Contribution of cowberry transpiration to evapotranspiration in larch forest

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Abstract

To demonstrate the contribution of cowberry transpiration to evapotranspiration in eastern Siberia larch forests, cowberry transpiration rate was measured from May to September 2004. Just after larch leaf developed, cowberry transpiration rate came considerably down, in spite of relatively high temperature and VPD. These results suggest that it may be caused by competition of water with larch. Thus, it is supposed that cowberry transpiration rate depends on phenology of larch. And we found that the latent heat by transpiration of cowberry occupied nearly 100% in the early stage of leaf development of larch, and 35 to 60% during the growing season, by analyzing the seasonal variation of latent heat flux. These results indicate that cowberry plays a very important role in water cycles in larch forest, and the effects for water cycles may be most conspicuous before growing season of larch.

Keyword: cowberry, transpiration, evapotranspiration, phenology of larch

1. Introduction

Forests in Eastern Siberia are dominated by deciduous conifer tree, Larch (*Larix cajanderi*), known as light taiga. In mature larch forest, the overstory is so sparse that the forest floor is covered with cowberry (*Vaccinium vitis*-idaea) due to its light environment. From many studies, it was found that understory vegetation, covering forest floor, have various effects on forest ecosystems. Some studies reported that understory vegetation affect soil characteristics, and growth and physiology of overstory such as root biomass, transpiration rate, and net primary production (Sanada et al., 1996, Robert et al., 2003, Busse et al., 1996, Kelliher and Black., 1986, Kari et al., 2003). Moreover, Kelliher and Black (1986) and Miller et al. (1998) reported that understory evapotranspiration is considerable, especially when trees are spaced with little understory shading. Therefore, it is very important to understand the role of understory vegetation in various substance cycles in a forest ecosystem. Recently, an interest in energy and water cycles in Siberian boreal forests has been growing, and many studies on these subjects have been conducted. Hamada et al. (2004) reported that the contribution of understory to entire evapotranspiration of larch forest was quite significant and was estimated 25% to 50%. Since cowberry is evergreen species, it is supposed that cowberry transpiration plays an important role in water cycle in larch forest. However, field observation data on the role of cowberry in larch forest have been little. The purpose of this study is to quantify the contribution of cowberry transpiration to larch forest evapotranspiration, and to reveal its seasonal contribution.

2. Study site and Methods

Study site was a larch forest at Spasskaya Pad (62 ° 14'29"N, 129 ° 39'2" E), located about 20km north of Yakutsk in eastern Siberia. The stand density is 840 trees ha^{-1}, and the mean annual temperature and the annual precipitation are－10.2℃ and 188mm, respectively.

We measured transpiration rate of cowberry using an infrared gas analyzer, LI-6400. Three plots (1m×1m) were chosen in a larch forest, and 4 shoots of cowberry from each plot were used for measurement. To obtain LAI (Leaf Area Index) of cowberry, all of shoots in five small plots (0.1m× 0.1m) were cut and the total leaf area were measured by scanning. The transpiration rate per unit area was calculated using LAI, and was converted to latent heat flux. Soil moisture at 10cm depth was monitored using TDR. The measurements were conducted from May (early stage of leaf development of larch) to September (early stage of leaf-fall of larch) in 2004. Temperature and relative humidity in each measurement day were measured at a flux tower, located about 300m east of the measurement plot of cowberry transpiration. The relative humidity was converted to vapor pressure deficit (VPD).

3. Results and Discussion

Figure 1 shows diurnal variation of cowberry transpiration rate of all observation days in 2004. Cowberry transpiration rate tended to reach a peak at 11 a.m. or 13 p.m. The seasonal change of cowberry transpiration rate at 11 a.m. and 13 p.m. during the observation period are shown in Fig.2. It showed a two-peak shaped variation, and on June 13, the transpiration rate came considerably down. In plant physiology, it is well known that transpiration rate is controlled by various environmental factors such as air temperature, VPD, or soil moisture, so on. These environmental factors during the observation period are showed in Fig.3. Temperature and VPD had highest values on July 2 and soil moisture showed the lowest values in the same day. These environmental factors could not explain the two-peak shaped transpiration rate of cowberry.

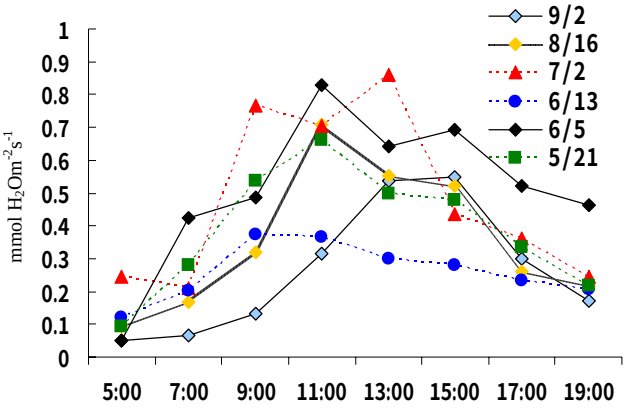

Fig. 1 Diurnal variation of cowberry transpiration rate per leaf area.

