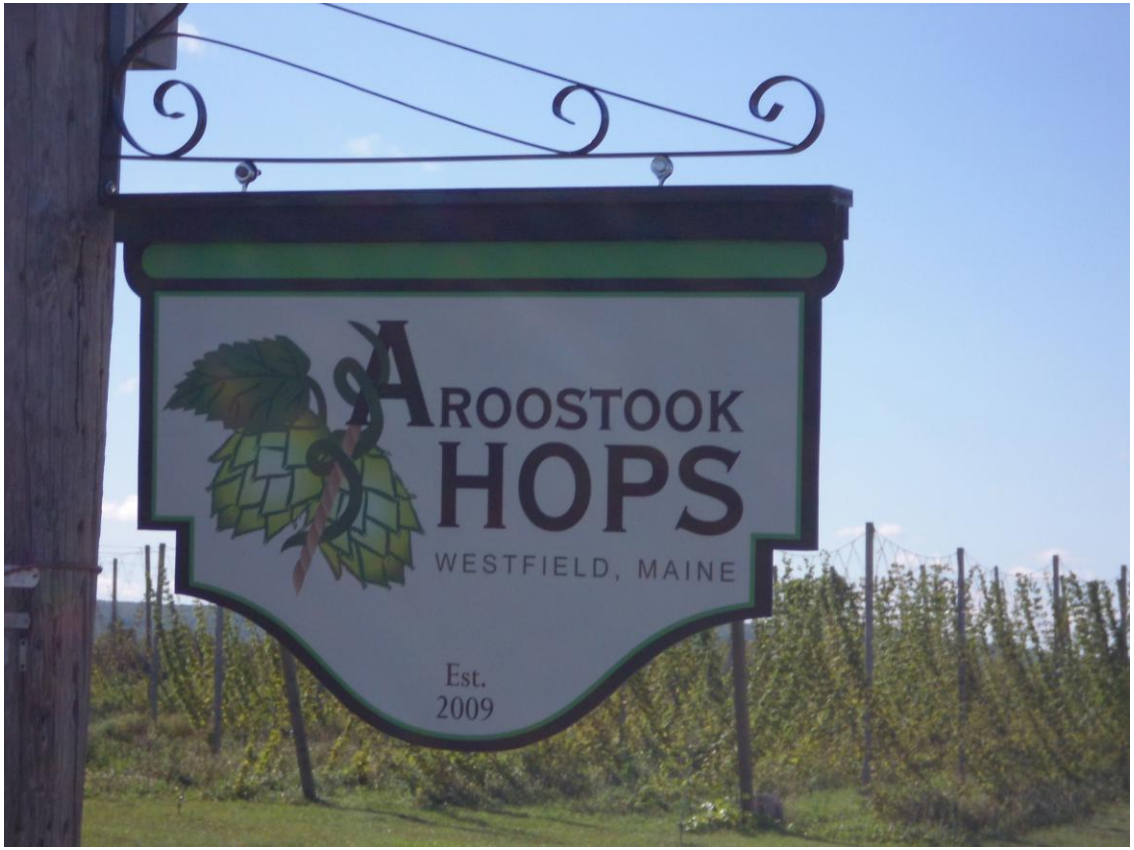
The Effectiveness of Irrigation and Cover Cropping to Produce Sustainable Hops



