OPVC FINAL PROJECT REPORT: 2015 **PROJECT YEAR**: 2 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 BUDGET REQUEST (all years): $20,045
Year 1: $10,485 Year 2:$9,560

PI: Ed Peachey
Organization: Oregon State University
Telephone: 541-740-6712
Email: ed.peachey@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 has not been demonstrated.

Four experiments were conducted over two years with varieties Captain (both years), 1477 (2014), and Owatonna (2015). Corn was planted at densities of 20, 24, 28, 32, 36, and 40,000 plant/A. Three popup fertilizer treatments were applied under the seed row at planting and corn growth and yield in these plots compared to an untreated check.

In 2014, popup fertilizer treatments had little impact on corn growth or yield. In 2015, both Owatonna and Captain plants were taller than the untreated check plots at V6, and the effect was clearly visible. The popup fertilizer treatments had no effect on sweet corn yield or net return, however.

Sweet corn yield was greatest for Captain at 40,000 plants/A in 2014 and 32,000 plants/A in 2015. Yield of 1477 was greatest at 32,000 plant/A in 2014. Owatonna yield was greatest at 28,000 plants/A in 2015. The additional costs associated with increased plant density lowered the adjusted gross return by 5 to 6%. However, with the exception of Owatonna in 2015, the value of corn at the optimum density averaged $112 to $181/A more than the standard of 28000/A, depending on year and variety.

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 and 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 parameters were 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 in some conditions (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.

OBJECTIVES

1. 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 will test whether the use of pop-up fertilizers.
2. Determine the optimum planting density of sweet corn when considering net ear yield, cutoff, waste, and return.

SIGNIFICANT FINDINGS

2014

- 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.

2015

- Popup fertilizer treatments increased the height of sweet corn at V6 but as in 2014, did not impact yield.

- Yield of Captain was greatest at 32,000 plants/A compared to 40,000 plants/A in 2014; yield of Owatonna was greatest at 28,000 plants/A.
- The value of corn var Captain at the optimum density of 32,000 averaged $112/A for more than the standard of 28,000 plants/A. There was no financial benefit to Owatonna populations greater than 28,000/A.

METHODS

Four experiments were conducted over two years with varieties Captain (both years), 1477 (2014), and Owatonna (2015) at three sites (Table 1). Plots were 40 or 50 feet long and four rows wide (10 ft). Corn was planted at 52,000 plants/A then thinned to 20, 24, 28, 32, 36, and 40,000 plant/A after emergence. Three popup fertilizer treatments were applied under the seed row at planting and growth and yield of corn compared to a fourth treatment that had no popup fertilizer applied. Starter fertilizer (16-16-16) was banded next to the row at 170 lbs/A at planting. Popup fertilizers were applied at planting at 3 GPA but diluted to a total volume of 10 GPA. A John Deere Max Emerge planter was retrofit with ‘Totally Tubular’ equipment to apply the popup liquid fertilizers beneath the seed row. Lorsban (8 oz/1000 ft of row) was applied over the row at planting and atrazine (1 qt/A) and Outlook herbicide (18 oz/A) applied after planting. Plots were cultivated at about V6 and urea banded next to the row at 100 to 120 lbs/A as determined by the PSNT soil test taken one week before. Plots were cultivated and hoed to keep them weed free. Irrigation was applied every 5 to 7 days depending on when soil matric potential exceeded 40 cb at 12 inches deep. Corn was harvested from 20 ft. of row in each plot, graded, and kernels cut from all harvested ears from each plot.

Table 1. Site and soil characteristics

Year	Site	Variety	Type	Soil	Previous crops (year)	pH	CEC	OM	P (Bray I)	K	NO_3 (ppm at V6)
2014	A12	Captain	Su	Chehalis silty clay loam	Potatoes (12), snap beans/fresh peas (13)	-	-	-	60	695	16
2014	A12	1477	Sh2								
2015	A9	Captain	Su		Corn (13)-Fallow (14)	6.7	17	1.8	49	197	21
2015	A18	Owatonna	Sh2		Hops (13)-Cole crops (14)	6	26	2.7	39	87	22

RESULTS

2015

Plant population effect.

