Soybean Yield and Chemical Composition in Response to Phosphorus–Potassium Nutrition in Kashmir

M. Kaleem Abbasi,* Majid Mahmood Tahir, Waleed Azam, Zaheer Abbas, and Nasir Rahim

ABSTRACT
Soybean [Glycine max (L.) Merr.] has increasing nutritional, commercial, and economical value, and P and K nutrition may be needed to increase yield and profit. A 2-yr (2008–2009) field experiment with rainfed soybean was conducted in the hilly region of the state of Azad Jammu and Kashmir (AJK), at Rawalakot, Pakistan. The aim of the study was to evaluate the effects of P–K fertilization on soybean root nodulation, seed yield, seed composition and N, P, and K uptake. The experiment was conducted in a randomized complete block design with three replications. Treatments included three levels of P (60, 90, and 120 kg P₂O₅ ha⁻¹), two levels of K (40 and 80 kg K₂O ha⁻¹), and a control, represented as P₀P₆₀, P₉₀, P₁₂₀, K₀, K₄₀, and K₈₀, respectively. Results indicated that number of root nodules increased with P–K fertilization to 75 and 136 compared with 68 in the control. Yield responses to P–K fertilization occurred to all rates, and the highest yield was observed in the combined treatment of P₁₂₀K₄₀. Total N, P, and K uptake in the plant (shoot + seed) tended to follow yield responses, while seed protein was increased by 8 to 13% due to P and 11 to 19% due to K. Application of P or K alone or in combination significantly increased oil content. This study demonstrates that P- and K-deficient soils are likely to produce crops with low yields and low seed oil levels, and appropriate P–K management could be an effective approach to increase and sustain soybean production in the mountain ecosystems.

Soybean is an important oilseed crop and source of high-quality protein for human consumption and fodder for animals and is also important in crop rotation systems. When grown in symbiotic association with Bradyrhizobium japonicum, soybean plants can fix up to 200 kg N ha⁻¹ yr⁻¹ (Smith and Hume, 1987). The composition of soybean, as well as the case and geographical range of its agricultural production, makes it an inexpensive source of oil and protein used as food and animal feed. Soybean production and yield in any agricultural system is directly affected by several environmental factors. Among these, fertilization with N, P, K, and other essential nutrients can affect yield and many physiological processes that, in turn, influence grain yield and protein or oil concentration (Adeli et al., 2005).

Phosphorus is an essential macronutrient that can limit normal plant growth if not provided by the soil or by appropriate quantities of fertilizer (Chaudhary et al., 2008). The role of P in legume development, root proliferation, nodulation, and biological N₂ fixation is well recognized (Singh et al., 2005; Schulze et al., 2006). Phosphorus deficiency in legumes reduces leaf area; decreases the number of leaves, nodes, and branches; and slows down the relative leaf appearance rate (Chaudhary et al., 2008). Phosphorus-deficient plants exhibit a reduced carbohydrate supply to nodules and are usually restricted in nodule initiation, development, and growth and in nitrogenase activity (Schulze et al., 2006).

Soybean response to P fertilization has been reported in different agroecological regions of the world (Borges and Mallarino, 2000; Buah et al., 2000; Haq and Mallarino, 2005; Fatima et al., 2007; Mabapa et al., 2010). Application of P to soybean has been noted to affect the functioning of the biological N₂ fixation system, with an enhancement in the specific nitrogenase activity of the nodule (Sa and Israel, 1991). It has also been observed that soybean response to P is dependent on soil available P, and P application is not likely to increase seed yield at soil P concentrations above 12 mg kg⁻¹ (Ferguson et al., 2006). Tsvetkova and Georgiev (2003) reported that P deficiency treatments in soybean decreased the whole-plant fresh and dry mass and the nodule weight, number, and functioning. Chizey and Onduze (2009) conducted a field experiment with soybean by applying 0, 13.2, 26.4, and 39.6 kg P ha⁻¹ in the northern guinea savanna zone of Nigeria and reported that P application increased the leaf area index, plant height, nodule dry weight, total dry matter, and grain yield.

Soybean has been found to respond to K application at various rates under a number of management regimes under different agro-climatic situations (Kolar and Grewal, 1994; Premaratne and Oertli, 1994; Yin and Vyn, 2004; Haq and Mallarino, 2005). Soybean takes up and accumulates K throughout the growing season, thus a deficiency of K at any time during the growing season may reduce soybean yield (Kolar and Grewal, 1994). Furthermore, a typical soybean crop requires 73% more K in the harvested grain than maize (Zea mays L.) (Fernández et al., 2008). It has been shown that soybean acquires most of

Abbreviations: AJK, Azad Jammu and Kashmir.