	small pole stage	30	53	11	3	3	70	17	6	0.96 ± 0.09^{b}
	pole stage stand	15	61	12	7	5	85	24	12	1.26 ± 0.10^{A}
	maturing stand	10	67	14	5	4	90	23	9	1.26 ± 0.09

Statistical significance of differences in I_{NK} between localities is marked in the growth stage of small pole (a, b) and in the growth stage of pole (A, B). In maturing stand significant differences were found

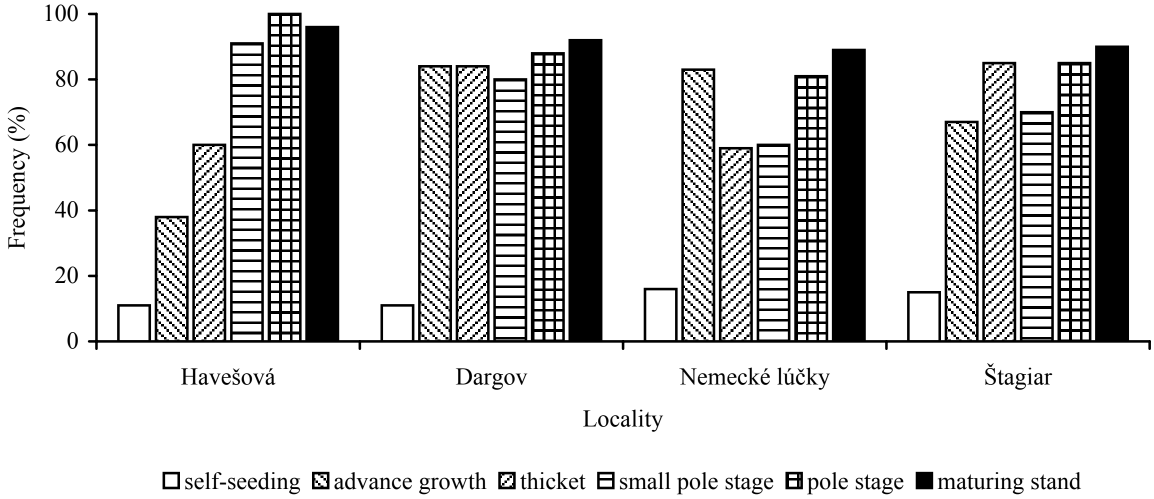

Fig. 1. Frequency of beech stem necrotisation from self-seeding to maturing stand

disease ranged from 7% to 51%. The increasing trend of frequency of necrotic damage of self-seeding, advance growth and thicket has several causes. The most frequent is a negative influence of climatic and ecological conditions in the clearing, particularly on the advance growth (Mihál et al. 1997). This is caused by the absence of shelterwood. The still higher frequency of necrotisation in thicket may also be caused by the contact mechanical damage due to the perfect or even excessive canopy closure. Surovec (1990) also mentioned the influence of abiotic and biotic factors (frost, hail, insects). A similar increase in necrotic damage of beech was also reported by Metzler et al. (2002), who found necrotic damage of only 1.9% in stands 1–2 m in height (advance growth stage), but even of 20% in stands 6–7 m in height (stage of thicket). In another paper (Metzler, Erffa 2000) they reported that the necrotic disease of beech increased from 1–5 years old tress to 16–20 years old trees, hence from advance growth to small pole stage. Surovec (1993) stated that more than 1,000 ha of beech stands of age class 1 in Slovakia showed a 100% infestation by necroses.

