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COMPARATIVE STUDY ON CROWN LEACHING COMPOSITION OF BLACK PINE, ATLAS CEDAR, COMMON OAK AND BLACK LOCUST

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Abstract

The rainfall amount and its chemical composition were studied in the period 2009–2013 in the Pismenovo arboretum, situated close to Black Sea coast (Tsarevo State Forest Service). The objective of the proposed work comprises conducting of prolonged studies on N, P_2O_5, K_2O, Ca and Mg content and the highlighting of the particularities in the seasonal dynamics of the above mentioned elements in the leaves of some tree species. The purpose of this work comprises a conducting of longer comparative research on the dynamics of the chemical composition of atmospheric precipitations under the canopy of different forest-tree plantations. The results showed that Black pine (*Pinus nigra* Arn.) crowns capture 29.2 % of the total rainfall amount at open field. The same percentage in Atlas cedar (*Cedrus atlantica* Manetti) was 34.4 %, in Common oak (Q*uercus robur* L.) – 6.5 %, in Black locust (*Robinia pseudoacacia* L.) – 23.3 % and the throughfall in the 75-year-old coppice oak forest was 15.8 %. A difference in the chemical composition of throughfall has been determined, depending on age and species (coniferous or deciduous). The pH value of the throughfall and that of rain water at open field had acid to slightly acid reaction, and the acidity increased during the winter. The lowest values of pH were measured in the water passed through Black pine crowns, and the highest ones – in the water passed through the crown of Black locust. Most nitrate ions were registered in the throughfall fluxes of Black pine. Most ammonium ions were detected in the throughfall fluxes of the 75-year old coppice oak forest, and chloride ions – in the throughfall of Atlas cedar. The content of calcium and magnesium in the throughfall also increases in comparison to that one measured in open field fluxes. The highest content of these two elements was recorded in the throughfall of Black locust.

Key words: ammonium ions, canopy, chlorides, nitrate ions, pH, forest, open field precipitation, throughfall.

Introduction

The throughfall fluxes of the tree species cause changes in their chemical composition and evidence many times higher mineralization. The amount of the elements washed away by rain water depends on tree species composition, age, phase of development etc. As referenced, a great attention is paid to research works focusing on the washing away of the biogenic elements by rain water from the tree vegetation crowns (Kolodyazhnaya 1963; Smit 1985; Ignatova 1986, 1987, 1992; Karpachevsky et al. 1988; Fikova and Ignatova 2003; Alenas and Skarby 1988; Hansen et al. 1994; Lindberg et al. 1990; Likens and Bormann 1995). This is be-

cause these research works are significantly important both for the examination of the cycling of the substances related to nutritional regimen of tree species and of the hydrothermal regimen of river basins in forest ecosystems (Bahmani et al. 2012, Ziegler et al. 2009). Dry deposition of base cations, nitrate, as well as particulate ammonium, and sulphate in coniferous forests was measured by Ferm et al. (2000). According to studies by Reinap (2011), dry deposition models are insufficient due to a lack of semi-empirical data and because of difficulties in parameterization of the efficiency (E) with which leaves capture aerosols.

The purpose of this work comprises a conducting of longer comparative researches on the dynamics of the chemical composition of the atmospheric precipitations passed under the canopy of different forest-tree plantations.

Objects and Methods

The rainfall amount and chemical composition has been measured for more than 10 years on the territory of Pismenovo arboretum, Tsarevo State Forest Enterprise, sector 12[5], in the peripheral sub-region of Strandzha mountain. The results, obtained within the period 2009–2013, are indicated in the study (Broshtilova 2009).

The rainfall quantity is collected into plastic collectors after the throughfall fluxes of the 20–25-year-old trees, as following: Black pine, Black locust, Common oak (plantations), 75-year-old *Quercus frainetto* Ten. coppice plantation, and the rainfalls at open field. Water samples are taken from each single throughfall flux where pH is potentiometrically determined, the ammonia and nitrate ions – by a direct distillation using the Parnas-Wagner apparatus, the contents of sulphates, calcium and magnesium – by the complex-metric method; while the content of chlorides is argentometrically detected using Mohr`s method.