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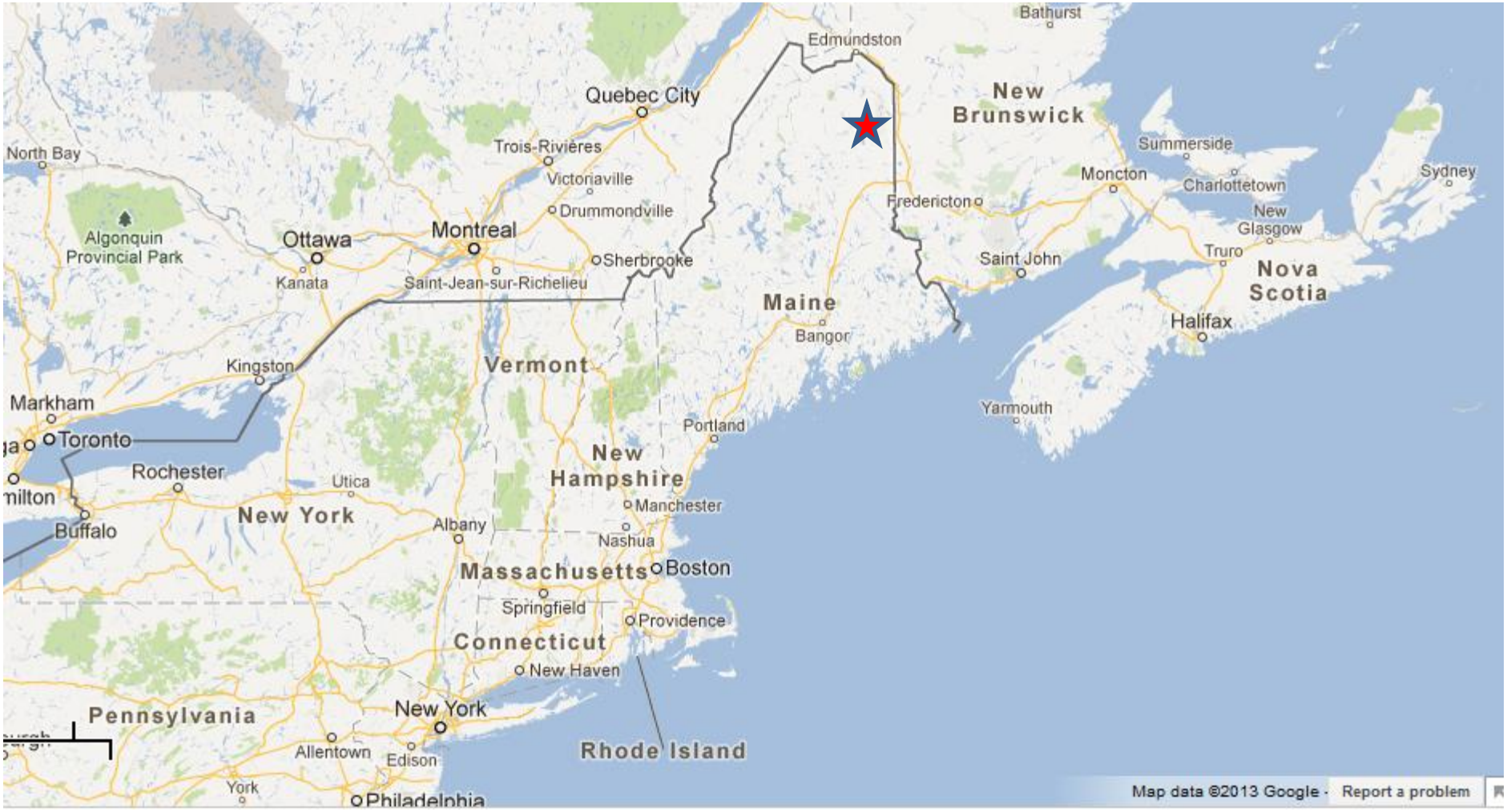
Where is Aroostook Hops?



We now have 4 acres @ 46.5°North

One-acre hopyard established 2009-’10

2012-2013 three-acre expansion

350 certified spruce poles

Setting the poles

“You don’t meet many first generation hops farmers” (For the Love of Hops, Hieronymus, 2012)

Our thanks to:

- USDA SARE (funding)
- Steve Johnson, UM Cooperative Extension
- Marcus Flewelling, Crop Production Services
- Kate and Larry Fisher
- NEHA
- Rosalie, Heather, the UVM team and collaborators
- Steve Miller et. al.
- Crannog Ales Hops Manual
- Family, friends & volunteers

