*INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH*
*INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS*

Nr II/2/2015, POLSKA AKADEMIA NAUK, Oddział w Krakowie, s. 377–384
Komisja Technicznej Infrastruktury Wsi

DOI: http://dx.medra.org/10.14597/infraeco.2015.2.2.030

# RAINFALL INTERCEPTION FOR SIXTY-YEAR-OLD PINE STAND AT THE TUCZNO FOREST DISTRICT

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***Summary***

The aim of the presented studies was to calculate interception values for the sixty-year-old pine stand located in Tuczno Forest District. The area subjected to analysis is located in the north-western part of Poland, in West Pomerania province. The calculations were based on the measurements of precipitation above the tree crowns (2 pluviometers) and at a height of 1 m above the surface (13 pluviometers). Precipitation measurements used in this work were carried out in 30-minute intervals during the entire 2014. The analyses were conducted using mainly A-STER tipping bucket pluviometers. Temporary interception in the studied sixty-year-old pine stand can reach even about seven millimeters. The daily difference between precipitation above the tree crowns and precipitation at 1 m above the surface can reach twelve millimeters. The calculated volume of the so called interception reservoir was about three millimeters (3.26 mm). The annual value of interception for the tested stand was 19.6% of the total annual precipitation.

**Key words:** interception, forest meteorology, monitoring-gauging station Tuczno

## INTRODUCTION

In field conditions, forest rainfall interception is defined as a difference between the precipitation measured above the tree crowns and the precipitation measured under tree cover (Calder 2001, Bryant et al. 2005, Pypker et al. 2005).

Attempts at mathematical description of interception process have been made for about fifty years (Czarnowski, Olszewski 1968, Crocford and Richardson 2000, Keim et al. 2004). They concerned particularly the interception for individual forest zones (Jong and Jetten 2007), the forest canopy (Gash et al 1995), or a component of water balance (Pike and Scherer 2003).

Studies on mathematical model of rainfall interception, both based on physical relationships (Rutter and Morton 1977) and conceptual ones (Suliński 1993) base on empirical laboratory or field measurements. The conceptual models usually assume the interception by trees may be identified with a process of "filling a leaky reservoir" (Osuch et al. 2005, Toba and Ohta 2008). The main affecting factors are: sprayed area (LAI index) (Suliński 1993, Jong and Jetten 2007) and rainfall characteristics (the rainfall intensity and the size of falling drops) (Keim et al. 2006).

A review description of various measurement methods applied so far and conceptions of mathematical descriptions of interception by trees and forest vegetation may be found e.g. in the paper by Klamerus-Iwan (2014).

This paper aims at presentation of a short lived (associated with precipitation episodes) and seasonal interception for sixty-year-old pine stand located in the central, lowland part of Poland.

## METHODS

A measurement tower, 34-m high, was constructed in the centre of TUCZNO research facility of the Department of Meteorology, Poznań University of Life Sciences. Two pluviometers were installed on its top, one A-STER tipping basket and the other forming a part of Vaisala meteorological station. Thirteen A-STER tipping basket pluviometers were arranged on a cross plan (N-S, E-W) in the forest bottom, on a standard height of 1m above the surface. Precipitation was summed up in 30 minute intervals for all 15 pluviometers (Olejnik et al. 2013, Urbaniak et al. 2014).

## DESCRIPTION OF THE OBJECT OF RESEARCH

The described experimental area is located in the north-western part of Poland in Tuczno Forest District, in the area of Martew forest inspectorate. The terrain is situated in the Drawa National Park buffer zone. Formerly it was an agricultural land, later afforested and now over sixty-year-old pine stand is growing on mixed forest habitat. The share of pine (*Pinus sylvestris* L.) in species composition of the stand reaches almost 99%. The remaining 1% is an admixture of silver birch (*Betula pendula* Roth.). The underbrush is composed mainly of beech (*Fagus sylvatica* L.) and hornbeam (*Carpinus betulus* L.). The soils were

identified as proper rusty soil, and rusty gley soil in some places, deposited on loamy sand (Chojnicki et al. 2009).

## RESULTS

Precipitations measured in 30 minute intervals above the tree crowns (PG) and at the height of 1 m above the surface (PD) were shown in Figure 1. These values are means for the measurements from respectively two and 13 pluviometers. The maximum value of PG was 13.70 mm ($\sigma_{(PG)}$ = 0.26 mm), whereas the maximum value of PD was 6.53 mm ($\sigma_{(PD)}$ = 0.16 mm). This proportion results from a high temporary interception value.

The daily PG and PD precipitation totals were shown in Figure 2. The maximum difference between PG and PD daily totals is 11.96 mm ($\sigma_{(PG-PD)}$ = 1.61 mm).