Results and Discussion

Of the total annual amount of throughfalls at the open field, 29.2 % throughfall fluxes are captured by Black pine crowns, 34.4 % by Atlas cedar ones, 6.5 % by Common oak, 23.3 % by Black locust and 15.8 % by the old oak forest, compared to the rainfall at open field (Table 1). The coniferous plantations capture in their crowns about 2 times more of rainfalls, as compared to the coppice oak forest, and approximately 5 times more in comparison with the Common oak plantation.

The reaction (pH) of the rain water at open filed and

Table 1. Detained rainfall of wood crowns, mean values (% of the total rainfall amount at open field).

Species\year	2009	2010	2011	2012	2013	Average
Pinus nigra Arn.	35.0	29.4	20.5	30.4	30.8	29.2
Cedrus atlantica Manetti	-	32.5	39.0	30.2	35.7	34.4
Robinia pseudoacacia L.	14.0	27.1	32.9	24.0	18.5	23.3
Q*uercus robur* L.	5.0	8.5	3.9	6.1	6.1	6.5
75-year old coppice oak forest	14.0	15.3	13.3	19.5	16.7	15.8

the throughfall fluxes under the canopy of the studied species in Pismenovo arboretum varies from slightly acid to acid (Fig. 1). The highest acidity is detected in the rainfalls in 2012 when a pH value of 4.78 in the throughfall fluxes of the old oak forest is measured in February (Fig. 2): probably, that is due to a higher degree of the atmospheric air pollution in the above mentioned region, within the respective period. During the whole period of study, pH values, measured in all of the species, are lower in the winter months. The average results, obtained within the period 2009–2013, show that the most acid rainfalls are in February, with the exception of the throughfalls of Common oak, having the highest acidity in January. As a hypothetical reason for such lower values of pH in that period, the predominance of snowfalls could be considered.

Most acid are the throughfalls fluxes of Black pine followed by Atlas cedar ones while the highest value of pH is measured in the throughfalls of Black locust (Table 2, Fig. 1 and 2).

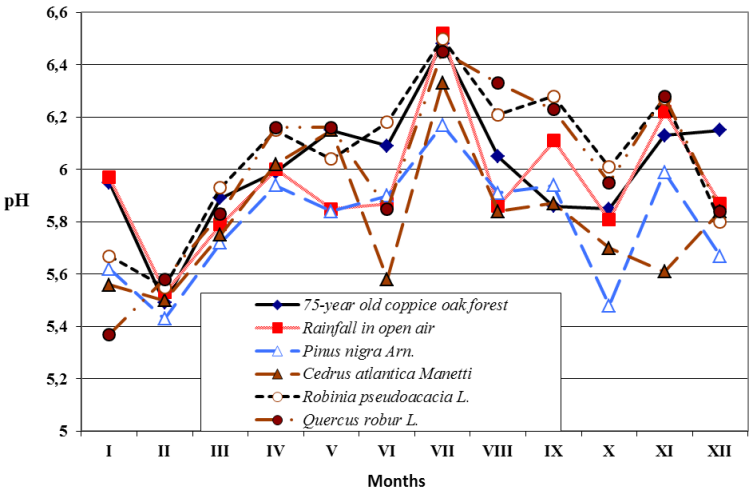

Fig. 1. The dynamics pH value of the rainfall for the period 2009–2013 (mean values).

The average concentration of the ammonia ions in the rainfalls is significantly lower, compared to that one of the nitrate ions (Table 2). The greatest difference exists in the throughfall fluxes of Black pine, as of 3.8 times, while the smallest one is