Weeds, yield, and cowpeas…

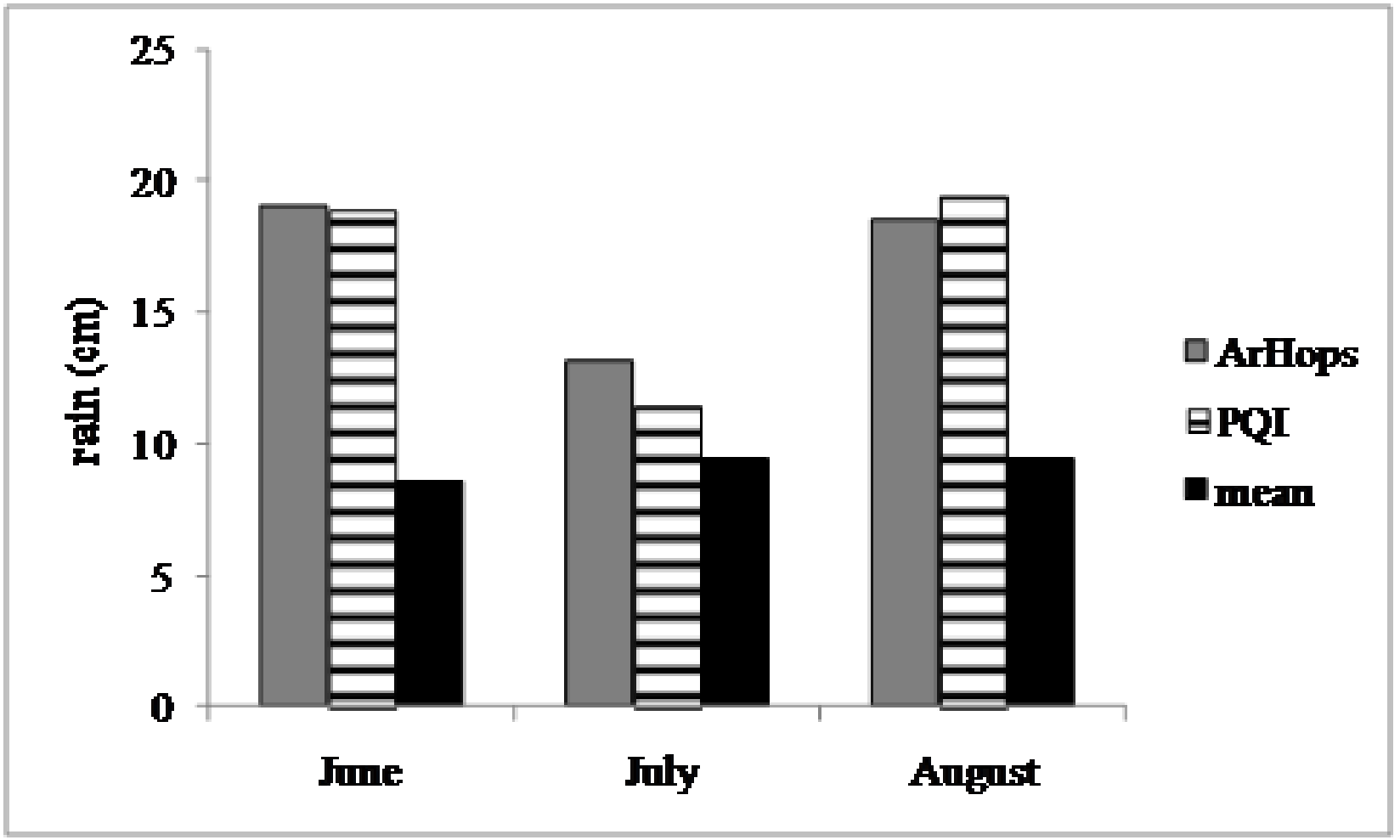
SARE
Sustainable Agriculture
Research & Education

Hopyard Map and Treatments

Row #	13	12	11	10	9	8	7	6	5	4	3	2	1
Growth Year	2	2	2	2	2	2	3	3	2	3	3	3	3
Cover Metho	A	S	A	S	A	S	A	S	mix	A	S	A	S
Irrigation	Y	N	N	Y	Y	N	N	Y	Y	N	Y	Y	
# hills	71	71	57	57	57	57	14	14	43	57	57	57	57
		Centennial							Ct				
50'													
100'		Nugget							Ng	Nugget		Nugget	
		Cascade					Centennial						
50'													
	Willamette												
50'													
KEY:													
A	alfalfa												
S	straw												
Y	yes - will be irrigated												
N	no - will not be irrigated												
Ct	Centennial												
Ng	Nugget												

Drip tape (inexpensive setup)

2011 Rainfall: (*what a year to study irrigation…)*



Mid-late April…Shoots!

Flowers: beauty is in the eye of the beholder…!

Cones!!! (Cascade)

4-year Nugget, ready to harvest

Harvest can be fun!...