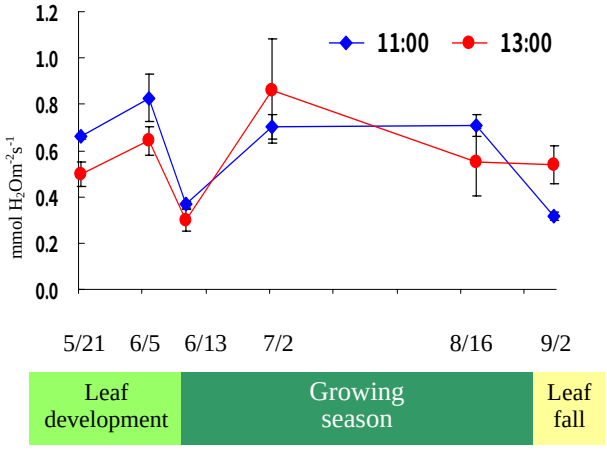

Fig. 2 Seasonal variation of cowberry transpiration rate at 11:00 a.m. and 13:00 p.m.

On the other hand, from a viewpoint of larch phenology, the date of snow disappearance was May 10, and leaf development of larch started from middle of May and ended on middle of June. Therefore, the day of the lowest cowberry transpiration (6/13) corresponded to the end of

leaf development. From these results, it is supposed that the decrease of transpiration rate on June 13 could be attributed to the competition of water uptake with larch, because the water uptake by larch may be vigorous at immediately after leaf development. That is, seasonal variation of cowberry transpiration rate may depend on the phenology of larch.

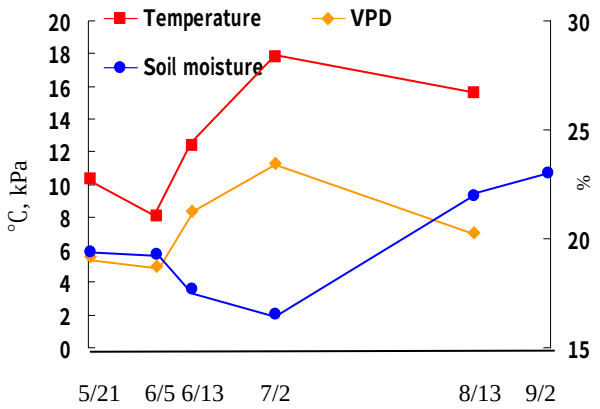

Fig. 3 Air temperature, vapor pressure deficit and surface soil moisture (10cm depth) at 11 a.m. in each measurement day of cowberry transpiration rate.

To make clear the contribution of cowberry transpiration to evapotranspiration, the latent heat flux by cowberry was calculated using transpiration rate. The LAI of cowberry is estimated at 2.1. Figure 4 shows percentages of cowberry latent heat flux in the canopy flux in forest with each flux. Latent heat flux by cowberry accounted from 35% to 100% in entire forest values. Especially before the larch leaf development, almost all of latent heat flux was attributed to the cowberry transpiration. And even on July 2, when the cowberry transpiration rate showed maximum value, 60% of latent heat flux was derived from cowberry. Percentage of latent heat flux by cowberry to entire one decreased from May to September, except for the value of June 5. This means that contribution of cowberry transpiration to evapotranspiration is more important before growing season than during growing season of larch.

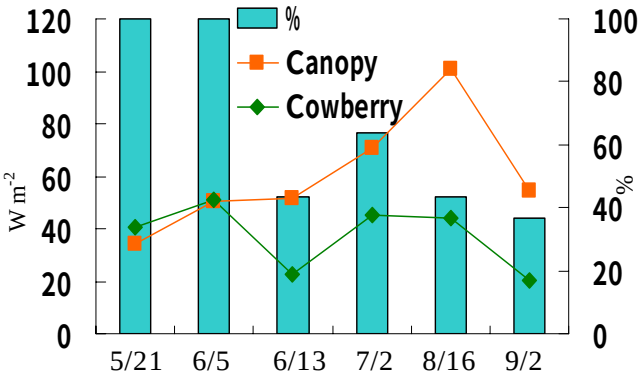

Fig. 4 Percentage of latent heat flux by transpiration of cowberry to entire latent heat flux at 11 a.m. and each flux.

4. Conclusion

It is suggested that cowberry transpiration rate depends on the phenology of larch, since it decreased significantly at immediately after leaf development of larch. Contribution of cowberry transpiration to evapotranspiration occupied nearly 100% in the early stage of leaf development of larch, and even during the growing season, it showed 35 to 60%. Therefore, it is demonstrated that cowberry plays a very important role in water cycle in larch forests, and the effects may be most conspicuous before growing season of larch.

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