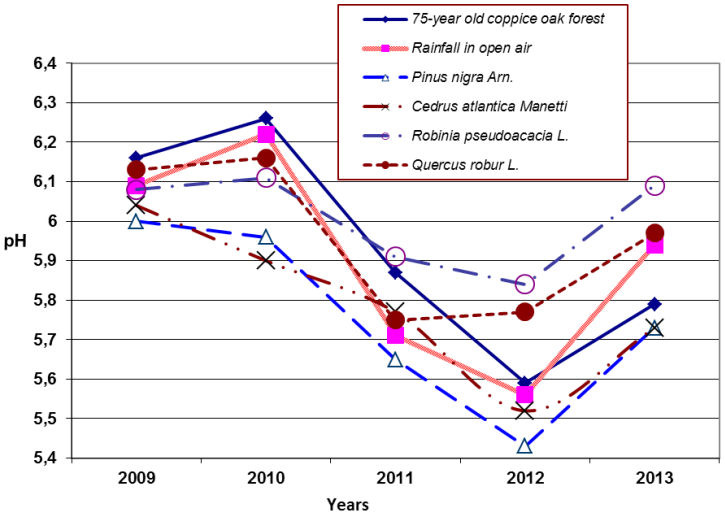

Fig. 2. Mean annual acidity of open field precipitation and forest throughfall for the period 2009–2013 (mean values).

Table 2. Average concentrations chemical ingredients in rainfall in open air and under the crowns (period 2009–2013).

Variant	pH	NH_4^+	NO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}
		mg/l					
Rainfall in open air	5.90	1.46	4.63	4.47	0.46	6.30	1.31
Pinus nigra Arn.	5.75	2.20	8.48	8.41	0.38	8.04	2.21
Cedrus atlantica Manetti	5.79	3.67	7.46	13.26	0.11	10.11	3.56
Robinia pseudoacacia L.	6.01	2.17	4.76	10.45	0.12	13.15	4.40
Q*uercus robur* L.	5.96	2.55	4.61	5.26	0.42	7.21	1.94
75-year-old coppice oak forest	5.93	4.80	7.02	8.33	0.12	11.3	2.84

registered in the throughfall fluxes of the old oak forest: 1.5 times.

The content of the ammonia ions is the lowest in the rainfalls at open field while in the throughfall fluxes of the old oak forest there is a difference of more than 3 times. The concentration of the ammonia ions in the throughfall fluxes of Atlas cedar is 2.5 times higher, as compared to that one in the rainfalls at open field. Within the period from April to June, the content of the ammonia ions, detected in the throughfall fluxes of the old oak forest and Common oak is significantly higher in comparison with that one in the rest months (Fig. 3). So, the obtained results have shown that more intensive washing away of biogenic elements from the tree leaves is evidenced when the leaves are younger, intensively growing during the above mentioned months.

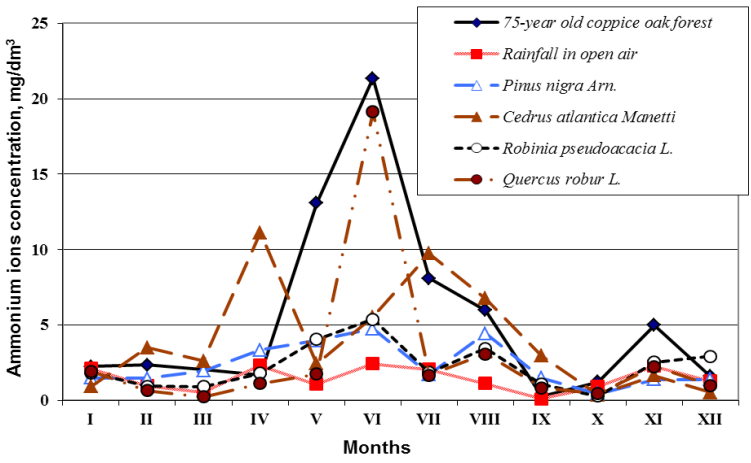

Fig. 3. Ammonium ions concentrations in the rainfall (period 2009–2013, mean values).

The concentration of the nitrate ions is the highest in the throughfall fluxes of Black pine: about 2 times higher than in the rainfalls at open filed and throughfalls of Com-

mon oak. About 1.7 times more nitrates are washed away from the Black pine crown by rainfalls in comparison with the nitrates washed out from the crowns of Common oak and Black locust (Table 2). The content of the nitrate ions in throughfalls of coniferous species within the period March-June is significantly higher compared to that one in the rest months (Fig. 4).