The response of the two varieties differed slightly as plant population increased. Fresh ear weight, kernel yield, and gross return peaked at 32,000 plants/A for the var. Captain and at 28000 plants/A for the var. Owatonna, respectively (Table 3, Figure 1). 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). The maximum number of ears produced/ton was 2450/t and 2500/t for Captain and Owatonna, respectively (based on gross yield that included no-makes).

Costs associated with changes in plant population were estimated and deducted from gross return (Table 3). These costs were estimated to be $37.80 for the variety Captain (@32000/A), 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. No additional costs were assessed for Owatonna. 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 for the variety Captain by 2.3% but the value of corn at the optimum density still averaged $112/A more than the standard of 28,000 plants/A (Table 3 and 4, Figure 2).

Popup fertilizer effect. The effect on early season growth and was significant and increased corn ht. at V6 by an average of 9% for the variety Captain and by 12% for the variety Owatonna compared to the plots without popup fertilizer (Table 2). This effect was easily visible in the field but had no effect on net ear yield or cutoff.

Table 2. Effect of popup fertilizer on early season corn growth 2015 (averaged over 6 density treatments, n=6)

Variety	Popup fertilizer	Corn growth ht. @ V6	
		in.	
Captain	10-34	16.8	a
Captain	4-16-16	17.4	a
Captain	6-24-6	17.5	a
Captain	Check	15.6	b
Owatonna	10-34	19.8	a
Owatonna	4-16-16	19.0	a
Owatonna	6-24-6	19.7	a
Owatonna	Check	17.2	b

2014

Plant population effect.

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 1). 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.

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. 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 3, 4, and 5; Figure 2).

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.

DISCUSSION

Differences were noted between varieties and between the two years of the study in response of sweet corn to increasing plant densities and stress. In 2014 the variety Captain was extremely productive and plant populations of 40,000 produced the greatest yield and net return. In 2015, Captain yield was greatest at 32,000 pl/A

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 3A. Effect of sweet corn variety and plant density on yield of sweet corn (**2015**).

Variety	Density	Obs	Ear no[a]	Avg. ear wt.	Fresh ear yield[b]	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*
Owatonna	20000	4	28967*	0.91	13.1	76.6	$1,440	1.2	10.2*	8.3	2.08	90.3	21.5	56.5*	11492*	43.5*	$ 1,453
Owatonna	24000	4	27878*	0.89	12.3*	76.2	$1,350	1.0	10.0*	8.2	2.07	90.5	19.0	63.8	12734*	51.8	$ 1,362
Owatonna	28000	4	32888	0.88	14.4	77.0	$1,580	1.1	11.6	8.2	2.07	89.3	19.3	62.0	14339	50.3	$ **1,538**
Owatonna	32000	4	33106	0.82	13.5	76.5	$1,480	1.0	10.9	8.1	2.04	90.0	18.8	63.3	13788	51.3	$ 1,435
Owatonna	36000	4	33759	0.83	14.1	76.4	$1,550	1.0	11.3	8.1	2.05	90.0	18.8	61.3	13908	49.5	$ 1,478
Owatonna	40000	4	35501	0.81*	14.4	76.2	$1,580	0.9	11.8	8.0	2.06	89.0	19.0	63.0	14842	51.8	$ 1,486
Captain	20000	4	21344*	1.13*	12.0*	70.8*	$1,320	0.95	8.6*	8.3*	2.08	99.0	22.3	57.5	9692*	40.0	$ 1,366
Captain	24000	4	23305	1.13*	13.2	70.9	$1,450	0.93	9.4	8.3*	2.08	99.3	17.3	52.5	9903*	37.8	$ 1,463
Captain	28000	4	26789	1.04	13.9	71.8	$1,530	0.95	10.1	8.1	2.05	98.8	18.8	55.5	11266	40.5	$ 1,526
Captain	32000	4	30274	1.01*	15.2*	71.6	$1,680	0.93	11.4*	8.2	2.05	97.5	18.0	53.0	12039	39.8	$ **1,625**
Captain	36000	4	30710*	0.95*	14.6	71.8	$1,610	0.86	11.0	8.0	2.03	98.5	18.3	53.5	11718	40.0	$ 1,552
Captain	40000	4	34195*	0.88*	15.0	72.3	$1,650	0.81	11.4*	7.8*	1.95*	98.3	19.5	49.3	11569	38.8	$ 1,572
ANOVA																	
Variety (V)			<.0001	<.0001	NS	0.0001	-	NS	0.01	NS	<.01	<.0001	<.004	<.0001	<.0001	<.0001	-
Density (D)			<.0001	<.0001	<.0005	NS	-	NS	<.0001	<.0001	0.003	NS	NS	NS	<.0001	0.07	-
V X D			NS	0.004	NS	0.02	-	0.12	NS	NS	0.003	NS	NS	0.05	NS	0.007	-