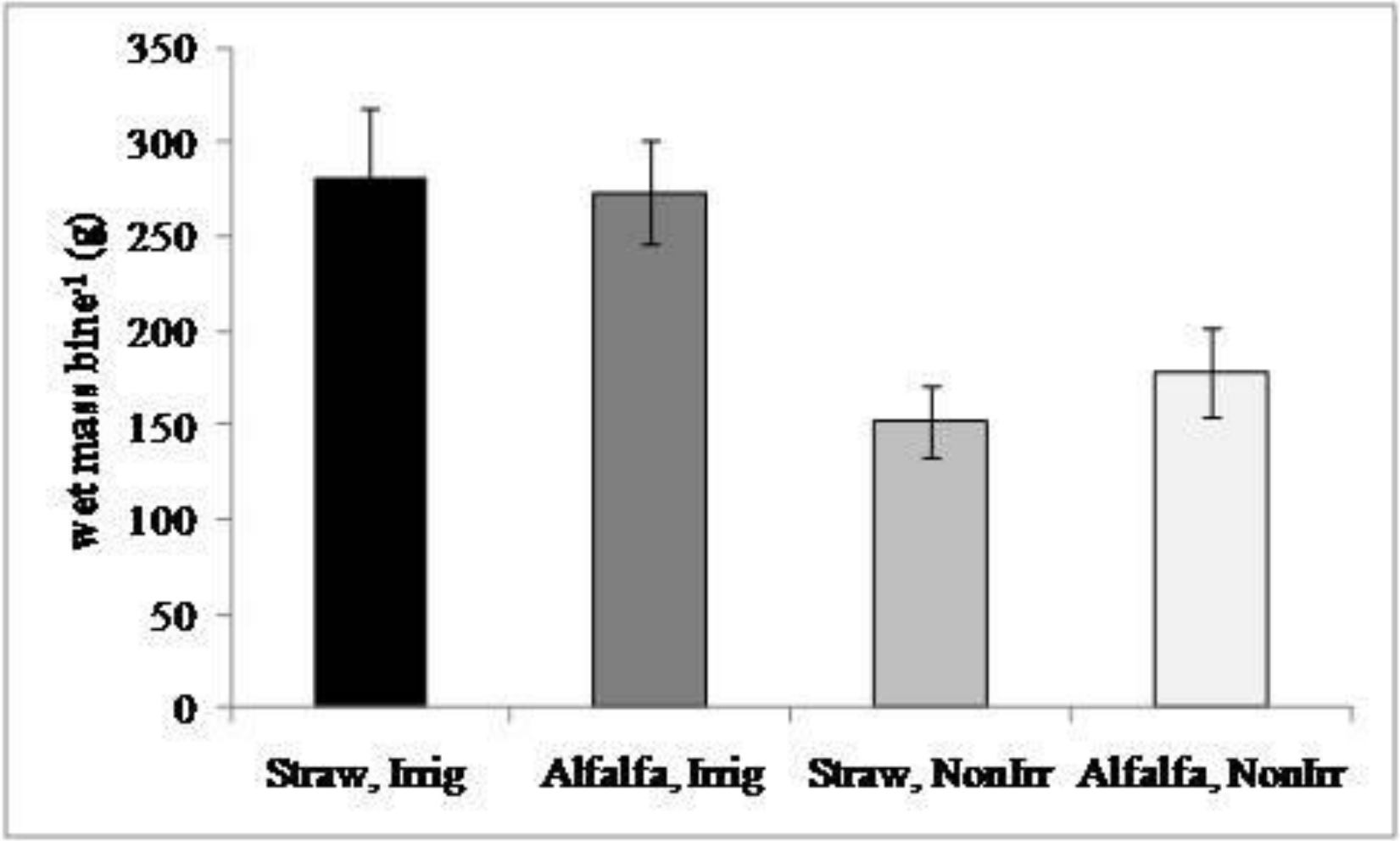
…But, it's A LOT of work!

…we need a harvester!