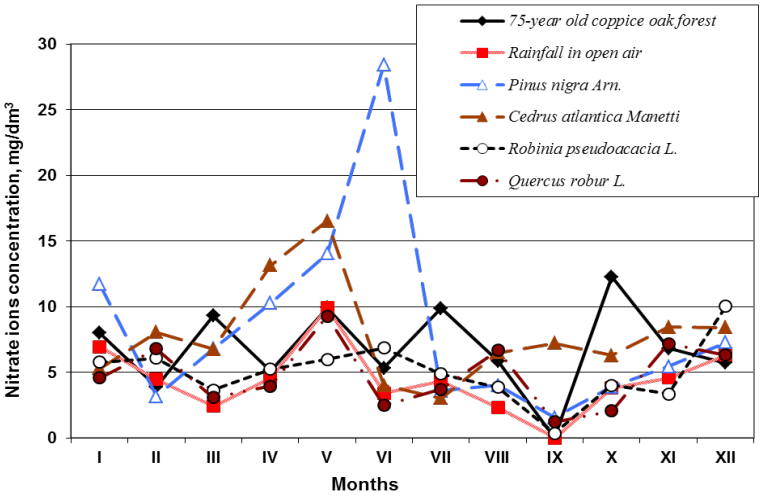

Fig. 4. Nitrate ions concentrations in the rainfall (period 2009–2013, mean values).

The content of chlorides is higher during the second half of the year, especially in the throughfalls of Black locust and Atlas cedar (Fig. 5). When the rainfalls pass through the crowns of the tree species, the concentration of chlorides in the throughfalls undergoes a significant change. The highest is the concentration of chlorides in the throughfall fluxes of Atlas cedar: about 3 times higher. It is 2.3 times higher in the throughfall fluxes of Black locust, 1.9 times higher in the throughfalls of the old oak forest and 1.2 times higher in the throughfalls under the Common oak canopy, compared to that one in the rainfalls at open field (Table 2).

There is also an increase of Ca and Mg content in the throughfall fluxes of the trees, in comparison with that one in the rainfalls at open field: the content of calcium ions is 2 times greater and that one of magnesium ions: 3 times greater (Table 2). The average results, obtained within

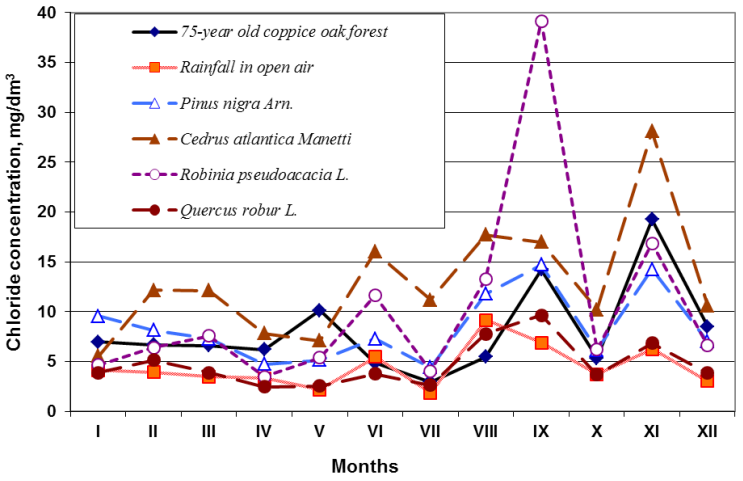

Fig. 5. Chloride concentrations in the rainfall (period 2009–2013, mean values).

the period (Fig. 6 and 7), have shown that the greatest amounts of calcium and magnesium ions are washed away by rainfalls from the crowns of Black locust trees. One of the reasons for more intensive washing away from the crown of Black locust is the significantly higher Ca and Mg content in its leaves.

Such comparatively high annual average concentrations of calcium and magnesium in the rain waters, registered in all of the variants, can be explained by the proximity of the examined sites to the sea (Likens and Bormann 1995).

