OPVC CONTINUING PROJECT REPORT: 2014 **PROJECT YEAR**: 1 of 2

1. OPVC REPORT COVER PAGE

PROJECT TITLE: Effect of pop-up fertilizers and planting density on early season sweet corn growth and ear yield.

OPVC Project Number:

TOTAL PROJECT REQUEST (Year 1): $10,485

PI: Ed Peachey
Organization: Oregon State University
Telephone: 541-740-6712
Email: peachey@hort.oregonstate.edu

Co-PI: Dan Sullivan
Organization: Oregon State University
Telephone: 541-737-5715
Email: dan.sullivan@hort.oregonstate.edu

2. SUMMARY

Prices paid for sweet corn are low relative to the cost of producing the crop, and every strategy possible must be used to maximize net return. Two strategies used to enhance profitability but that have received little research attention under Western Oregon conditions are the use of pop-up fertilizers and increased plant populations. Despite indications that popup fertilizers improve early-season growth, concrete evidence that these fertilizers ultimately enhance growth and yield are often lacking. Seeding density also can be increased to improve crop yield up to a point, but intraspecific competitive ability and the competitive stress tolerance of varieties currently produced in the Willamette Valley are poorly understood.

In a single stress test of plant density on sweet corn growth and yield in 2014, popup fertilizer treatments had little impact with the exception of the variety Captain at the highest plant population on 40,000/A. The response of the two varieties differed slightly as plant population increased. Fresh ear weight, kernel yield, and gross return peaked at 40,000 plants/A for the var. Captain at 36000 plants/A for the var. 1477. Conversely, as plant population increased, ear length and width decreased slightly. Kernel yield followed trends very similar to fresh ear wt.

Costs associated with changes in plant population were estimated to be $69 and $99 for the varieties 1477 (@36000/A) and Captain (@40000/A), respectively, when accounting for the additional costs of greater planting densities. The additional costs associated with increased plant density lowered the adjusted gross return by 5 to 6%, but the value of corn at the optimum density still averaged $131 to $181/A more than the standard of 28000/A.

3. FULL REPORT

BACKGROUND

Prices paid for sweet corn are low relative to the cost of producing the crop, and every strategy possible must be used to maximize net return. Two strategies that are used but have received little research attention under Western Oregon conditions are the use of pop-up fertilizers and increased plant population. Popup fertilizers are applied near the seed row or just above the seed at planting and thought to improve corn growth yield, particularly in early plantings when temperatures are colder and P mobility may be restricted. However, data from an experiment in 2013 indicated little benefit to overall corn fresh ear yield, despite early indications that the corn was growing better when pop-up fertilizers were applied. Corn cutoff was measured in the study to make sure that some other yield parameter was not altered that would have demonstrated higher yield.

Significant changes have been made over the last 50 years in both field and sweet corn genetics, and when coupled with improved management practices, the changes have greatly increased yield potential. Modern varieties are tolerant to a host of biotic stresses compared to only two decades previous. A good case in point is the tolerance some varieties now have to Fusarium root rot in the PNW. Another stress that corn is better able to tolerate now is competition with both weeds and with other neighboring corn plants. Plant populations for sweet corn production today are much greater than the seeding rates of only forty years ago. Yield stress tests are used to determine at what point an increase in population no longer sustains a yield increase. Recent experiments indicate that for some varieties, plant populations up to 35000/A will optimize yield (Williams, 2013; Watters and Wohleb, 2013).

Soil fertility obviously impacts the relative competitive ability of competing corn plants and weeds, and pop-up fertilizers may be a key to early season growth. What is not known is whether the increase in early season growth that is often observed with pop-up fertilizers will result in a corresponding increase in yield, and if an increase in plant population will optimize the corn response to the pop-up fertilizers.

We hypothesize that the use of pop-up fertilizers (to enhance early season growth) and increased plant density in concert may be essential to maximizing profit margins. Certainly, the additional cost of seed must be outweighed by additional yield. Greater seed densities also equate with greater competitive abilities with weeds, and this benefit may be harder to quantify than the additional cost of seed.

