Phosphorus fertigation of trickle-irrigated potato

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Abstract
A 3-year field study, on Pellic Vertisol, investigated the response of trickle-irrigated potato (Solanum tuberosum L.) to four P levels applied with the irrigation water. Waters supplied with 130 and 120 mg l\(^{-1}\) of N and K, respectively, and with P levels of 0, 20, 40 and 60 mg l\(^{-1}\), were applied when the soil water potential was between 0.03 and 0.04 MPa. The water applied at each irrigation was equivalent to 0.8 of pan evaporation from a screened USWB Class A pan. With the application of 40 mg P l\(^{-1}\) no P accumulation deeper in the soil profile occurred, whereas P in petioles was at levels recommended for high yield of good quality. At this P concentration in irrigation water, removal of P from soil by tubers was 22 kg/ha/year. The highest yield of good quality was obtained at 40 mg P l\(^{-1}\).

Introduction
High-frequency phosphorus fertigation may increase substantially the time-averaged P concentration in the soil solution above that expected from P solubility considerations (Bar-Yosef et al., 1989). This can be achieved with frequent irrigation and fertilization, thus minimizing the use of the soil as a storage reservoir for water and nutrients (Phene and Beale, 1976; Papadopoulos, 1988). Combined irrigation and fertilization (fertigation) is ideal for this purpose (Phene et al., 1979), particularly under calcareous conditions. In this way the fertilizer is placed in the soil volume in which roots are most active (Bar-Yosef and Sheikhoslimi, 1976; Papadopoulos 1985; Phene and Beale, 1976; Phene and Sanders, 1976). Trickle (drip) irrigation, enables flexibility in fertilizer application and is ideally suited for fertigation. It has been reported that N fertigation with trickle irrigation is a promising means for high potato yield of good quality, maintaining N during the growth period at proper concentration, without excess or undue losses by leaching (Papadopoulos, 1988). Little is known, however, about the concentration of P in the irrigation water to sustain a required uptake rate by potatoes, since P concentration in the soil solution under trickle irrigation, particularly at the presence of high CaCO\(_3\), must exceed the concentrations under other irrigation techniques to compensate for the reduced root weight per plant (Bar-Yosef et al., 1989). Such conditions can be achieved by frequent P application via the irrigation stream.

The objective of this paper is to evaluate the influence of four P concentrations applied with every irrigation through the irrigation stream on potato yield and quality. This information should help to promote more efficient use of P fertilizer and to improve potato yield and quality.

Materials and methods
Field studies were conducted for three consecutive years from 1987 to 1989, on a Pellic Vertisol (26% sand, 32% slit, 42% clay, 55% CaCO\(_3\)).
At the beginning of the experiment the surface 45 cm of soil had a pH of 8.2. The initial mean values of soil extractable-P (P-Olsen) in 15-cm increments to a depth of 90 cm is given in Figure 1.

Potatoes (var. spunta) were planted on 2 February 1987, 8 February 1988, and 6 February 1989. At planting no fertilizers were applied to the soil. The fertilizer treatments started with the second irrigation.

Treatments, consisting of four P concentrations (0, 20, 40 and 60 mg P L⁻¹) in the irrigation water, were obtained by injecting appropriate volumes of phosphoric acid into the irrigation water during the growth period. Nitrogen and potassium were uniformly supplied to all treatments through the irrigation water at 130 and 120 mg L⁻¹, respectively. The experimental design was Randomized Complete Block, replicated eight times. Plots were 3 m wide and 10 m long, and each plot contained five rows, of which the center three rows were used for data collection.

The irrigation/fertigation consisted of two injectors, four main lines of plastic tubing, in which the four P rates were injected, and five lateral lines in each plot (Papadopoulos and Eliades, 1987; Papadopoulos, 1988). The drippers were spaced on laterals at 0.4 m. One fertilizer injector served for supplying all treatments with uniform concentration of N and K. To produce the P levels, phosphoric acid was injected by the second injector in ratio of 1:2:3, in the irrigation stream of P₁, P₂, and P₃ treatments, respectively. In Po no P was injected. All treatments were irrigated simultaneously.

Three sets of tensiometers were installed at a 15 and 30 cm soil depth beneath the dripper, the irrigation was done when the soil water potential, at the 15 cm depth, was between 0.03 and 0.04 MPa (0.1 MPa = 1 bar). The amount of water applied was 0.8 of Epan evaporation (United States Weather Bureau, Class A screened pan), which has been shown to be adequate for high yield (Phene and Sanders, 1976; Stylianou and Orphanos, 1981; Papadopoulos, 1988).

Potato leaves were sampled three times during

![Fig. 1. Residual soil extractable-P as influenced by concentration of P applied with every irrigation through the irrigation stream.](image-url)