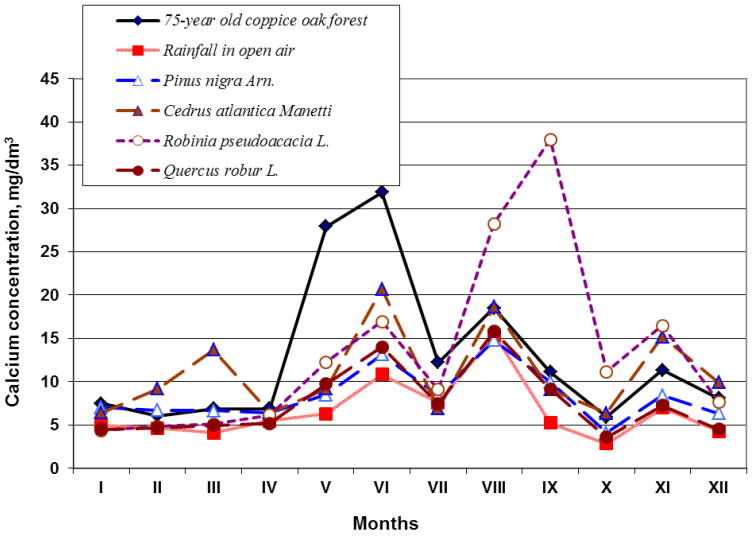

Fig. 6. Calcium concentrations in the rainfall (period 2009–2013, mean values).

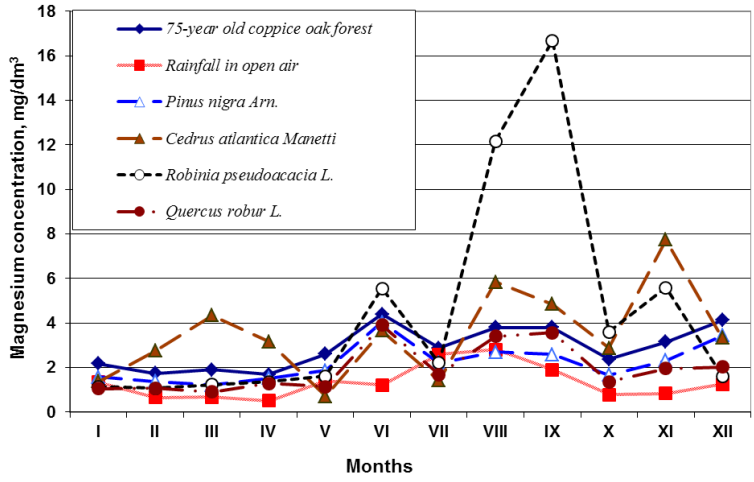

Fig. 7. Magnesium concentrations in the rainfall (period 2009–2013, mean values).

As about sulphates, certain amounts of them are detected in the rain waters only in some years (when the study was conducted), and, mainly, in January, February and March. In contrast to the other studied elements, the content of sulphates in the rain water at open field is greater than in the throughfall fluxes of the examined tree species (Table 2).

Confronting the annual dynamics of sulphates (Table 3), it is evident that their content corresponds to the highest acidity of the precipitation: a fact which proves an existing relationship between the acidification of the atmospheric precipitations and the content of pollutants of industrial origin (Fikova and Ignatova 2003).

Table 3. Sulfates content in rainfall, mean values (mg/dm^3).

Variant\years	2009	2010	2011	2012	2013
Rainfall in open air	0	0.35	1.33	0.60	0
Pinus nigra Arn.	0	0.35	1.15	0.40	0
Cedrus atlantica Manetti	0	0.35	0	0.21	0
Robinia pseudoacacia L.	0	0	0	0.58	0
Q*uercus robur* L.	0	0.17	0.77	1.15	0
75-year old coppice oak forest	0	0	0	0.58	0

Conclusions

Black pine crowns capture 29.2 % of the total rainfall amount at open field. The same percentage in Atlas cedar was 34.4 %, in Common oak – 6.5 %, in Black locust – 23.3 % and the throughfall in the 75-year-old coppice oak forest was 15.8 %.

A difference in the chemical composition of throughfall has been determined, depending on age and species (coniferous or deciduous).

The pH value of the throughfall and that of rain water at open field had acid to slightly acid reaction, and the acidity increased during the winter. The lowest values of pH were measured in the water passed through Black pine crowns, and the highest ones – in the water passed through the crown of Black locust.

Most nitrate ions were registered in the throughfall fluxes of Black pine. Most ammonium ions were detected in the throughfall fluxes of the 75-year-old coppice oak forest, and chloride ions – in the throughfall of Atlas cedar.

The content of calcium and magnesium in the throughfall also increases in comparison to that one measured in open field fluxes. The highest content of these two elements was recorded in the throughfall of Black locust.

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