Introduction

The potato crop requires substantial amounts of N, P, and K fertilizers for optimum yield and quality. Especially, most if not all, phosphate is tightly bound to inorganic or organic components of soils. Thus, the low root density of potato plants makes mobilization and aquisition of phosphate a key factor in potato plant growth. Altenatively, soil moisture stress may also limit P uptake by the plants (MacKay et al., 1988). Crop rotations serve multiple functions and provide numerous benefits to crop production through conserving or replenishing soil resources such as organic matter (Kaiser et al., 2007). Crop rotations can also alter soil chemical, physical, and biological properties (including P dynamics and availability). However, this is not as well-documented for potato and other specialty crop systems as it is for grain production systems. In this work, we evaluated soil test P and sequentially-extracted P in 10 potato fields which had subjected to three-year crop rotations with and without irrigation.

Materials and Methods

Field studies were established in 2004 and soils samples under both irrigated and rain-fed management with 5 replications were collected in May 2007 after three-year crop rotations. Rotation systems were designed and managed as (1) continuous potato (PP), a non-rotation control; (2) potato(Yr 1)-barley(Yr 2) -potato(Yr 3) (a 2-yr rotation typical for potato growers, BP); (3) disease suppressive (DS), mustard green manure (Yr 1) – sudangrass green manure (Yr 2) followed by winter rye – potato (Yr 3); (4) soil conserving (SC), barley underseeded with timothy (Yr 1) – timothy sod (Yr 2) – Potato (Yr 3) with mulch after harvest; and (5) soil improving (SI), same as SC, with compost added to each crop. For Olsen P content, soils (1.0 g) were extracted by 25 mL of 0.5 M $NaHCO_3$ (pH 8.5) for 30 min. Sequentially-extracted P fractionation was performed according to a procedure in a previous report (He et al., 2008). Soluble inorganic P (P_i) in these extracts was determined by a modified molybdate blue method (He and Honeycutt, 2005) and total P was determined with an ICP-AES (Plasma 400 Emission Spectrophotometer, Perkin-Elmer, Norwalk, CT). Organic P (P_o) was calculated as the difference between total P and inorganic P.

Results and Discussion

The maximum Olsen extractable P_i was 121.7 mg kg^{-1} soil in the PP field, and the minimum was 103.4 mg kg^{-1} soil in the SC field (Fig. 1). Therefore, the difference in Olsen P_i was small between soils from different rotation systems. The average of Olsen P_i in the five rainfed fields was 114.4 mg kg^{-1} soil with the standrad error of 2.9. Compared to data of the rainfed fields, irrgation reduced the Olsen P_i level in the potato fields as the average of Olsen P_i in the irrgated fields was 104.9 mg kg^{-1} soil with the standrad error of 3.0. However, the statistical significane was not very high as the difference was observed only at P=0.11. There was no obvious differeince in the Olsen-P levels of these samples measured by the molydenate blue method or the ICP-AES (data not shown), indicating there was not much Olsen-extractable P_o in these potaoto fields. Thus, based on theses data, we concluded that the current 3-year crop rotations and irrgation did not alter the P avaialbilty in the potato fields significantly whereas the longer term impacts remain to be evalauted further.

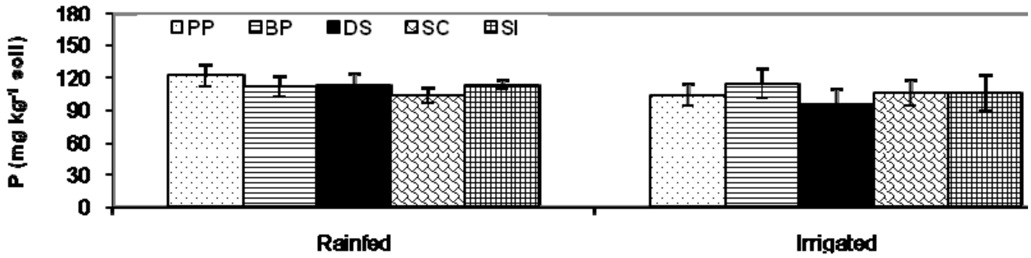

Fig. 1. Olsen P in rainfed and irrigated potato fields with different cropping managements.