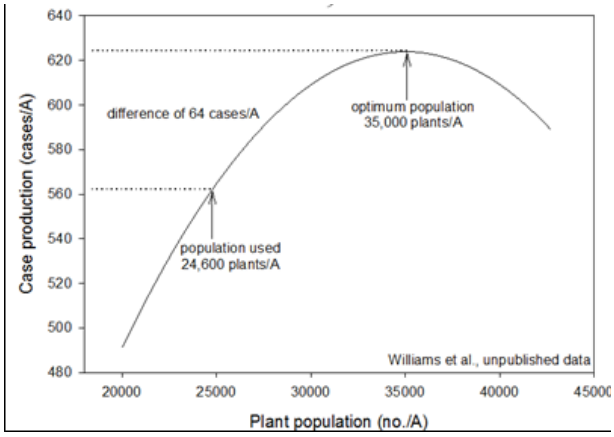

Figure 1. Sweet corn response to increasing plant population, Mendota, Ill, 2013 (Williams, M.M., unpublished data, Stress Tolerance. Report to ISCDA. USDA-ARS, University of Illinois).

OBJECTIVES

Determine the effect of enhanced early season fertility with the use of pop-up fertilizers on the competitive ability of sweet corn growth and yield.

We hypothesize that the use of pop-up fertilizers (to enhance early season growth) and increased plant density in concert may be essential to maximizing profit margins. Certainly, the additional cost of seed must be outweighed by additional yield. Greater seed densities also equate with greater competitive abilities with weeds, and this benefit is harder to quantify than the additional cost of seed.

SIGNIFICANT FINDINGS

- Popup fertilizer treatments had little impact on corn growth or yield, with the possible exception of increased yield with the variety Captain at the highest plant population of 40,000/A.
- Yield of Captain was greatest at 40,000 plants/A; yield of 1477 was greatest at 36,000 plants/A.
- The value of corn at the optimum density averaged $131/A (1477) to $181/A (Captain) more than the standard of 28,000 plants/A.

METHODS

This trial was conducted at the OSU Vegetable Research farm. The soil test in April indicated 60 PPM P (Bray test). Sweet corn was planted at a density of 57,000 seeds/A on May 13 at 1 in. deep. The field chosen for the study was managed as a single unit for the 3 years previous. The field was split into half with one side of the field planted to var. 1477 and the other side to the var. Captain with 60 ft. between plots to lessen cross pollination potential. The full suite of 4 pop-up fertilizer treatments and 6 corn densities was applied to each variety (see Table 2 for the full list of treatments). Each experimental unit was only replicated one time within each variety. Plots were 10 ft wide and 50 ft long, with four rows per plot on 30 in rows.

Fertilizer (16-16-16) was banded next to the row at 170 lbs/A at planting. Popup fertilizers were applied at planting at 3 and 5 GPA (diluted 50% to a total volume of 6 and 10 GPA) to rows 2 and 3, respectively in each plot. Our John Deere Max Emerge planter was retrofit with 'Totally Tubular' equipment to apply the popup liquid fertilizers beneath the seed row. Emergence counts indicated greater variability within the 5 GPA treatments, and the row with the 3 GPA treatment was used for growth and yield estimates.

Lorsban was applied over the row at planting and atrazine (1 qt/A) and Outlook herbicide (18 oz/A) applied over the top the following day (May 17). Rain was sporadic and insufficient to fully activate the atrazine and Outlook, and irrigation as applied on June 2. Corn was thinned on May 29 in the two middle rows of each plot to required densities. Plots were cultivated on June 19 and urea banded at 100 lbs N/A based on the PSNT soil sample tests taken one week earlier.

Measurements taken during the season included a visual evaluation of corn growth at V6 and a measurement of corn height when the corn was approximately 4 ft. tall. Corn was harvested from 20 ft. of row in each plot, graded, and kernels cut from all harvested ears from each plot.

RESULTS & DISCUSSION

Plant population effect. The was very little evidence statistically that popup fertilizers improved growth or yield of sweet corn (Table 1), and therefore, the data were averaged across the four pop-up fertilizer treatments before data were analyzed. There were trends of interest related to the popup fertilizer treatments however, and these will be discussed in the section below.

