Study of Improving Yield Prediction and Sulfur Deficiency Detection Using Optical Sensors

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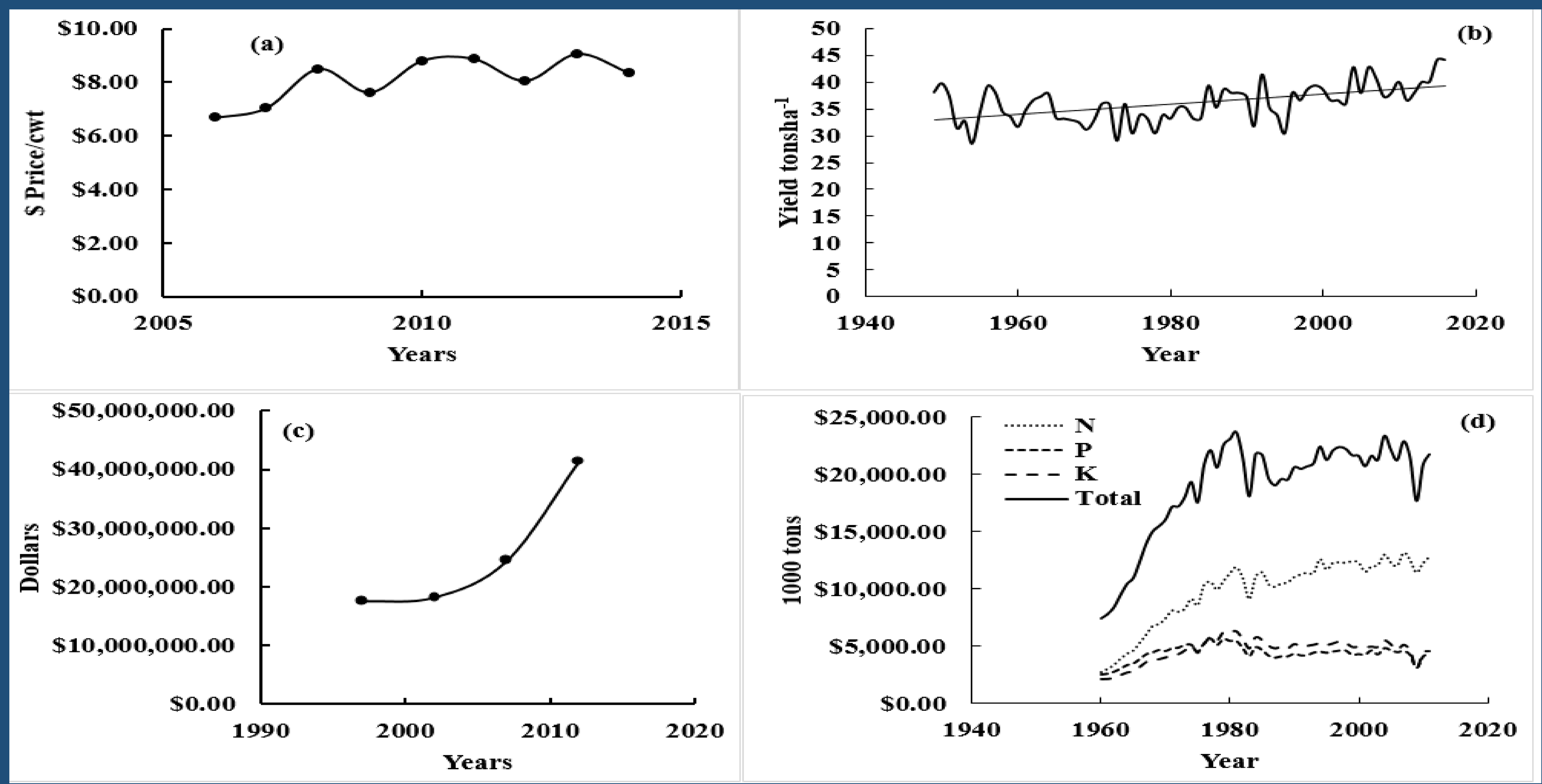

Potato price in United States over the years (a), Potato yield varies in the United States over the Years (b), Input Expense (c) Fertilizer use in potatoes in the United States over the years (d) source: USDA, National Agricultural Statistics Services

OBJECTIVES

1. Can GBAO sensors predict dry land potato yield?
2. Is there any difference in yield predicting abilities of two sensors under dryland potato cultivation?
3. Are N sources affecting sensors prediction models.
4. Does LAI help in improving yield and NDVI relationship in potatoes?
5. Could sensors detect S deficiencies in potatoes?
6. Is there any relationship between weather data and dry land potato yield in Maine conditions?