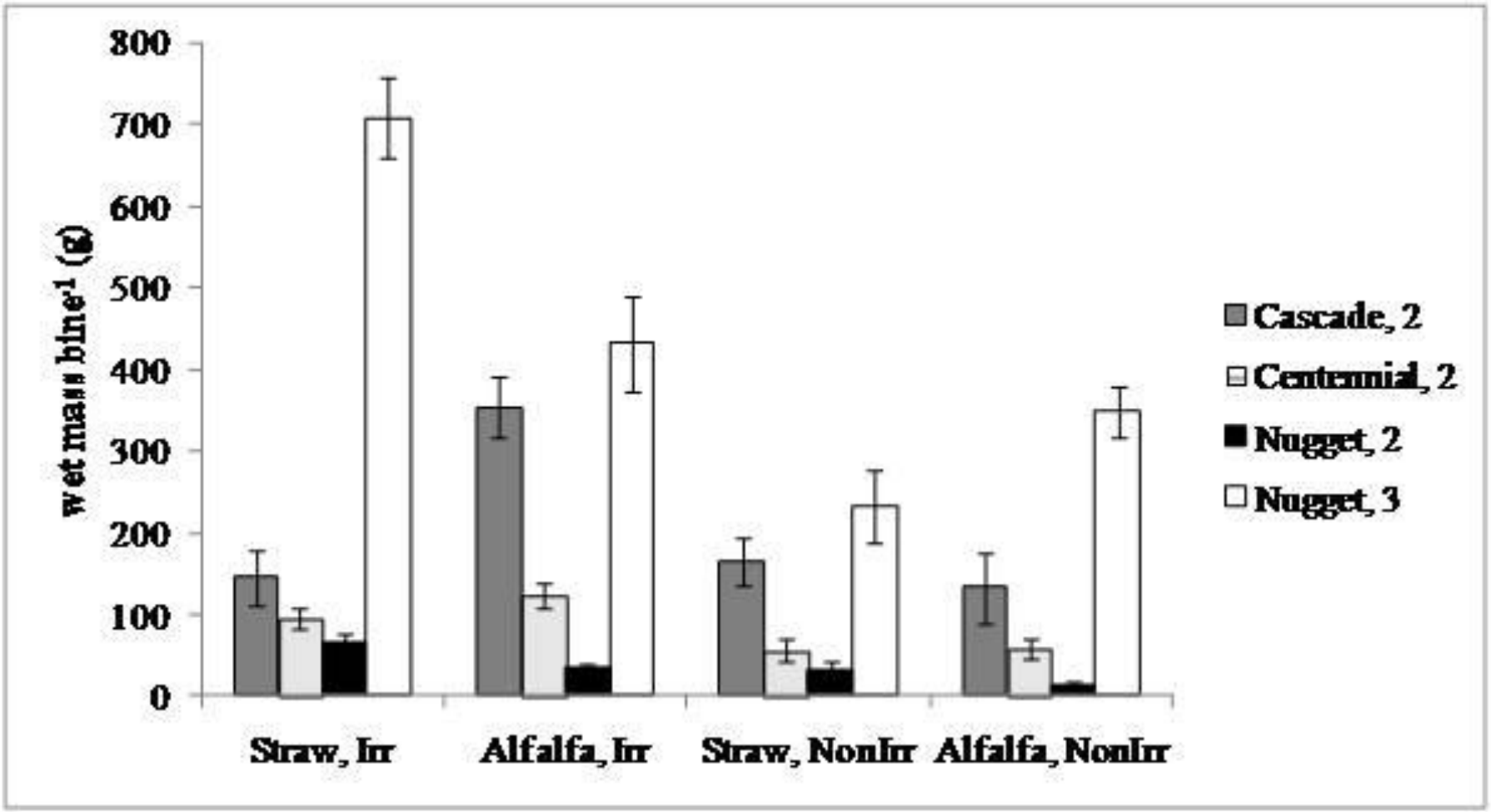
Marking 3rd-year Nugget for Yield Data

Irrigated Nugget bines (foreground)