The results of evaluation of the beech bark necrotic disease in the stages of small pole, pole and maturing stands are given in Table 4. They are interpreted by means of I_{NK} and necrotisation frequency in individual degrees of damage. Necrotisation frequency is given here in order to characterise the influence of the proportion of trees in individual degrees of necrotisation on the final values of $I_{NK.}$ Table 4 shows I_{NK} to increase in all localities, except for the Havešová locality, from small pole stage to maturing stands. Unlike other localities, the values of I_{NK} in the Havešová locality were influenced by a high proportion of trees in degrees 3 and 4 of necrotisation. In other localities, as well as in all growth stages, the proportion of trees in individual degrees of necrotisation is strongly balanced. Most cases of statistically significant differences in I_{NK} between individual localities were found in the small pole stage. In the pole stage, we recorded only one case whereas in the maturing stands we did not record any case of statistically significant difference between the I_{NK} values (Table 4; Mann-Whitney's *U* test $P = 0.05$). Cicák and Mihál (2002) gave the value 1.22 as average I_{NK} for whole Slovakia. The results given in Table 4 are similar to that value in five cases. Only in the localities Nemecké lúčky and Štagiar did we record lower values of I_{NK} than the whole Slovakia average. The increasing trend of necrotic disease from self-seeding to maturing stands is also documented by necrotisation frequency only in the tree stems (Fig. 1). The largest negative changes in the necrotic disease were found in the stage of advance growth. Since that stage, the trend of negative changes in the disease of stems became less marked and was accompanied by smaller fluctuations. One of the causes of the unfavourable state of beech bark necrotic disease in the pole stage may be negative factors connected with thinning (Cicák et al. 2003). This was also confirmed by Štefančík and Štefančík (1999), who gave the value 1.5% of negative health selection of trees in beech pole stands before the first thinning, but before the third thinning the value was even 20.7%. They also observed a strong decline of average annual diameter increment (i_d) in the period 1984–1993, which was caused, according to their opinion, by the beech bark necrotic disease. In the same stand (studied by Štefančík, Štefančík 1999), Cicák et al. (2003) also observed negative changes in the necrotic disease in beech pole stand in a relatively short period of 1996–2000. Negative influence of necrotic disease also appears in maturing stands. Štefančík and Leontovyč (1966) reported that even 40% of trees had to be removed from the circular sample plot in consequence of the necrotic disease. Houston (1997) stated that older stands of *Fagus grandifolia* Ehrh. with the average stem diameter of 25 cm were very vulnerable and showed high mortality. The frequent cause of their dying were fungi of the genus *Nectria* (Fr.) Fr. The American annual review (American Beech 1993) reported that more that 50% of beeches with the average stem diameter of

20.5 cm in the state Maine were heavily affected by necrotic disease. Houston (1975) mentioned that, due to the necrotic disease, only few trees with the stem diameter exceeding 30.5 cm occurred in the state Maine.

CONCLUSIONS

Results of investigation of the present state of beech bark necrotic disease in the stages of self-seeding, advance growth, small pole, pole and maturing stand confirmed the following findings. The least affected stage was self-seeding. The greatest negative changes in necrotic disease were observed in the stage of advance growing. Since that stage the trend of negative changes became less marked and was accompanied by smaller fluctuations. The lowest degree of necrotic disease expressed by stem necrotisation index was in the small pole stage, it slightly increased in the pole stage and in the maturing stands. The frequency of stem necrotisation in maturing stands in four localities in Eastern and Central Slovakia ranged from 89% to 96%. The results show the beech bark necrotic disease belongs to significant phytopathological problems influencing development of beech stands.

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References

AMERICAN BEECH, 1993. Forest Health Assessment for the Northeastern Area. U.S Department for Agriculture, Forest Service and U.S. Environmental Protection Agency: 9–11.

CHIRA D., CHIRA F., 1998. Beech problems in Romania. In: IUFRO Workshop Complex Diseases, Vienna, Austria: 23–28.

CICÁK A., MIHÁL I., 1997. Metodika hodnotenia nekrotizácie kôry kmeňov buka. Lesnictví-Forestry, *43*: 104–109.

CICÁK A., MIHÁL I., 1998. Index nekrotizácie kôry kmeňov buka. Lesnictví-Forestry, *44*: 474–477.

CICÁK A., MIHÁL I., 2002. Relationship of necrotic disease of beech trunks to the sociological position of trees in the stand. J. For. Sci., *48*: 38–41.

CICÁK A., MIHÁL I., ŠTEFANČÍK I., 2003. Development of necrotic disease and health condition of trees of selective quality in a systematically tended beech pole-stage stand. J. For. Sci., *49*: 11–18.

GAJEVAJA V.P., ISIKOV V.P., MEREZHKO T.A., DUDKA A.I., 1995. Ksilotrofnaja mikobiota buka na Ukrajine. Mikol. i Fitopatol., *29*: 6–11.

GREGUŠ C., 1968: Rastové stupne a doba ich presunu. Zvolen, Ved. Práce VÚLH, *10*: 167–199.

HOUSTON D.R., 1975. Beech bark disease. J. For., *73*: 660–663.

HOUSTON D.R., 1997. Beech Bark Disease. In: Exotic Pests of Eastern Forest. Conference Proc., Nashville, U.S.A.: 7.

JANČAŘÍK V., 1992. Chřadnutí buku. Lesn. Práce, *71*: 161.

JANČAŘÍK V., 2000. Tracheomykózní onemocnění v lesních školkách. Technické informace pro lesnickou praxi. Praha, VÚLHM, *4*: 7.

KORPEĽ Š. et al., 1991. Pestovanie lesa. Bratislava, Príroda: 472.

KUNCA A., LEONTOVYČ R., 1999. Relationship between beech bark wounds and bark necrosis and possible methods to control bark necrosis. Lesn. Čas., *45*: 317–324.