The two research sites used for this study in 2016 were; Aroostook Research Station (ARF), latitude and longitude as 46.668486, -68.013048, a S-deficient site (Table 1), and a farmer field in Easton (Easton site), latitude and longitude as 46.689560, -67.919864, under two soil types. The ARF was used to determine sensor ability to detect S deficiencies.

Trimble GreenSeeker® (TGS) and Holland Scientific Crop Circle™ ACS-430 (HCCACS-430) sensor were used for this study.

$$NDVI = (NIR - Red)/(NIR + Red) \quad \text{-----equation 1}$$

$$Red\ Edge\ NDVI = (NIR - Red\ Edge)/(NIR + Red\ Edge) \quad \text{-----equation 2}$$

RESULTS

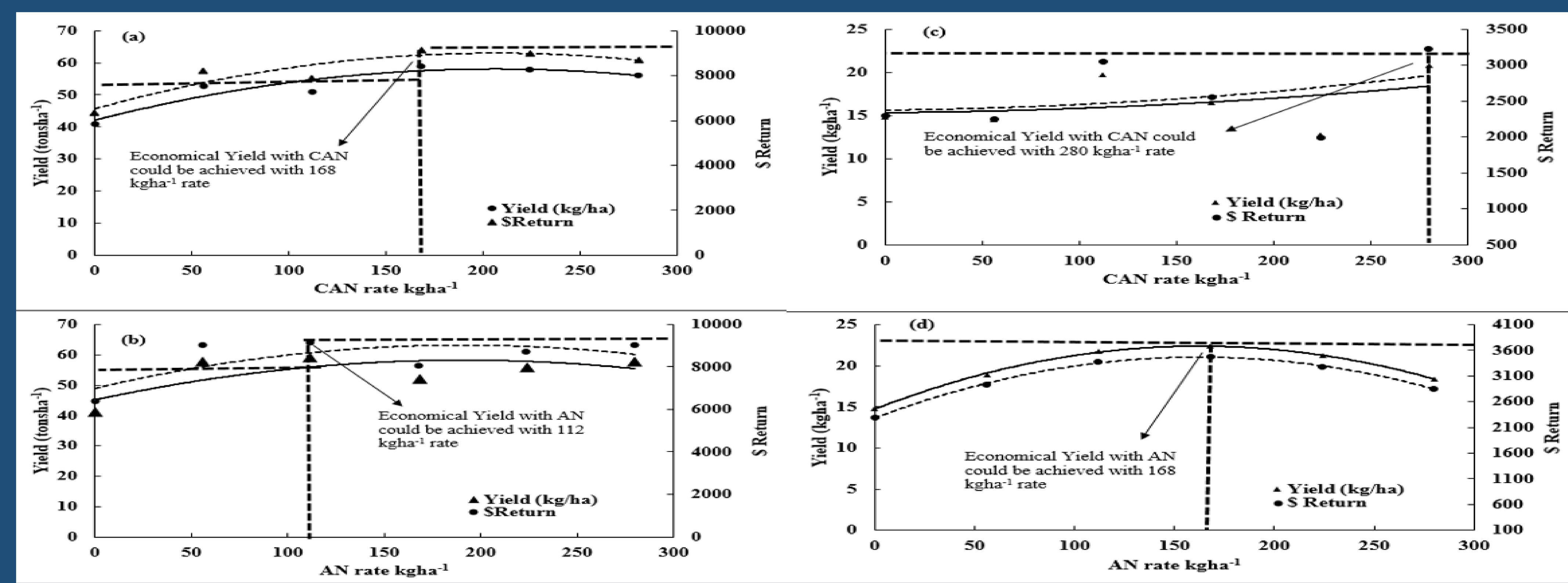

Figure 2: Representing MPY† response with CAN‡ and AN†† rates. On the secondary axis, dollar return represents the economic output with increasing yield. On the left side (a) and (b) figures are from Easton site. Right side (c) and (d) are from ARF site. † Marketable potato yield, ‡Calcium ammonium nitrate, ††Ammonium nitrate

Table 1 Regression analysis between MPY† and NDVI‡ from TGS†† and HCCACS-430‡‡ at Easton site. The coefficient of determination from the exponential relationship was used to measure the strength of the relationship between MPY and NDVI. Another relationship was developed using sensor PPLAI multiplied with sensor NDVI and then develop a relationship with MPY. The strength of PPLAI‡‡ and sensor readings was also determined using regression analysis.