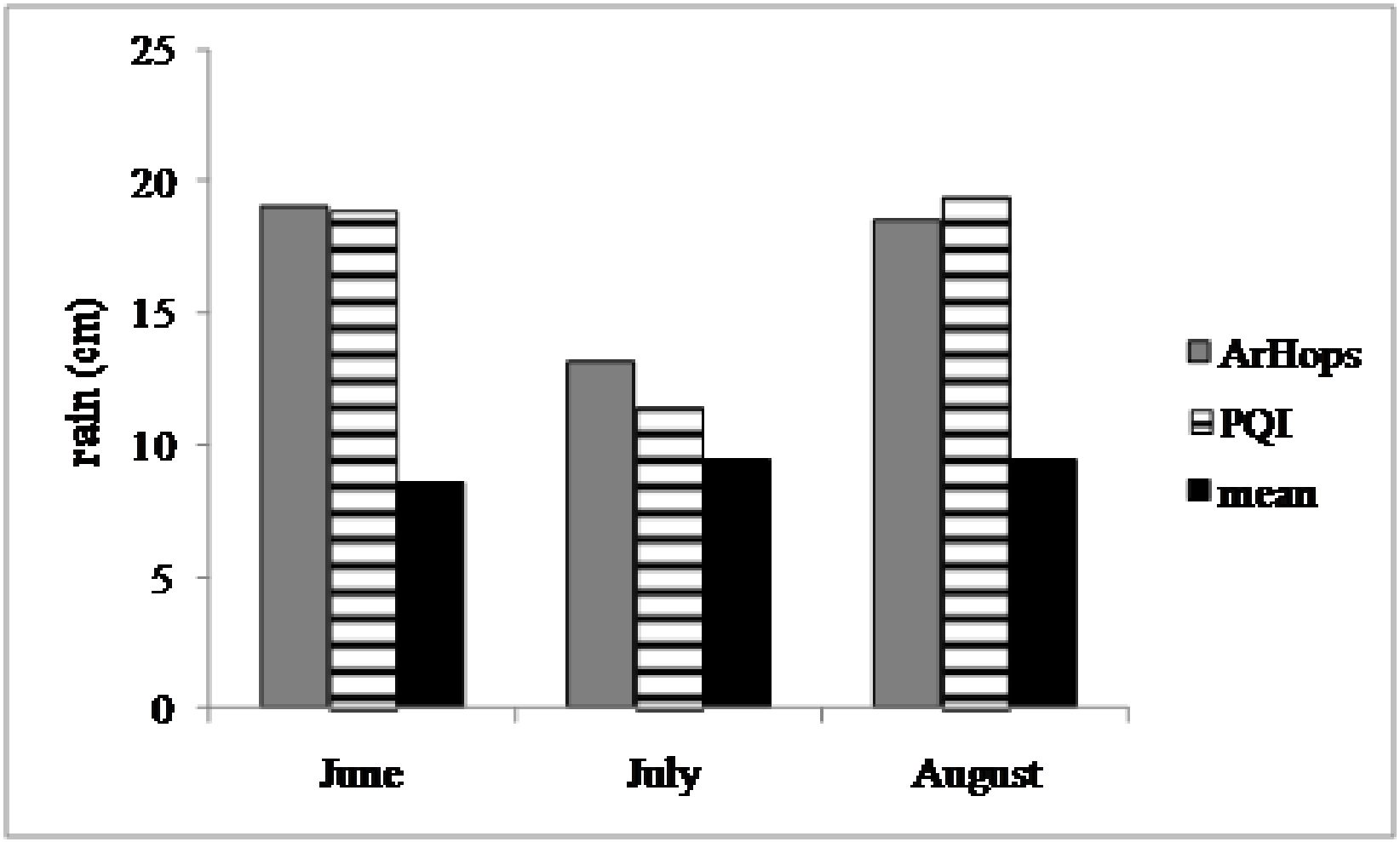
Wet Mass per Bine, varieties pooled



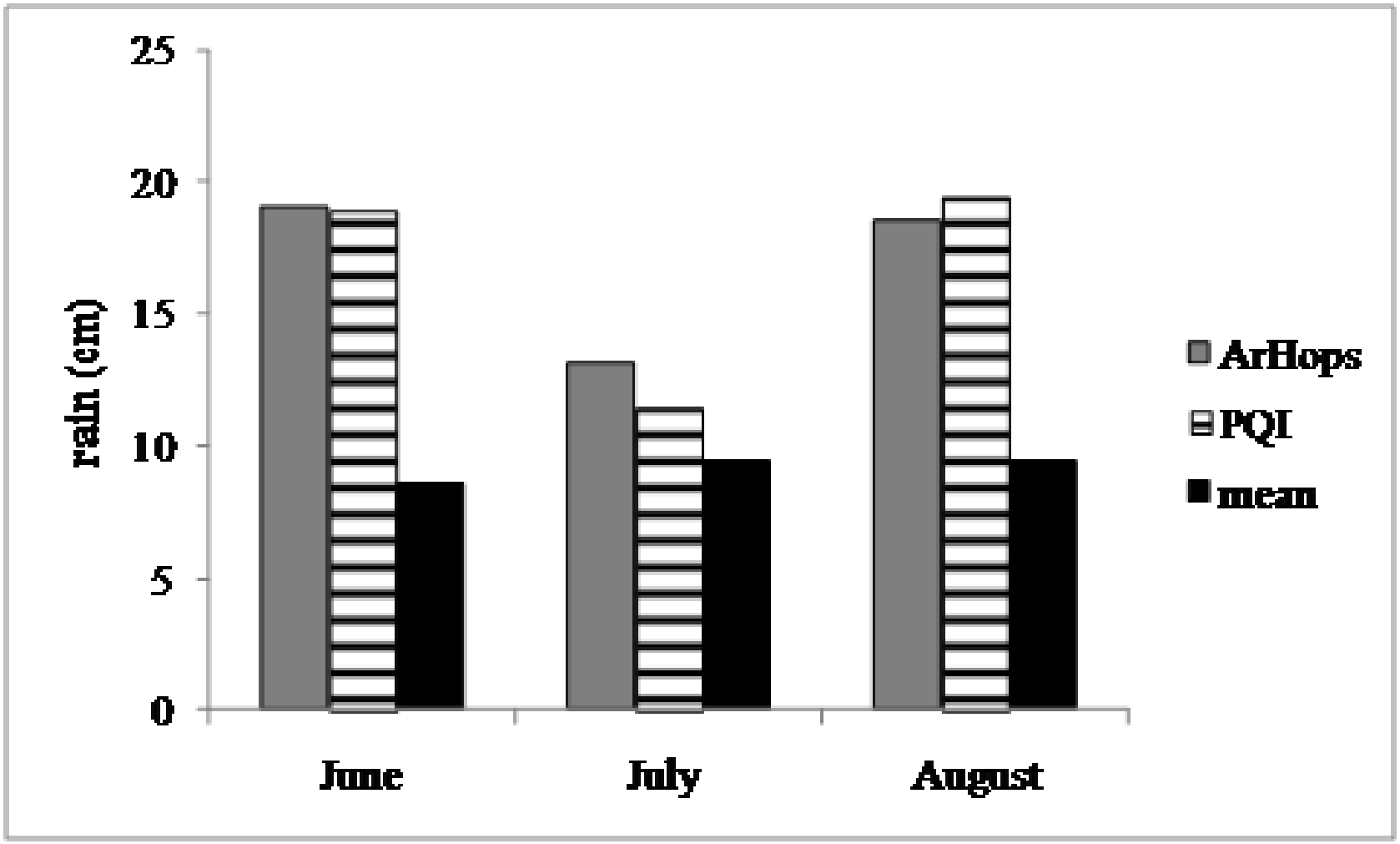
Wet Mass per Bine, by Variety



Recall 2011 Rainfall



However, only 0.37” of rain fell between 10 and 20 July



Yield Increase Factor

Ratio of Irrig vs. NonIrr Yield	
Cascade, 2	0.88
Centennial, 2	1.66
Nugget, 2	2.05
Nugget, 3	3.04

Extrapolated yield/acre (pounds)

	Irrigated		Non-Irrigated	
	Straw	Alfalfa	Straw	Alfalfa
Cascade, 2	144.9 ± 34.4	353.2 ± 37	165.3 ± 28.7	132.7 ± 42.9
Centennial, 2	94.6 ± 12.6	123.9 ± 14.9	56.9 ± 14.9	59.4 ± 12.1
Nugget, 2	66 ± 10.3	36.5 ± 4.2	32.2 ± 10.3	12.8 ± 4.4
Nugget, 3	707.6 ± 48.1	431.4 ± 58.8	233.1 ± 44.8	348.2 ± 31

Irrigation Costs ~ $193/acre/year

Irrigation Installation Costs

21 X 200 feet rows (@ 10' row spacing, plants spaced 3.5")
4200 l.f. driptape

$39.00 spigot timer
$82.00 head setup (regulator, filter, guage, etc.)
$232.00 mainline ($1/ft. * 220)
$184.39 drip tape
$2.10 endsleeves
$10.00 repair
$53.60 freight

$603.09 Total Installation costs/acre
$120.62 Ammortized cost (assumes 5 year life)
$48.07 annual operating costs (water free)

$168.68 total annual material cost/acre

$120 estim. Installation labor costs/acre
$24 annual cost (assume 5 year grub/dripline replacement)