KUNCA A., ZÚBRIK M., LEONTOVYČ R., 2000. Nekrotické ochorenie bučín a modely obhospodarovania takto postihnutých porastov. In: Zbor. Aktuálne problémy v ochrane lesa. Zvolen, LVÚ: 105–108.

LEONTOVYČ R., GÁPER J., 1997. Hlavné fytopatologické problémy v lesoch Slovenska a možnosti ich eliminácie. In: Zbor. Aktuálne problémy v ochrane lesa. Zvolen, LVÚ: 89–94.

METZLER B., ERFFA R., 2000. Zur Verbreitung von Buchenkrebs in Naturverjüngungen in Baden-Württemberg-Einfluss von Überschirmung und Standortsfaktoren. Forstw. Cbl., *119*: 297–309.

METZLER B., MEIERJOHANN E., KUBLIN E., WÜHLISCH G., 2002. Spatial dispersal of *Nectria ditissima* canker of beech in an international provenance trial. For. Path., *32*: 137–144.

MIHÁL I., CICÁK A., 2003. State of necrotic disease of beech in the growth phase of natural seeding in Slovakia. Ekológia (Bratislava), *22*: 42–50.

MIHÁL I., CICÁK A., ČUNDERLÍK I., 1997. Poškodenie buka nekrózami kôry v rastovej fáze nárastu. Lesnictví-Forestry, *43*: 201–205.

MIHÁL I., CICÁK A., ŠTEFANČÍK I., 1998. Health condition and bark necrotic disease of trees of selective quality in a systematically tended beech pole-stage stand. Lesnictví-Forestry, *44*: 97–102.

PERRIN R., 1981. De quei souffre l' écorce du hêtre? Schweiz. Z. Forstwes., *132*: 1–16.

SCHÜTT P., SUMMERER H., 1983. Waldsterben-Symptome an Buche. Forstw. Cbl., *102*: 201–206.

SUROVEC D., 1990. Príznaky a príčiny chradnutia mladých bučín na Slovensku. Les, *46*: 12–13.

SUROVEC D., 1992. Tracheomycoses of young beech stands from natural regeneration. Acta Inst. For. Zvolen., *8*: 97–105.

SUROVEC D., 1993. Vývoj nekróz v mladých bučinách. In: Zbor. referátov Ochrana lesov proti škodlivým činiteľom. Zvolen, LVÚ: 45–51.

ŠTEFANČÍK L., LEONTOVYČ R., 1966. O nekróze kôry – maizgotoku – buka na východnom Slovensku. Lesn. Čas., *39*: 521–532.

ŠTEFANČÍK I., ŠTEFANČÍK L., 1999. Štrukturálne zmeny bukovej žrďoviny vplyvom úrovňovej voľnej prebierky na výskumnej ploche Štagiar-Zábučie. Folia Oecol., *25*: 63–80.

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Nekrotické ochorenie buka v jednotlivých rastových fázach

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ABSTRAKT: V práci prinášame výsledky aktuálneho stavu nekrotického ochorenia buka v rastových fázach náletu, nárastu, mladiny, žŕdkoviny, žrďoviny a dospievajúcej kmeňoviny zo štyroch lokalít stredného a východného Slovenska. Zistili sme, že najmenej je nekrotickým ochorením postihnutá fáza náletu. Najvýraznejšie negatívne zmeny v nekrotickom ochorení vyjadrené frekvenciou nekrotizácie sme zistili vo fáze nárastu. Od tejto fázy je trend negatívnych zmien nekrotického ochorenia miernejší a sprevádzaný malými výkyvmi. Miera nekrotického ochorenia vyjadrená indexom nekrotizácie kmeňov (I_{NK}) bola najnižšia v rastovej fáze žŕdkovina, mierne sa zvýšila vo fáze žrďovina a vo fáze dospievajúca kmeňovina. Frekvencia nekrotizácie kmeňov v rastovej fáze dospievajúca kmeňovina sa pohybovala v rozpätí od 89 % do 96 %. Výsledky potvrdzujú skutočnosť, že nekrotické ochorenie patrí medzi významné fytopatologické problémy ovplyvňujúce vývin bukových porastov.

Kľúčové slová: *Fagus sylvatica* L.; nekrotické ochorenie kôry; rastové fázy buka; Slovensko

Cieľom príspevku bolo kvantifikovať aktuálny stav nekrotického ochorenia buka v rastových fázach – od náletu až po dospievajúcu kmeňovinu. Opis a vymedzenie rastových fáz drevín, ktoré predstavujú rozdielne trvajúce úseky ich života, uvádzame v tab. 1.