The level of H_2O extrable P_i was lower than that of Olsen P_i (Fig. 2) since water is a weaker extractant than $NaHCO_3$. Crop rotations with DS, SC, and SI increased the level of H_2O extrable P_i. Irrigation increased H_2O extrable P_i in the PP field. The distribition of pattern of H_2O extrable P_o was somewhat like to that of H_2O extrable P_i, but at smaller scale.

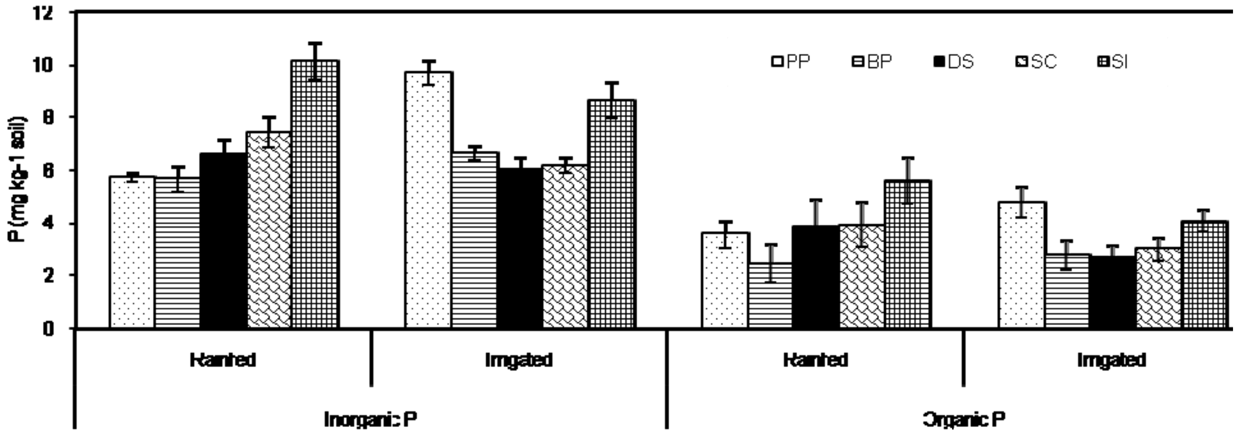

Fig. 2. Water extractable P in rainfed and irrigated potato fields with five cropping managements.

The average of P_i in the sequentially-extracted $NaHCO_3$ fraction was 176.2 ± 4.5 mg kg^{-1} for the five rainfed fields and 153.2 ± 4.8 mg kg^{-1} for the five irrgated field samples (Fig. 3). Thus, the level of P_i in the sequentially-extracted $NaHCO_3$ fractions from either rainfed or irrigated fields was greater than the level of corresponding Olsen P_i which was also extracted with $NaHCO_3$. In addition, around 80 mg P_o kg^{-1} soil was also extracted into the $NaHCO_3$ fractions of all 10 soil samples from both rainfed or irrigated fields. The longer extraction (16 h) or a prior water extraction used in the sequentail fractionation could be the reason for more P extracted in the sequential $NaHCO_3$ fractionation shceme. Except the unchangd P_i level of the SI fields, irrigation reduced the P_i level of samples from four other cropping systems. Obviously, with more P extracted, the impacts of irrigation on $NaHCO_3$ extractable P_i become more obversable as the two sets of data were signifcantly different at $P<0.001$.

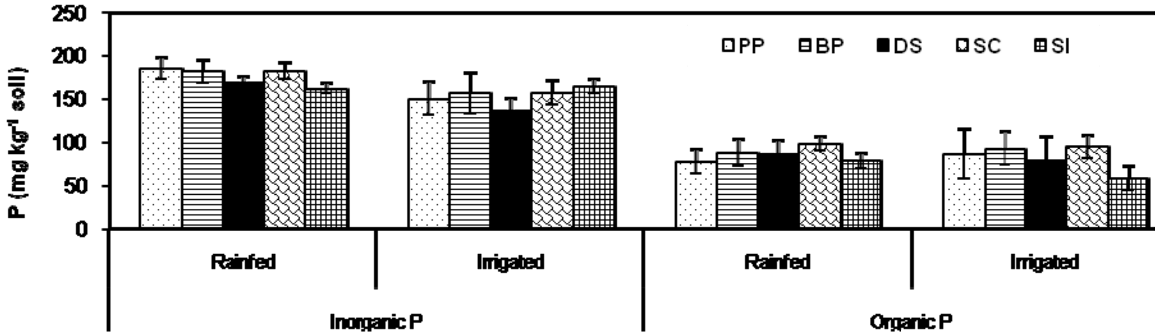

Fig. 3. $NaHCO_3$ extractable P in rainfed and irrigated potato fields ith five cropping managements.