[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).
[b] Net yield (gross yield less no-makes).

Table 3B. Effect of sweet corn variety and plant density on yield of sweet corn **(2014)**.

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 4. Additional costs associated with treatments, normalized to 28000 plants/A, for 2014 and 2015 experiments. Treatments with adjusted net returns greater than or equal to the value at 28,000 plts/A are shaded.

Variety	Plant population	Gross return/A ($110/t)	Additional seed cost *($3.4/M for Captain; $4/M for Sh2 var.)*	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 net return/A
			--- $/A	*---*				
2015								
Owatonna	20000	$1,440	-32.00	0	-15.24	-7.49	-54.73	$1,495
Owatonna	24000	$1,350	-16.00	0	-25.01	-12.30	-53.31	$1,403
Owatonna	28000	$1,580	0	0	0	0	0	$1,580
Owatonna	32000	$1,480	16.00	0.00	-10.64	-5.23	0.13	$1,480
Owatonna	36000	$1,550	32.00	0.00	-3.74	-1.84	26.42	$1,524
Owatonna		$1,580	48.00	0.00	0.00	0.00	48.00	$1,532
Captain	20000	$1,320	-26.72	0	-22.14	-10.88	-59.74	$1,380
Captain	24000	$1,450	-13.36	0	-8.62	-4.24	-26.23	$1,476
Captain	28000	$1,530	0	0	0	0	0	$1,530
Captain	32000	$1,680	13.36	0.00	16.39	8.06	37.80	$1,642
Captain	36000	$1,610	26.72	0.00	9.20	4.52	40.44	$1,570
Captain	40000	$1,650	40.08	0.00	13.22	6.50	59.81	$1,590
2014								
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 5. 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	**2015**		**2014**	
		Var. Owatonna	Var. Captain	Var. 1477	Var. Captain
Ear no	no./A	40000	40000	40000	40000
Avg. ear wt.	lb./ear	20000	24000	40000	24000
Fresh ear yield	tons/A	**=**	**32000**	**36000**	**40000**
Husked ear wt.	tons/A	=	=	40000	40000
Ear length	inches	=	24000	24000	20000
Ear width	inches	=	=	20000	24000
Husk wt	% of total ear	20000	=	20000	20000
Cobb wt	% of total ear	40000	=	40000	=
Kernel yield	lb./A	=	=	36000	40000
Cutoff	% of total ear	=	=	=	=