The response of the two varieties differed slightly as plant population increased. Fresh ear weight, kernel yield, and gross return peaked at 40,000 plants/A for the var. Captain and at 36000 plants/A for the var.1477, respectively (Table 3, Figure 2). Conversely, as plant population increased, ear length and width decreased slightly. Kernel yield followed trends very similar to fresh ear wt. (Fig. 3). None of the treatments produced more than 3000 ears/ton, a level that may be penalized (data not shown).

Table 1. Effect of popup fertilizer on early-season corn growth, averaged over the two varieties. Values in the same column and followed by the same letter do not differ statistically (alpha 0.05).

Pop up fertilizer	Obs	Corn growth (compared to the check)		Midseason corn height (avg. of 10 plants)		Std. deviation of corn height measurements	
		%		*----ft. (average of 10 plants)----*			
10-34	12	3.8	a	3.88	a	0.20	b
16-16-16	12	-2.9	a	3.86	a	0.19	b
6-24-6	12	-2.1	a	3.83	a	0.25	a
Check	12	-		3.81	a	0.24	ab

Costs associated with changes in plant population were estimated and deducted from gross return (Table 3). These costs were estimated to be $69 and $99 for the varieties 1477 (@36000/A) and Captain (@40000/A), respectively, when accounting for additional seed costs, hauling costs because of greater yield, slower planter speeds (increased labor), and greater time and cost to harvest compared to the standard of 28,000 /A. Values from OSU enterprise budget sheets (Julian, Peachey, et al. 2008) were used to estimate costs. A conservative value of $110/t for fresh ears was used to calculate gross return. The additional costs associated with increased plant density lowered the adjusted (estimated) gross return by 5 to 6% but the value of corn at the optimum density still averaged $131 to $181/A more than the standard of 28,000 plants/A (Table 2, 3 and 4, Figure 4).

Popup fertilizer effect. As stated above, the effect on early season growth and yield was small to non-existent. However, an examination of corn yield response to plant population and popup fertilizer across the two varieties indicated differences that should be explored in future research (Fig 5). There was no difference in yield with the Var. 1477, but there appeared to be a small benefit associated with the use of 6-24-6 when applied to the var. Captain at the highest plant density. It is important to remember however, that this value represents a single data point. A similar trend of increasing yield in 1477 compared to other popup fertilizers is evident with 6-24-6. As density increases so does the stress test. Perhaps the best fit of popup fertilizers is under high-stress conditions that occur as plant populations increase.

Increasing plant populations, with the potential to increase yield and overall return, may also improve weed suppression. Another factor to consider is the impact that increasing plant populations may have on damage caused by birds and insects, or even percentage of seeds that emerge as chlorpyrifos is phased out.

Table 2. Effect of sweet corn variety and plant density on yield of sweet corn.

Variety	Density	Obs	Ear no [a]	Avg. ear wt.	Fresh ear yield	Kernel moisture	Value	Ears/ plant	Husked ear wt.	Ear length	Ear width	Tip fill	Husk wt	Cobb wt	Kernel yield	Cutoff	Adjusted value
	plants/A		*no./A*	*lb.*	*t/A*	*%*	*$/A*	*no/ plant*	*t/A*	*in.*	*in.*	*%*	*% of total*	*% of total*	*lb./A*	*%*	*$/A*
1477	20000	4	23740*	0.89	10.5*	77.2	$1,160	0.88	8.0*	8.1	2.01	90.0	24*	45*	8400*	54	$1,219
1477	24000	4	25047*	0.88	11.1	76.9	$1,220	0.94	8.5	8.2*	2.00	90.3	24*	43	9310	56	$1,254
1477	28000	4	28532	0.84	12.1	76.7	$1,330	0.96	9.3	8.0	2.00	91.0	21	44	10000	55	$1,330
1477	32000	4	31799*	0.83	13.2*	76.5	$1,450	0.98	10.2*	8.0	2.00	89.3	23	45*	10550*	53	$1,411
1477	36000	4	34630*	0.81	13.9*	76.6	$1,530	0.97	10.9*	7.8*	2.01	89.8	22	46*	11460*	53	**$1,461**
1477	40000	4	39204*	0.71	13.8*	76.5	$1,520	0.96	10.9*	7.3*	1.98	89.5	22	46*	10810*	50*	$1,436
Captain	20000	4	25265*	1.00	12.6*	71.4	$1,390	1.01	9.0*	7.7	2.10	98.0	27	42	10500*	58	$1,425
Captain	24000	4	25047*	1.05	13.1	71.8	$1,440	0.96	9.5	7.7	2.16	97.5	27	43*	10680	57	$1,453
Captain	28000	4	27661	0.99	13.6	72.2	$1,500	1.00	9.9	7.6	2.10	97.0	27	42	11310	57	$1,491
Captain	32000	4	31145*	0.97	15.1*	72.4	$1,660	0.96	11.1*	7.6	2.13	98.8	26	43	12620*	57	$1,608
Captain	36000	4	35284*	0.87*	15.2*	72.7	$1,670	0.95	11.3*	7.4*	2.05*	95.8	25*	43*	12680*	56	$1,602
Captain	40000	4	37244*	0.88*	16.2*	72.3	$1,780	0.93	11.9*	7.4*	2.04*	97.0	25*	43	13080*	55	**$1,681**
ANOVA																	
Variety (V)			NS	<.0001	<.0001	0.0001	-	NS	0.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	-
Density (D)			<.0001	<.0001	<.0001	NS	-	NS	<.0001	<.0001	0.001	NS	0.003	0.003	<.0001	0.002	-
V X D			NS	0.14	NS	0.02	-	0.12	NS	0.004	0.04	NS	0.12	0.0001	NS	0.14	-