Hodnotenie nekrotického ochorenia buka sme uskutočnili počas jarných a jesenných mesiacov v rokoch 2002 a 2003 na štyroch vybraných lokalitách východného a stredného Slovenska (tab. 2). Na každej lokalite sme vyhodnotili 100 jedincov vo fázach od náletu po dospievajúcu kmeňovinu. Zmeraním výšky nárastu a zmeraním hrúbky $d_{1,3}$ mladiny, žŕdkoviny, žrďoviny a dospievajúcej kmeňoviny sme získali údaje o kvantitatívnych znakoch, ktoré vymedzujú jednotlivé fázy. Pri rastovej fáze nálet sme strednú výšku do 50 cm odhadovali okulárne.

Pri hodnotení náletu a nárastu sme postupovali podľa metodiky autorov MIHÁLA et al. (1997), podľa ktorej sa hodnotí prítomnosť nekróz na kmeňoch a konároch. V rastovej fáze mladina sme z dôvodov zhoršenej dostupnosti korunovej časti hodnotili frekvenciu výskytu nekróz len na kmeňoch. Pri hodnotení nekrotického ochorenia žŕdkoviny, žrďoviny a dospievajúcej kmeňoviny sme postupovali podľa metodiky autorov CICÁKA a MIHÁLA (1997). Výsledky získané touto metodikou môžeme interpretovať pomocou indexu nekrotizácie (I_{NK}), alebo zjednodušene, len ako frekvenciu nekrotizácie kmeňov. Použitie dvoch rozdielnych metodických postupov hodnotenia je podmienené výraznou odlišnosťou vonkajších kvantitatívnych znakov buka v jednotlivých rastových fázach (tab. 1).

Porovnávanie výsledkov je z hľadiska použitia dvoch metodík hodnotenia možné iba medzi jednotlivými lokalitami. Hodnotenie frekvencie nekrotického poškodenia len kmeňovej časti stromov nám umožňuje porovnávať výsledky jednotlivých rastových fáz na konkrétnej lokalite, ale aj medzi jednotlivými lokalitami. V takom prípade sú však z hodnotenia vyradené konáre (fázy náletu a nárastu) a v prípade žrdkoviny, žrďoviny a dospievajúcej kmeňoviny aj rozsah nekrotického poškodenia kmeňov, ktorý reprezentuje I_{NK}.

Pri testovaní rozdielov v indexoch nekrotizácie medzi jednotlivými lokalitami sme pri štatistickom hodnotení použili Mann-Whitney *U* test $P = 0{,}05$. Tento test sme zvolili vzhľadom na neparametrický charakter údajov, vyplývajúci z diskrétnych hodnôt použitých v stupnici hodnotenia.

Výsledky hodnotenia nekrotického ochorenia buka v rastových fázach nálet, nárast a mladina uvádzame v tab. 3. Hodnoty frekvencie nekrotického poškodenia náletu na jednotlivých lokalitách majú rozpätie od 11 % do 28 %. Vyššie hodnoty a väčšie rozdiely sme zistili pri náraste od 58 % do 92 % a pri mladine od 59 % do 85 %. Výsledky hodnotenia nekrotického ochorenia kôry buka v rastových fázach žŕdkovina, žrďovina a dospievajúca kmeňovina uvádzame v tab. 4. Interpretované sú jednak formou $I_{NK,}$ ale aj formou frekvencie nekrotizácie v jednotlivých stupňoch poškodenia. Z tab. 4 vidieť, že na všetkých lokalitách, okrem lokality Havešová, majú hodnoty I_{NK} stúpajúci trend, od žrdkoviny po dospievajúcu kmeňovinu. I_{NK} v rastovej fáze žrďovina na lokalite Havešová bol v porovnaní s ostatnými lokalitami ovplyvnený vysokým podielom stromov v 3. a 4. stupni nekrotizácie. Na ostatných lokalitách – ale aj vo všetkých rastových fázach – je podiel stromov vo všetkých stupňoch nekrotizácie veľmi vyrovnaný. Najviac prípadov štatistickej signifikantnosti rozdielov v hodnotách I_{NK} medzi lokalitami sme zistili pri rastovej fáze žŕdkovina. Vo fáze žrďovina sme zistili len jeden prípad a vo fáze dospievajúca kmeňovina sme nezistili ani jeden prípad štatistickej signifikantnosti rozdielov v hodnotách I_{NK}.

Trend nárastu nekrotického ochorenia od náletu po dospievajúcu kmeňovinu dokumentujú výsledky frekvencie nekrotizácie len kmeňovej časti stromov (obr. 1). Najväčšie negatívne zmeny v nekrotickom ochorení sme zistili vo fáze nárastu. Od tejto fázy je trend negatívnych zmien ochorenia kmeňov miernejší a sprevádzaný malými výkyvmi.

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