Among the four sequential extractants, NaOH extracted most P from the soil samples (Fig. 4). The average of P_i in the NaOH fractions was 770.7± 21.6 mg kg^{-1} soil for the five rainfed samples, and 572.0 ± 10.7 mg kg^{-1} soil for the five irrgated field samples. The average of P_o in the NaOH fractions was 290.3± 14.6 mg kg^{-1} soil for the five rainfed, and 350.4 ± 14.5mg kg^{-1} for the five irrgated field samples. Crop rotation did not make signifcant changes in either P_i and P_o in the NaOH fractions. However, the signifcance of the changes due ot irrgation was at P=0.000035 for P_i and 0.019 for P_o. It should be noted that irrigation decreased P_i , but increased P_o of NaOH fractions.

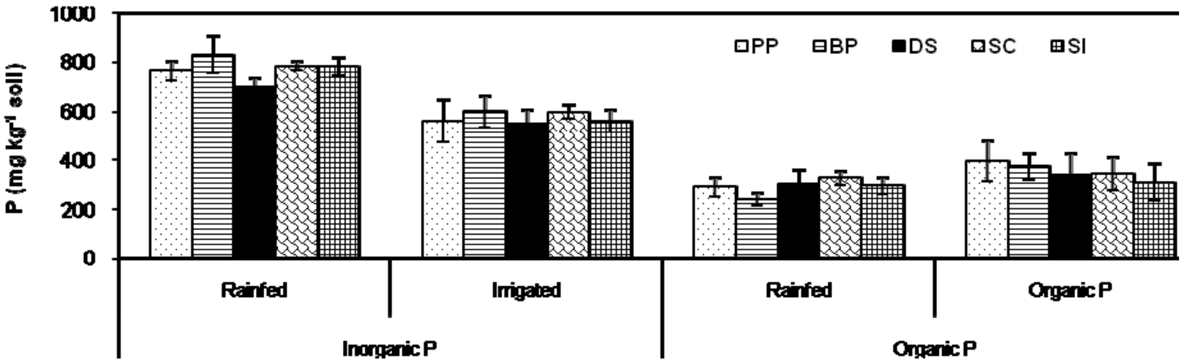

Fig. 4. NaOH extractable P in rainfed and irrigated potato fields with five cropping managements.

There was only P_i detected in the HCl fraction (data not shown). The average of P_i in the HCl fractions was 177.5± 3.6 mg kg^{-1} soil for the five rainfed samples, and 233.1 ± 5.9 mg kg^{-1} soil for the five irrgated field samples. Although crop roration did not impact the P_i level in the HCl fraction, irrigation increased did (P=0.000045). The combined increase of P_i in the HCl fractions and P_o in the NaOH fractions due to irrigation was 115.7 mg kg^{-1} soil, less than 198.7 mg P_i kg^{-1} soil or 58% which was the average reduced amount in the NaOH fractions by irrigation. In other words, another 42% of P_i in the NaOH fractions reduced by irrigation might have been mobilized and lost by either taken up by plants, runoff, or leached from the irrgated soils.

Conclusions

A 3-year crop rotation and irrigation treatment did not significantly change Olson soil test P in sandy loam potato fields. However, sequential fractionation of P in these soil samples revealed that the distribution of P in different labile pools had changed under these crop management practices. Crop rotation mainly increased water extractable inorganic P. Irrigation had a greater impact as it casued stable P pools in NaOH and HCl fractions inter-changed. A longer experiement is needed to comfirm whether the inter-change of P in different frations would eventually alter the soil test P levels in these potato fields.

References

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