[a] Values followed by an asterisk (*) within each variety differ significantly from the value at a population of 28,000 plants/A, highlighted in gray (means separated at alpha= 0.05)

Table 3. Additional costs associated with treatments, normalized to 28000 plants/A.

Variety	Plant population	Gross return/A ($110/t)	Additional seed cost *($3.4/M for Captain; $4/M for 1477)*	Slower planter *(planter labor @ $2.54/A at 5 mph; assume 1 mph reduction per 4000 seeds/A)*	Additional hauling cost *($12/t)*	Additional corn harvester cost ($5.9/t)	Additional expense compared to 28000 plants/A	Adjusted return/A
			---------- *$/A*----------					
1477	20000	$1,160	-32.00	0	-18.30	-9.00	-59.30	$ 1,219
1477	24000	$1,220	-16.00	0	-12.00	-5.90	-33.90	$ 1,254
1477	28000	$1,330	0	0	0	0	0	$ 1,330
1477	32000	$1,450	16.00	3.05	13.50	6.64	39.19	$ 1,411
1477	36000	$1,530	32.00	3.66	22.50	11.06	69.22	$ 1,461
1477	40000	$1,520	48.00	4.39	21.00	10.33	83.71	$ 1,436
Captain	20000	$1,390	-26.72	0	-12.00	3.39	-35.33	$ 1,425
Captain	24000	$1,440	-13.36	0	-6.00	6.34	-13.02	$ 1,453
Captain	28000	$1,500	0	0	0	0	0	$ 1,500
Captain	32000	$1,660	13.36	3.05	17.70	18.00	52.10	$ 1,608
Captain	36000	$1,670	26.72	3.66	18.90	18.59	67.86	$ 1,602
Captain	40000	$1,780	40.08	4.39	30.60	24.34	99.41	$ 1,681

Table 4. Summary table of yield parameters. Listed under each variety is the plant population that gave the largest numerical value for each variable measured and that was statistically different from the value at 28,000 plants/A.

Variable	Unit	Var. 1477	Var. Captain
Ear no	no./A	40000	40000
Avg. ear wt.	lb./ear	20000	24000
Fresh ear yield	tons/A	**36000**	**40000**
Husked ear wt.	tons/A	40000	40000
Ear length	inches	24000	20000
Ear width	inches	20000	24000
Husk wt	% of total ear	20000	20000
Cobb wt	% of total ear	40000	=
Kernel yield	lb./A	36000	40000
Cutoff	% of total ear	=	=