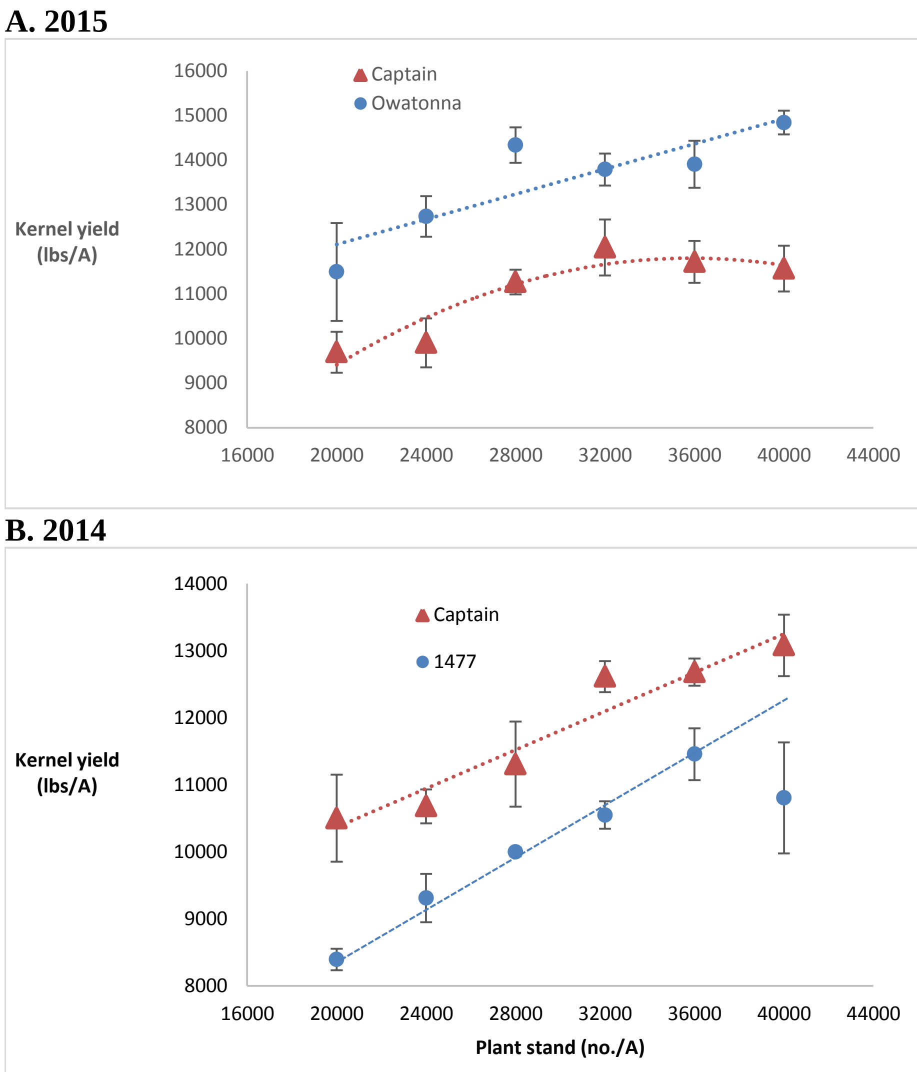
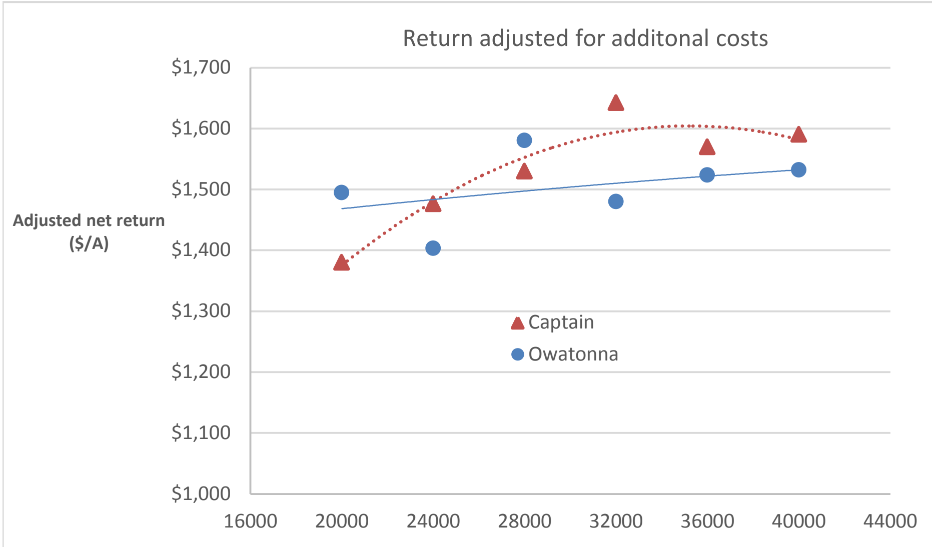


Figure 1. Effect of plant population on kernel yield (± SE, N=4).