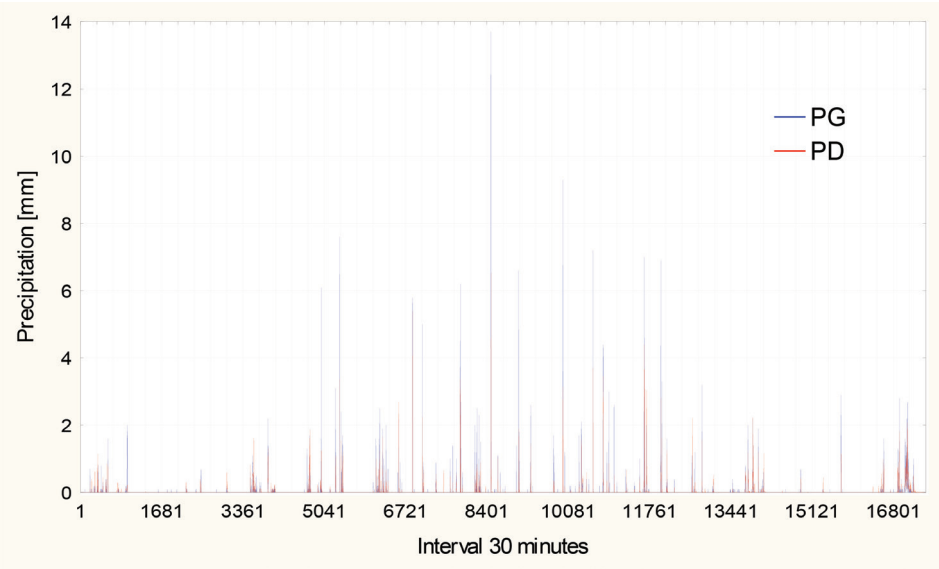


**Figure 1.** Precipitation measured at 1 m above the surface (red line) vs. measured above the forest canopy (blue lines)

The linear regression relationship between PG and PD for 34 rainfall episodes, identifiable in the investigated 2014, was presented in Figure 3. Linear correlation is statistically significant ($\alpha < 0.001$).

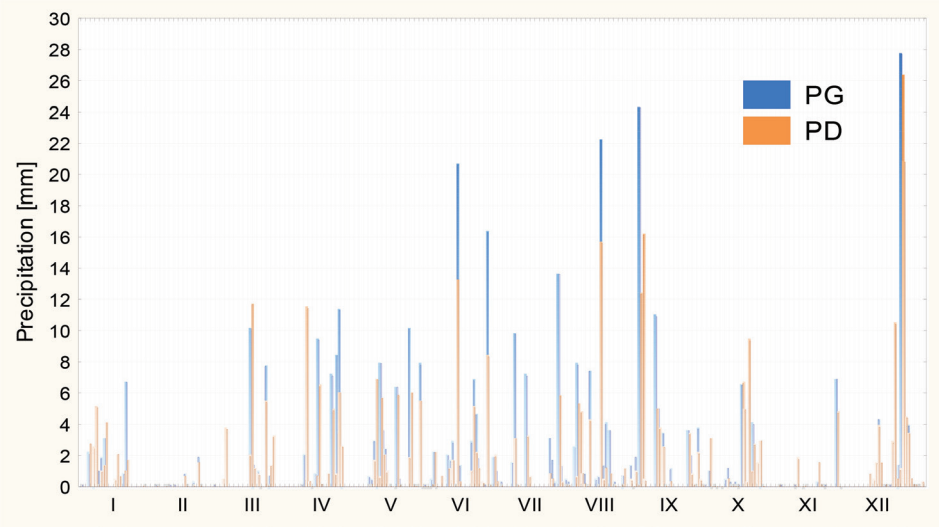


**Figure 2.** Daily precipitation at 1m above the surface (PD) vs. daily precipitation above the forest canopy (PG)

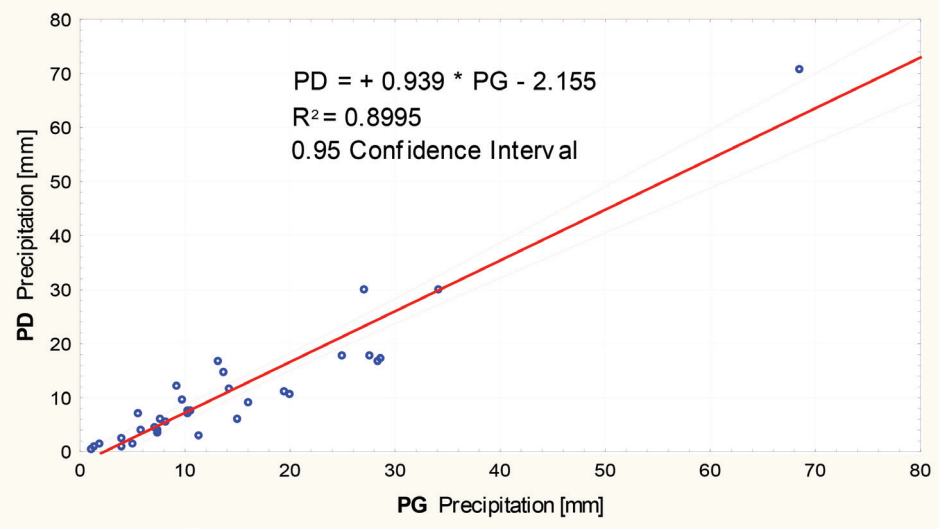


**Figure 3.** Relationship between precipitation above the forest canopy (PG) and precipitation at 1m above the surface (PD)