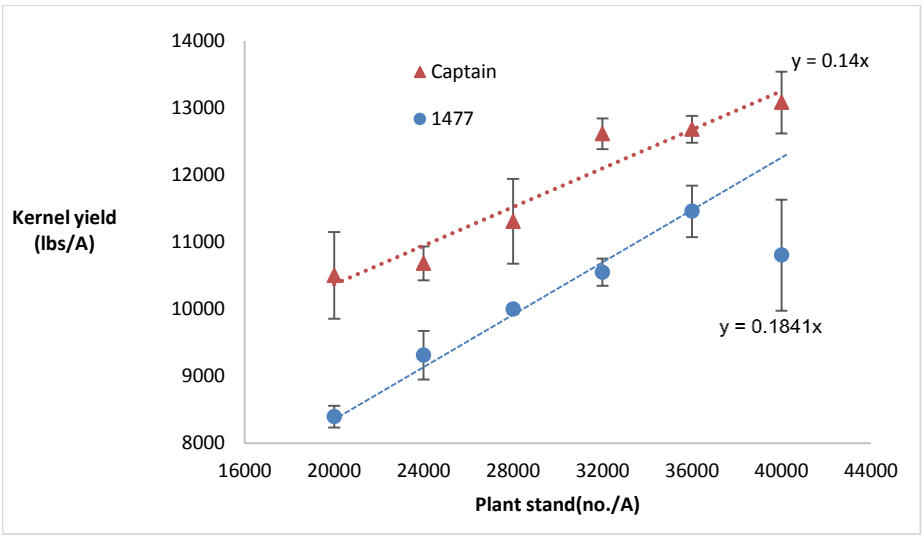

Figure 2. Effect of plant population on kernel yield (± SE). Regression analysis indicated an increase of 560 and 720 lbs kernels/A for each 4000 plant/A in plant population of Captain and 1477, respectively (excluding the yield of 1477 at 40000 plants/A).

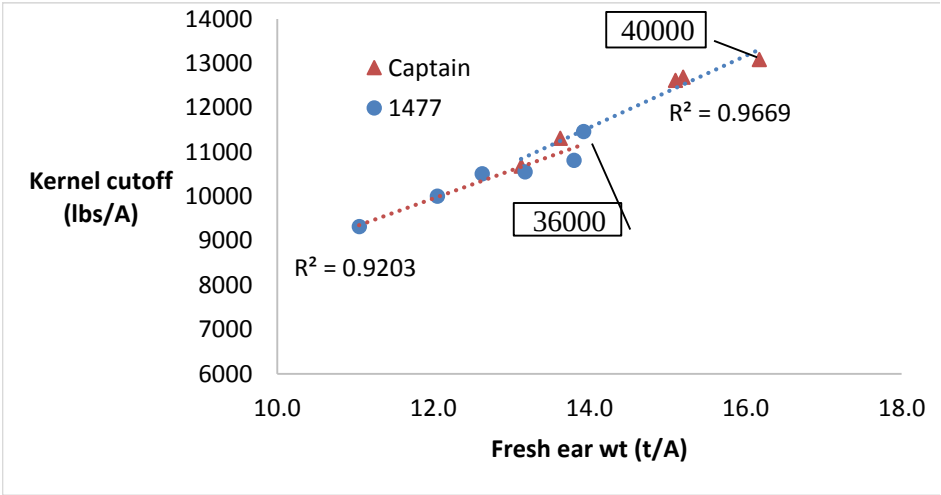

Figure 3. Relationship between kernel cutoff (lbs/A) and fresh ear wt. (t/A).