A. 2015



B. 2014

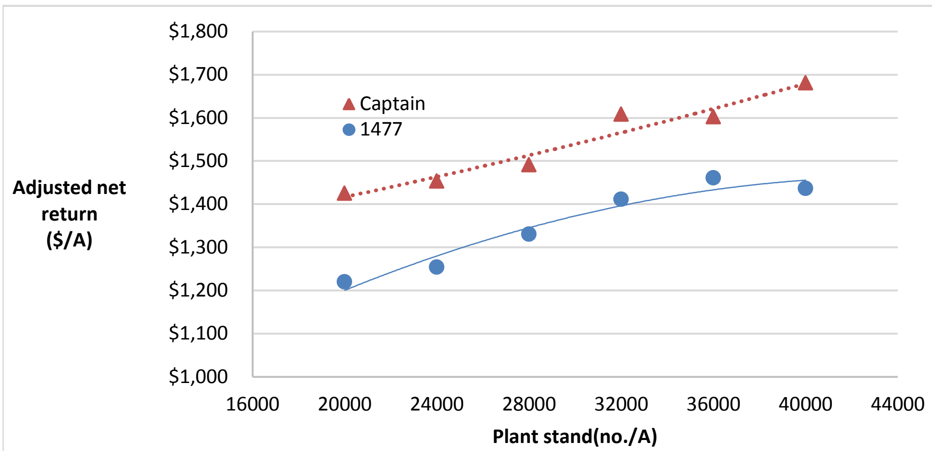


Figure 2. Effect of plant population on adjusted gross return of sweet corn when accounting for costs associated with each treatment (see Table 4 for an itemized breakdown of costs). Costs were assessed against the standard of 28,000 plants/A and a value of $110/ton of fresh ear wt.

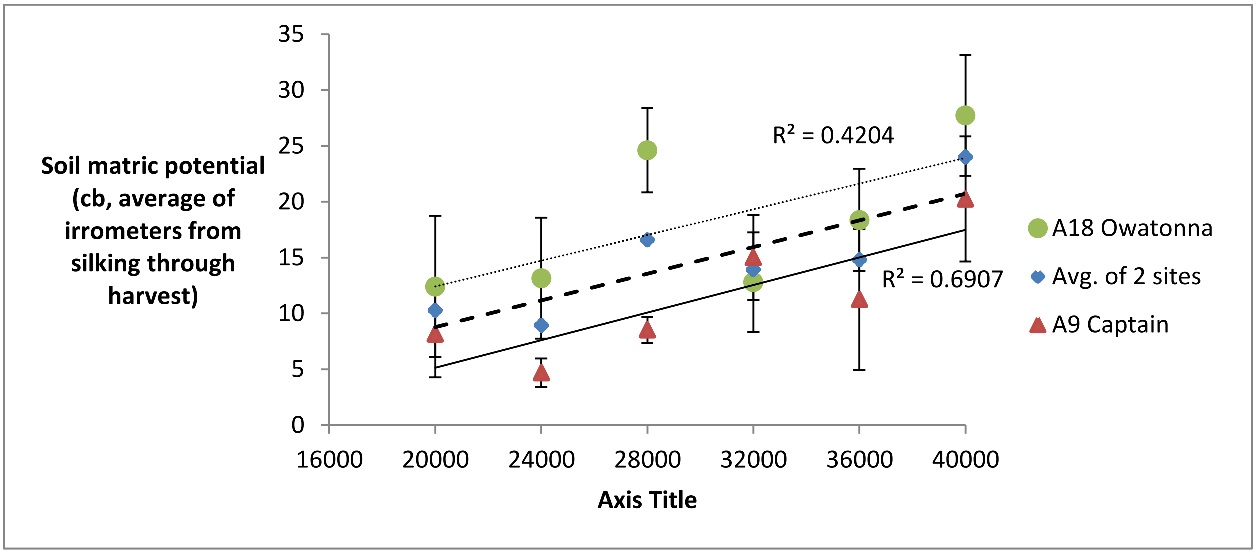


Figure 3. Average soil matric potential averaged across all readings from silking through harvest.