Genesis of the interception phenomenon shows that the relationship between precipitation above tree crowns (PG) and precipitation at the height of 1m above the surface (PD) may be described by a following equation:

$$PD = PG + a \cdot \exp(b \cdot PG) \quad (1)$$

In the equation above (1) constants $a$ and $b$ are obtained in the estimation/calibration process. The results of such estimation using CurveExpert 1.4 package were presented in Figure 4. It was computed that $b = -0.01$ and $a = -3.26$. It follows that the volume of so called interception reservoir for the discussed sixty-year-old pine stand may be estimated for slightly over 3 mm (3.26).

Monthly PG and PD precipitation totals were compiled in Table 1. For the winter half year monthly PG and PD totals are similar, whereas half-year PG and PD totals are almost identical i.e. 180.0 mm each.

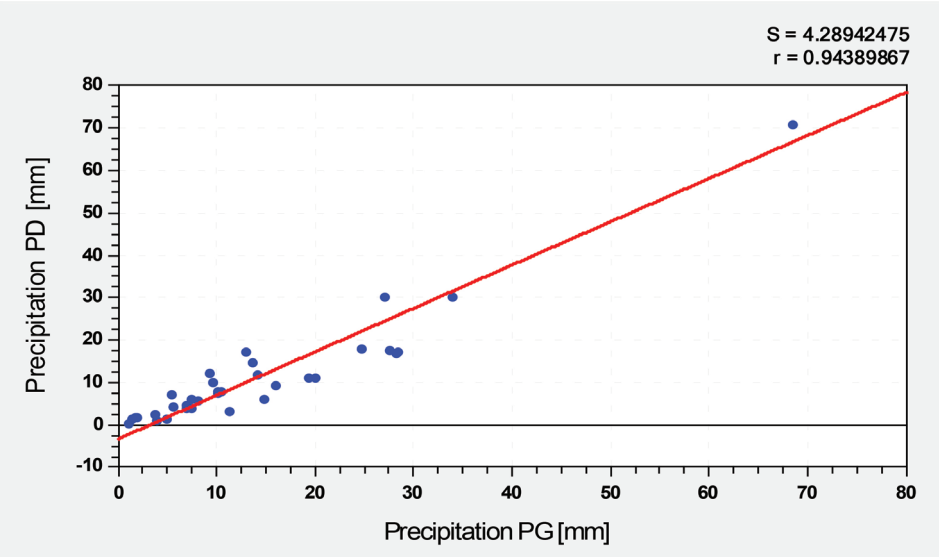


**Figure 4.** Estimated equation PD = f(PG)
$PD = PG - 3.26 \cdot \exp(-0.01 \cdot PG)$

On the other hand, for the summer half-year the differences in monthly and half year totals are apparent. Precipitation total in the summer half-year over tree crowns (PG) was 304.3 mm and rainfall at the height of 1m above the surface 209.3 mm.

**Table 1.** Monthly precipitation above the forest canopy (PG) and monthly precipitation at the height of 1 meter above the surface (PD)

| Months | PG [mm] | PD [mm] |
|---|---|---|
| January | 21.3 | 23.0 |
| February | 3.4 | 2.4 |
| March | 24.7 | 29.6 |
| April | 47.4 | 37.9 |
| May | 50.4 | 37.2 |
| June | 66.5 | 40.2 |
| July | 39.7 | 14.7 |
| August | 83.1 | 49.0 |
| September | 37.4 | 37.9 |
| October | 27.2 | 30.3 |
| November | 9.1 | 8.2 |
| December | 74.1 | 79.0 |
| Jan-Dec | 484.3 | 389.3 |

## SUMMARY AND CONCLUSIONS

Conducted analyses allowed to formulate the following conclusions:

1. The temporary interception for the analysed sixty-year-old pine stand may reach about seven millimeters.
2. Daily difference between precipitation over the canopy and precipitation at the height of 1 above the surface may reach twelve millimeters.
3. Computed volume or so called interception reservoir was about three millimeters (3.26mm).
4. Annual value of interception for the analysed stand constitutes 19.6% of the annual precipitation total.

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Received: 02.01.2015
Accepted: 14.05.2015