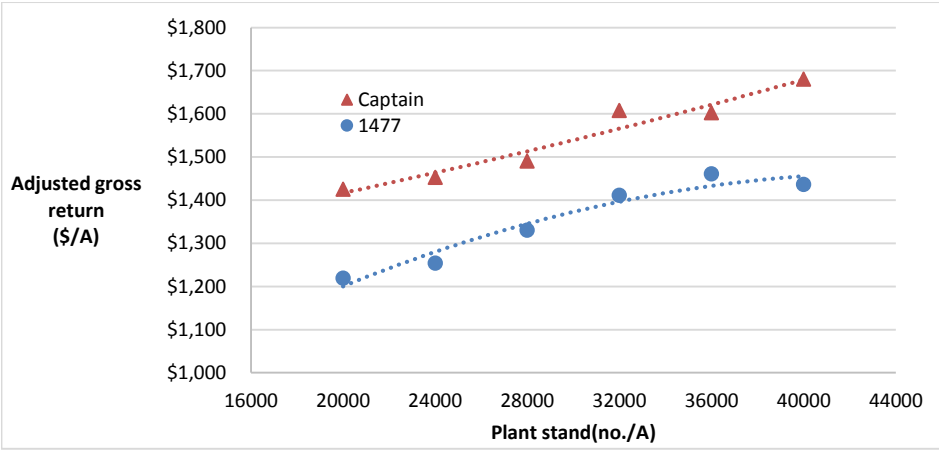

Figure 4. Effect of plant population on adjusted gross return of sweet corn when accounting for costs associated with each treatment (see Table 3 for an itemized breakdown of costs). Costs were assessed against the standard of 28,000 plants/A and a value of $110/ton of fresh ear wt.

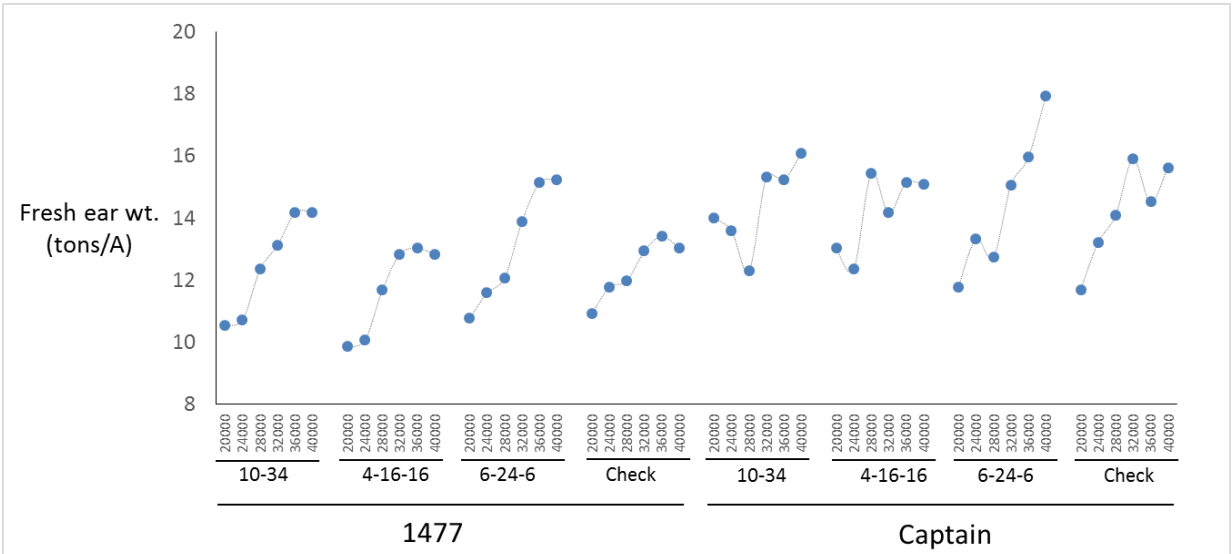

Figure 5. Effect of popup fertilizers on fresh ear wt. yield as plant population increased for the varieties 1477 and Captain. Each dot on the chart represents a single data point.

References

Julian, J., D. McGrath, McReynolds, E. Peachey and C. Seavert. 2010. Enterprise budgets for conventional processed sweet corn. Willamette Valley region. AEB0006. Oregon State University Extension Service, Corvallis.

Watters, T., and C. Wohleb. 2013. Evaluation of processing sweet corn hybrids at four plant populations in the Columbia Basin, WSU Extension.

Williams, M.M.II and R.A. Boydston. 2013. Crop seeding level: implications for weed management in sweet corn. Weed Sci. 61:437-442. 2013.

Williams, M.M. 2013. Stress Tolerance. Report to ISCDA. USDA-ARS, University of Illinois

4. BUDGET DETAILS

Salary:		FTE	Amount	OPE (benefits)
	Faculty (Peachey)	0.02	1250	525
	Res Assistant	0.10	3800	2318
	Other Labor (summer help, 8.50/hr)		1360	109
	OPE for all categories		2952	
Travel:				
	Domestic (in state)		0	
	Domestic (out of state)			
Field rental			595	
Supplies:	Nutrient analysis		528	
Equipment:			0	
Total			10485	