$192.68 total ann. Material + labor cost/acre over 5 years

Net Financial Gain from Irrigation

	Non-Irrigated		Irrigated	
	Straw	Alfalfa	Straw	Alfalfa
Wet yield bine^{-1}	233.1	348.2	707.6	431.4
Wet yield plant^{-1}	466.2	696.4	1415.2	862.8
Wet yield (kg) acre^{-1}	580.2	866.7	1761.3	1073.8
Dry yield (kg) acre^{-1}	145.1	216.7	440.3	268.5
Gross revenue acre^{-1}	$885.82	$1,323.22	$2,689.01	$1,639.40
Irrigation install	$0.00	$0.00	$144.62	$144.62
Irrigation annual	$0.00	$0.00	$48.07	$48.07
Straw bales	$191.47	$0.00	$191.47	$10.00
Straw labor	$105.00	$0.00	$105.00	$0.00
Alfalfa seed	$0.00	$310.19	$0.00	$310.19
Alfalfa labor	$0.00	$45.00	$0.00	$45.00
Treatment costs acre^{-1}	$296.47	$355.19	$489.16	$557.87
Treatment revenue gain acre^{-1}	$0.00	$378.69	$1,610.50	$492.18

Alfalfa made only minor increase in nitrates by first fall

	pH	P	K	Mg	Organic	NO_3
Alfalfa, Irrig	6.2±0.04	41.3±1.8	620.3±63.5	243.3±10.1	4.13±0.32	6±0.71
Alfalfa, NonIrr	5.9±0.12	35±1.8	480.7±25.4	235.7±6.5	4.07±0.03	6.67±1.3
Straw, Irrig	6.5±0.12	50.6±4.4	587±164	344±26.5	4±0.21	4.33±1.5
Straw, NonIrr	6.05±0.1	39.1±1.7	643.5±89.2	219.5±14.5	3.78±0.11	3.25±0.25

Can rapeseed cover-cropping make a 1-year planting delay worth it?

Year 1: with straw mulch

Year 1: no mulch or tilling

What we've learned (so far!)