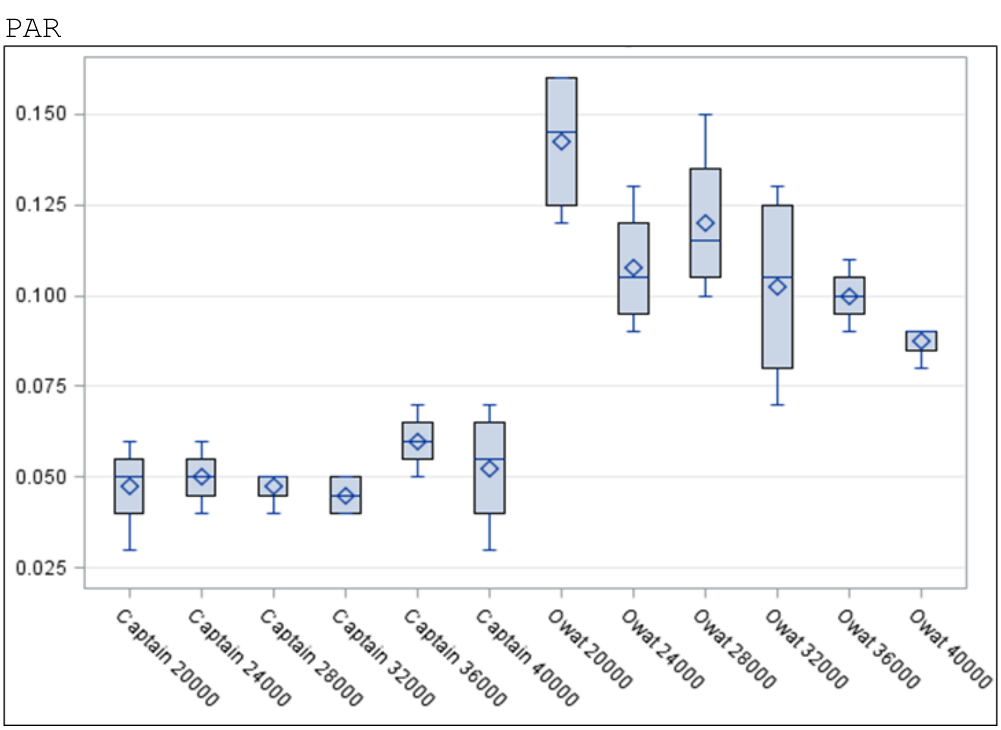
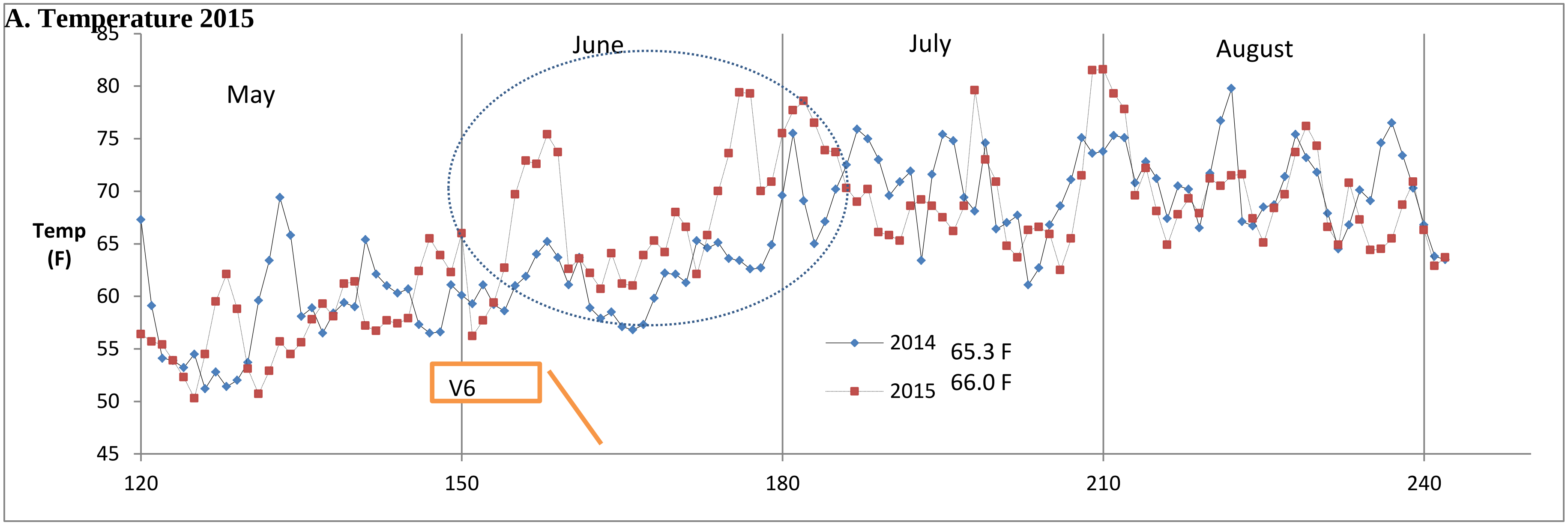