N source	ST	WL	NDVI and Yield	(NDVI x LAI) and Yield	NDVI and LAI
CAN+AN	HCC	Red edge	$y = 13.377e^{5.1926x}$ $R^2 = 0.57$***	$y = 29.925e^{1.9611x}$ $R^2 = 0.58$***	$y = 22.741e^{0.7791x}$
	ACS-430	Red	$y = 10.941e^{1.9033x}$ $R^2 = 0.48$***	$y = 28.285e^{0.6897x}$ $R^2 = 0.58$***	$R^2 = 0.58$***
	TGS	Red	$y = 4.9323e^{2.6857x}$ $R^2 = 0.48$***	$y = 25.828e^{0.7424x}$ $R^2 = 0.60$***	
CAN	HCC	Red edge	$y = 243.9x - 11.495$ $R^2 = 0.59$***	$y = 95.468x + 25.323$ $R^2 = 0.62$***	$y = -1.1685x + 83.7$
	ACS-430	Red	$y = 84.432x - 17.199$ $R^2=0.46$***	$y = 32.49x + 23.473$ $R^2 = 0.59$***	$R^2 = 0.42$***
	TGS	Red	$y = 5.3235e^{2.5815x}$ $R^2 = 0.59$***	$y = 26.218e^{0.7183x}$ $R^2 = 0.69$***	
AN	HCC	Red edge	$y = 257.03x -14.109$ $R^2=0.62$***	$y = 99.959x + 24.831$ $R^2=0.64$***	$y = -1.6606x +$
	ACS-430	Red	$y = 104.65x - 32.411$ $R^2=0.64$***	$y = 35.318x + 21.984$ $R^2=0.66$***	99.059 $R^2=0.64$***
	TGS	Red	$y = 4.6811e^{2.7571x}$ $R^2 = 0.60$***	$y = 26.153e^{0.7399x}$ $R^2 = 0.70$***	

Table 2 Regression analysis between MPY† and NDVI‡ from TGS†† and HCCACS-430‡‡ at ARF site. The coefficient of determination from the polynomial relationship was used to measure the strength of the relationship between MPY and NDVI. Another relationship was developed using sensor PPLAI multiplied with sensor NDVI and then develop a relationship with MPY. The strength of PPLAI‡‡ and sensor readings was also determined using regression analysis.

N source	Sensor type	WL	NDVI and Yield	(NDVI x LAI) and Yield	NDVI and LAI
CAN+AN	HCC ACS-430	Red edge	$y = -93.851x^2 - 65.368x + 29.592$ $R^2 = 0.44$***	$y = 263.34x^2 - 133.38x + 25.403$ $R^2 = 0.44$***	$y = 3.6912x^2 - 27.691x +$
		Red	$y = 2.7838x^2 - 21.484x + 29.259$ $R^2 = 0.40$***	$y = 14.275x^2 - 30.907x + 24.835$ $R^2 = 0.43$***	29.076 $R^2 = 0.44$***
	TGS	Red	$y = 136.23x^2 - 228.73x + 113.74$ $R^2 = 0.13$*	$y = 13.803x^2 - 35.707x + 28.8$ $R^2 = 0.43$***	
CAN	HCC ACS-430	Red edge	$y = 924.38x^2 - 414.15x + 59.023$ $R^2 = 0.53$***	$y = 1039x^2 - 277.72x + 31.693$ $R^2 = 0.50$***	$y = 0.1235x^2 - 7.1541x +$
		Red	$y = 60.696x^2 - 100.34x + 55.745$ $R^2 = 0.44$***	$y = 64.08x^2 - 67.932x + 31.369$ $R^2 = 0.48$***	117.81 $R^2 = 0.49$***
	TGS	Red	$y = 168.64x^2 - 278.12x + 130.41$ $R^2 = 0.35$**	$y = 59.946x^2 - 76.598x + 37.495$ $R^2 = 0.52$***	
AN	HCC ACS-430	Red edge	$y = 163.38x^2 - 123.64x + 32.407$ $R^2 = 0.35$**	$y = 487.19x^2 - 152.39x + 25.469$ $R^2 = 0.34$**	$y = -0.0048x^2 + .8875x -$
		Red	$y = 17.743x^2 - 34.495x + 31.499$ $R^2 = 0.34$**	$y = 34.634x^2 - 38.558x + 25.071$ $R^2 = 0.34$**	6.7679 $R^2 = 0.26$**
	TGS	Red	$y = 153.57x^2 - 253.26x + 123.46$ $R^2 = 0.03$	$y = 7.0663x^2 - 28.936x + 27.383$ $R^2 = 0.32$**	