THE ROLE OF PHOSPHORYLATION IN PHYTOCHROME-MEDIATED SIGNAL TRANSDUCTION

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Introduction

Phytochromes are molecular light switches that regulate many aspects of plant growth and development, including seed germination, leaf and stem growth, chlorophyll synthesis, shade avoidance, and flowering (Kendrick and Kronenberg, 1994; Quail et al., 1995; Smith, 2000). Phytochromes are dimeric chromoproteins with covalently linked tetrapyrrole chromophore phytochromobilin. They exist in two photo-interconvertible species, red-light absorbing Pr and far-red-light absorbing Pfr forms. The Pfr form is considered the active form of phytochrome because of the promotive effect of red-light on most physiological responses (Kendrick and Kronenberg, 1994; Quail et al., 1995).

Phytochromes are known as phosphoproteins for a long time, since it could be labeled with ^{32}P isotope *in vivo* (Quail et al., 1978). The sites of phytochrome phosphorylation *in vivo* and *in vitro* have been investigated with oat phytochrome A (phyA) (Lapko et al., 1996, 1997, 1999). There are two *in vivo* phosphorylation sites - Ser7 and Ser 598, and two *in vitro* phosphorylation sites - Ser17 and Ser598. Phosphorylation at Ser7 in the N-terminal extension is similar in both Pr and Pfr forms, whereas Ser598 in the hinge region is phosphorylated in a Pfr-preferential manner (Lapko et al., 1999). Ser17 is phosphorylated *in vitro* primarily in a Pr-preferential manner, whereas *in vitro* Ser598 phosphorylation is preferred in the Pfr form (McMichael and Lagarias, 1990; Lapko et al., 1996; Watson, 2000). Fig. 1 summarizes the current status of oat phyA phosphorylation.

Although phytochromes have been studied intensively by a broad range of experimental approaches since their first discovery in 1965, there is no clear and unified picture about how phytochromes transduce a light signal into physiological responses. A number of observations and indirect lines of evidence for the possible role of protein phosphorylation in the downstream of the phytochrome-mediated light signal transduction pathway have been discussed (Park et al., 2000, Watson, 2000; Neff et al., 2000; Kim et al., 2002b). However, the *in vivo* functional role of