Figure 4. Proportion of photosynthetically active radiation (PAR) reaching the soil surface at the midpoint between rows, averaged from silking through harvest at weekly intervals.



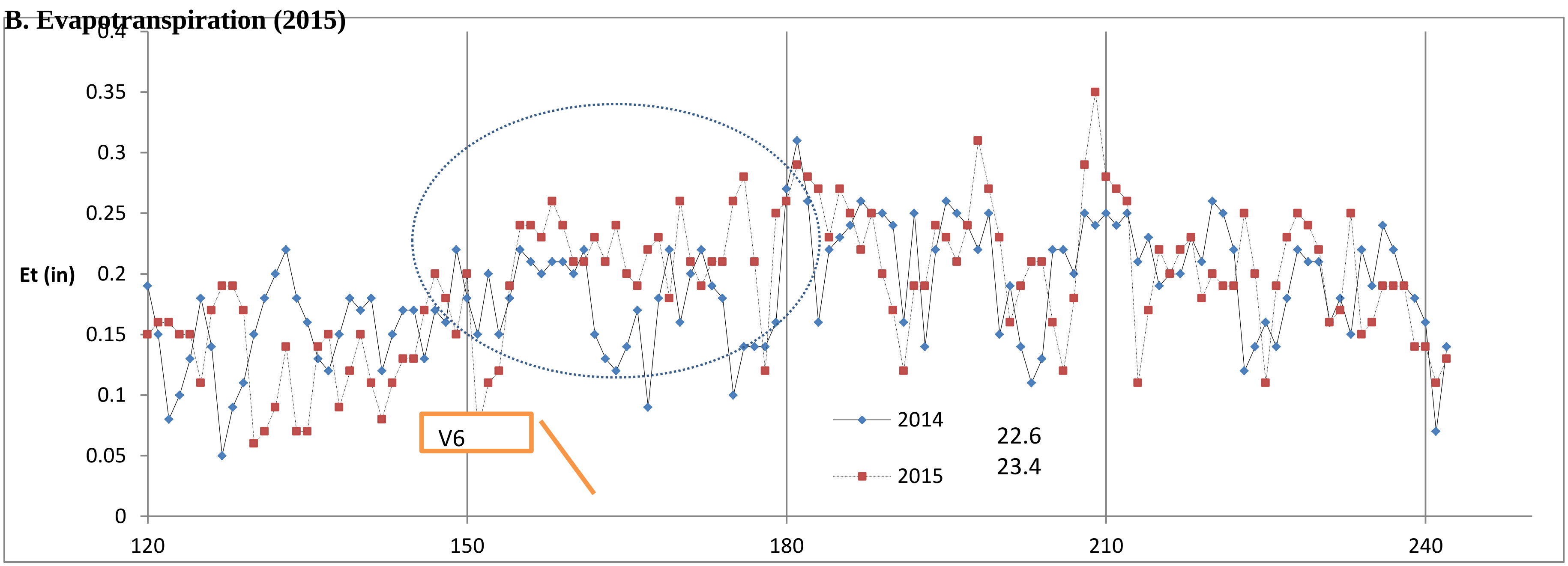


Figure 5. 2014 and 2015 average temperatures (A) and evapotranspiration (B) at Ag Weather Net (WSU) station at the USDA Hop Farm, Corvallis, OR.

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