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Letter to the Editor
Reply to Comment by Yoo and Kim on "Woody Tissue Respiration in Stems of Red Pine (*Pinus densiflora*) Trees"

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편집장 통신
"소나무 (*Pinus densiflora*) 줄기의 목부조직 호흡" 논문에 대한 의견 (유재일, 김 준)의 답변

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We would like to express our gratitude to Yoo and Kim (2008) for their interest and favorable comments on our study of woody tissue respiration (Kim *et al*., 2007).

The aims of our study were to inform that the stem respiration is an important component of the carbon cycle in the forest ecosystem, and to find the differences between the stem respiration rates on winter and summer. Stem respiration varies according to tree species, annual mean temperature, leaf area index, stand age, and latitude (Kim *et al*., 2007). However, few studies have dealt with the stem respiration in forest ecosystem in the world, especially in South Korea.

Yoo and Kim (2008) gave comments on five matters to our paper: the using of the term 'total respiration' in abstract, representativeness of the sampled data, evaluation of Q_{10} by regression analysis, calculation of stem respiration, and conversion of units between area and volume basis. We will reply to their comments in order.

Firstly, we should admit that there was an error in our original paper (Kim *et al*., 2007). The sentence 'the woody tissue respiration in stems of red pine trees during the summer season amounted about 50% of the total respiration rates' means that 'if the respiration rates measured during the winter are only maintenance respiration rates, growth respiration rates during the summer season will reach to approximately 50% of the total respiration rates (sum of maintenance and growth respiration rates)'.

Secondly, we are in accordance with their suggestion that more data are needed to ensure the representativeness of the dataset, especially dataset for the summer period. We reduced the number of collected data for the rainy days (precipitation was 3 mm and 12 mm at 29 and 30 June, respectively) to compare two periods of clear days. However, the analysis including the data obtained during the rainy days was similar to the previous result (Fig. 1).

Thirdly, It is also acceptable that more dataset (measured during spring and fall periods) is necessary for the accurate analysis of the data. However, we believe that it will be useful to explain the difference in the responses of CO_2 efflux from stem segment to temperature change in the winter and summer, the one of our aims. If our dataset was expressed by one regression line suggested by Yoo and Kim, the result would be

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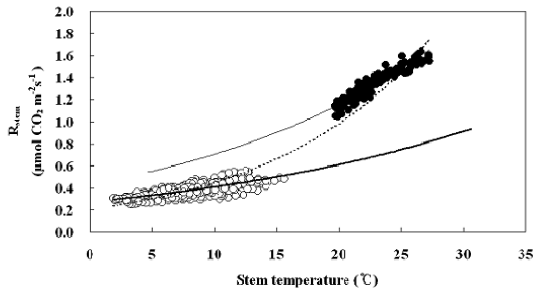

Fig. 1. Comparison of the relationships between hourly mean stem temperature and woody tissue respiration rate (R_{stem}) in summer (●) and winter (○). Dotted line represents the regression line induced by total dataset of summer and winter. Estimated regression equations are y=0.4298exp (0.0495x) for summer, y=0.2741exp (0.0401x) for winter, and y=0.203exp(0.0788x) for whole dataset.

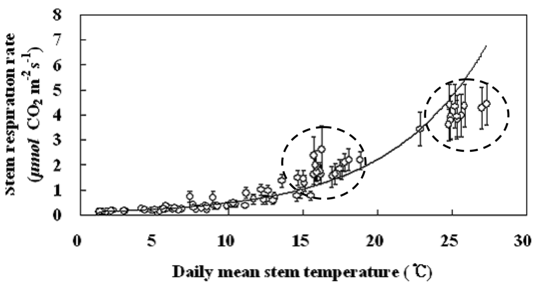

Fig. 2. Relationship between the daily mean stem temperature and stem respiration rates. Adapted from Kim *et al.* (2006).

overestimated at nearly 15°C and over 25°C stem temperature, and underestimated at nearly 20°C stem temperature (Fig. 1). On our other paper (Kim *et al.*, 2006) based on the whole year's measurements for black locust trees, there were an underestimation and an overestimation at the growing season (Fig. 2). Also, most of studies indicated that respiration could be subdivided into two components, growth respiration and maintenance respiration (Ryan *et al.*, 1994; Damesin *et al.*, 2002; Kim and Nakane, 2002; Zha *et al.*, 2004). Above all, Damesin *et al.* (2002) and Zha *et al.* (2004) reported that stem respiration rates at 15°C temperature were higher in the growing season (spring and summer) than in the non-growing season (winter), although the annual Q_{10} remained relatively constant. Kinerson (1975) for loblolly pine reported that there were different relationships between CO_2 efflux on stem and temperature before and after initiation of cambial activity. Although it might not be appropriate to say that our datasets are complete, we believe that they are providing useful information for understanding the characteristics of stem respiration rate. According to our results, I suggest that the datasets either measured throughout an entire year commented by Yoo and Kim, or measured at least the two periods (dormant and growing seasons) should be needed for estimating stem respiration at stand level.

Fourthly, a transport of CO_2 dissolved in the transpiration stream was mentioned firstly by Negisi (1972). McGuire and Teskey (2004) calculated quantitatively the stem respiration rate based on the mass balance approach. Their approach to quantify both internal and external fluxes of CO_2 in stem has improved our understanding of the actual rate of stem respiration. On our and many of studies, respiration rates of woody tissues have been commonly estimated from the CO_2 efflux of that tissue. However, researchers should calculate stem respiration rate considered about the transport of CO_2 by sap flow based on the mass balance approach from now on. On the other hand, it is important to look for the method scaling-up the measurements at a special position to stand level, because the final purpose to measure stem respiration is to estimate total CO_2 efflux from stem at the stand level. In that meaning, the approach method by the relationships between diameter (or height) and respiration rates is also useful and important to estimate and understand stem respiration at the stand level. On our previous study (Kim *et al.*, 2007), we think that even the absolute values (meaning of actual stem respiration) is incorrect, but the relative comparison of the values collected on winter and summer does not cause problems, because we measured CO_2 effluxes at the same height as 15 trees reached at canopy and in summer and winter by the same tree.

Finally, we agree with their comment for the conversion of units between area and volume basis. In many woods, heartwood can be readily distinguished from sapwood by heartwood's darker color. We have tried to differentiate the heartwood and the sapwood, because many authors had emphasized the usefulness of sapwood volume to predict woody respiration rate (Lavigne *et al.*, 1996; Ryan, 1990; Ryan *et al.*, 1994). But there was very little color difference between the heartwood and the sapwood in the Japanese red pine trees. The basis for calculating stem respiration is good for using the living cell, directly taking part in respiration. The matter is a skill of distinction of living cells from whole stem tissues. The relative distribution of living cells within stems depends on tree species and size. In a case of narrow sapwood, stem surface is a good basis for estimating CO_2 efflux from stem segments. Therefore, some authors suggested the surface to basis (Negisi, 1972, 1975; Kinerson, 1975; Linder and Troeng, 1981; Hagihara and Hozumi, 1981; Ryan *et al*. 1997; Meir and Grace, 2002), and other authors suggested the volume (total volume or sapwood volume) to basis (Edwards and Hanson, 1996; Carey *et al*., 1997; McGuire and Teskey, 2004). It is important to know the characteristics of sample trees before estimating stem respiration.

We would like to thank Yoo and Kim for their comments, and also wants to supply good information to other researchers, who are interested in stem respiration.

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