SOIL AND WATER MANAGEMENT RESEARCH PROGRESS IN MAINE

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The results of a multi-year study of soil and water management in potato cropping systems are discussed. This work was supported by a grant from the Aroostook Water & Soil Management Board via U.S. Army Corps of Engineers funding and by several other grants obtained by University of Maine researchers. This project consists of two experiments examining the effects of levels of water availability on four potato variety tuber yields and quality, and the effects of soil amendment, crop rotation and supplemental water treatments on tuber yield and quality of a single variety. Experiment I consists of six moisture levels including rain-excluded; rainfall only; and reduced, moderate, frequent and excessive irrigation. Experiment II consists of three irrigation treatments (rainfall only, reduced and moderate) on four soil amendment (-/+) and crop rotation (oat/green manure) combinations. Our report focuses on the 1993 and 1994 responses of the potato crops to changes in moisture availability, whether by addition and moisture retention improvements, as well as nutrient availability, in the soils.

Background

The grant funding a large part of this project was originally prepared more than ten years ago. Its main objectives were to establish the feasibility of using irrigation in Maine for potato production, to demonstrate systems throughout the region, and to identify potential water resources for use in irrigation. When funds became available to the Water Board in 1991, an interdisciplinary team of researchers from the University of Maine submitted a proposal to investigate potential yield and quality improvements that might result from supplemental water application. Furthermore, a literature survey was proposed for use in systems modeling of irrigated potatoes. Finally, a study of methods of improving the availability of moisture through soil manipulation was planned; this was thought to be more accessible to all growers than irrigation systems. The first two parts of the research were initiated in 1992; the final study was started in 1993.

Responses in Crop Yield and Quality (Experiment I and II)

In one experiment, we examined the effects of drought stress and varying supplemental irrigation programs on growth and productivity of four potato varieties ('Superior', 'Atlantic', 'Shepody', and 'Russet Burbank'). During both growing seasons (1993 and 1994), "drought" imposed from mid-July to late August with "rain-out" shelters reduced plant biomass production, leaf growth, and tuber yields (yield reduction: 17% for 1993 and 25% for 1994). Yield loss in response to the "drought" was greater for 'Superior' and 'Russet Burbank' than for the other two varieties during 1993, while 'Russet Burbank' and 'Shepody' displayed the greatest yield loss during 1994. Supplemental irrigation very slightly increased yields during 1993 (6%, not statistically significant)

with few effects on tuber size or external quality. The 1994 growing season was drier than 1993 and consequently, supplement irrigation strongly and significantly increased tuber yields [85 cwt/A (28%), averaged over the four varieties]. 'Atlantic' and 'Superior' displayed more yield response to irrigation than 'Shepody' and 'Russet Burbank'. Tuber size was increased by irrigation during 1994, while specific gravity was decreased. Percent rot increased with increasing supplemental irrigation during both growing seasons. Growth and physiological measurements during 1994 confirmed the irrigation treatment's effectiveness at reducing plant water stress.

A second field study examined soil improvement with organic amendments and rotation crops as alternatives to supplemental irrigation for water management. During both growing seasons, early crop growth (cv. 'Superior') and late-season haulm vigor were strongly enhanced by the amendment treatment. Irrigation enhanced mid-season crop growth and late-season haulm vigor during 1994. U.S.#1 yields were increased by 29 cwt/A (15%) and 70 cwt/A (29%) by the soil amendment treatments for 1993 and 1994, respectively. Rotation crop did not affect yield, tuber size or quality during either growing season. Supplemental irrigation did not increase yields during 1993 but increased U.S.#1 yields by 83 cwt/A (36%) during 1994. Irrigation greatly reduced tuber specific gravity during 1994, while the soil amendment did not. Tuber size was enhanced by irrigation and by soil amendment use during 1994. During both growing seasons, supplemental irrigation and soil amendment treatments resulted in greater tuber rot incidence; however, the effect of irrigation was much greater than that of the soil amendment.

Responses in Soil Physical Properties (Experiment II).

Bulk Density. Organic matter addition did not significantly affect soil bulk density. For three sampling dates, bulk density for amended plots was the same or slightly lower than the unamended plots. It is possible that these density improvements are real, but may require a long time to evolve given the historically deficient organic matter levels. Furthermore, the amount of rock fragments may influence or mitigate the expression of treatment effects in this study. Similar results have been found in other on-farm studies.

Water Stable Aggregates The combined application of compost and manure within the irrigation/soil management experiment has resulted in significantly enhanced soil structure as measured by water stable aggregate content. Total water stable aggregate content of the soil increased from 34% to 40% (d.w. basis) after a single season of application. Soil samples collected after the second season of treatment application will be analyzed this winter. Results from similar studies conducted on Aroostook Farm over the past few years (potato compost study, potato ecosystem project) have also shown positive effects of the compost and manure treatments on water stable aggregate content. We believe that the increase in soil aggregation is due to enhanced soil organic matter content.

Infiltration. Steady-state (approximately) infiltration was measured using a double ring infiltrometer. In 1992, background (pre-potato production) infiltration rates were measured and found to be relatively low (0.012 to 0.039 cm/min). There were insufficient measurements to assess soil amendment treatment effects. In 1993, more tests were undertaken, but again no effects of soil amendment were evident; rates ranged from 0.076 to 0.8 cm/min for unamended soil and from 0.06 to 1.195 cm/min for amended soils. Data for 1994 have been collected and are being evaluated.

Moisture Retention Curves. Pressure extraction tests on disturbed soil samples (particles > 2 mm removed) were run for all plots (subtreatment, but not sub-subtreatment) in this study. Results of

these tests show that amended soils have greater gross moisture content at a given pressure, while rotation crops do not affect moisture holding capacity. There are no consistent increases in the curves' slopes showing there is no treatment effect on net available moisture. These results are consistent with other on-farm experiments (potato compost study, potato ecosystem project).

Soil Organic Matter. Although rotation crop treatments did not affect soil organic matter, the combined application of manure and compost within the irrigation/soil management experiment has resulted in significantly increased soil organic matter content within the soil (3.2% vs. 3.8%; Walkley-Black method). This dramatic increase occurred after a single season of treatment application. Soil samples collected after the second season of treatment application will be analyzed this winter. Results from similar studies conducted on Aroostook Farm over the past few years (potato compost study, potato ecosystem project) show that continued applications of the organic amendments will progressively increase soil organic matter content over time. The benefits and possible risks associated with these increased organic matter levels need to be examined in future studies.

Possible Future Studies. Much more remains to be understood about the potential benefits and/or risks of using compost for soil improvement. Studies of applied water vs. yield and quality improvements, which I believe have reached their logical conclusions, should be replaced with research focussing on pathogen/disease transmission via composted organic waste application, which has important long-term implications. Also, the permanence of soil amendment and rotation effects. must be evaluated so that the use of these practices may be optimized.