- Irrigation significantly increased yield
- Irrigation is cost-effective (at current scale)
- Summer alfalfa as 'green manure' may actually reduce yield
- Straw is the best mulch (of what we've tried)
- Previously established perennial weeds hard to eliminate

Current cultivation strategy

Current cultivation strategy

- Start with as weed-free intrarow as possible in early spring (grub, hand-tiller, new planting, etc.)
- Till interrow
- Apply lime, fertilizer, etc.
- Straw mulch intrarow when bine shoots are 6-12”
- Plant interrow with perennial (clover) or annual (e.g. rapeseed) as green manure and/or nitrogen source
- We would really like to know what others do!

Thanks to UVM!

Thanks to Northeast Hops community!

Soil Test Differentials (Fall '10 → Fall '11)

Cover	Irrig	SoilHist	Variet	Age	pH	Lime2	Plbs	Klbs	Mglbs	Calbs	CEC	Ksat	MgSat	CaSat	Acid	Org	Sulf	Copp	Iron	Mn	Zn	NO_3	NH_4
		Po (2010)			7	0	17.4	518	349	7628	11.1	5.9	13	81.1	0	6.6	9	0.56	5	9.6	14.9	6	3
		Gr (2010)			5.8	5.82	33	397	169	1896	7.3	6.9	9.5	64.2	19.4	3.4	16	1.39	7.2	3.8	2.7	1	1
A	Irrig	Gr	N	3	1.1	0.55	0.5	245	259	3525	4	0.3	6	13.1	-19.4	2.9	-4	-0.7	-2.4	3.2	-2	7	3
S	Irrig	Gr	CT	3	1.1	0.46	18	523	178	3291	3.7	3.8	3.5	12.1	-19.4	2.5	-7	-0.79	-2.5	5.1	-1.8	2	4
S	Irrig	Gr	N	3	0.7	0.3	-2.2	446	139	1810	2	4.6	4	10.7	-19.4	1.9	-5	-0.52	-1.3	3.2	-2	2	2
A	Non	Gr	CT	3	1	0.49	6.2	366	206	2987	3.6	2	4.5	12.9	-19.4	2.8	-5	-0.79	-2.4	3.8	-1.8	5	3
A	Non	Gr	N	3	0.6	0.27	-3.7	191	158	1372	1.8	1.3	5.2	12.9	-19.4	2	-6	-0.61	-1.5	1.8	-2	2	2
S	Non	Gr	N	3	1.4	-5.82	-14.9	87	315	11335	4.7	-1.8	7	14.2	-19.4	2.7	-7	-0.95	-2	10.5	-2	3	1
A	Irrig	Po	W	2	-0.7	5.99	24.3	90	-93	-4609	-2.7	3.3	-0.6	-2.7	0	-1.7	1	0.51	0.7	-3.6	-14	0	1
A	Irrig	Po	CA	2	-0.8	6.01	27.1	284	-92	-4783	-3.4	7.4	0.7	-8.1	0	-2.2	2	0.56	0.1	-3.4	-13.9	1	1
A	Irrig	Po	N	2	-0.9	5.99	18.6	-3	-135	-5044	-4.5	4	0.2	-4.1	0	-3.1	1	0.41	2.1	-4.3	-14	1	2
A	Irrig	Po	CT	2	-0.8	6.01	25.4	38	-103	-4837	-4	4.1	1.2	-5.2	0	-2.9	1	0.4	0.7	-4.1	-14	-2	2
S	Irrig	Po	CA	2	-0.5	6.16	31.4	96	2	-3891	-2.6	3.3	3.8	-7.2	0	-2.2	0	0.32	0.3	-3.5	-14.2	-4	-1
S	Irrig	Po	N	2	-0.7	6.05	26.7	270	-54	-5082	-3.8	7.8	3.4	-11.2	0	-2.9	-1	0.61	2.2	-5	-14	1	-1
S	Irrig	Po	CT	2	-0.3	6.18	41.6	651	37	-4351	-2.5	11.4	5.5	-16.9	0	-2.7	0	0.46	1.1	-4.8	-14.1	-2	-1
A	Non	Po	CA	2	-0.9	5.92	18	-22	-101	-4846	-4	2.9	1.3	-4.2	0	-2.6	1	0.57	2.1	-4.9	-14	-2	0
A	Non	Po	N	2	-1.1	5.87	14.2	-87	-123	-5525	-4.5	2.3	0.9	-3.2	0	-2.5	1	0.47	2.7	-4.9	-14	2	0
A	Non	Po	CT	2	-1.3	5.76	20.5	-3	-116	-5738	-2.8	2.1	-1.4	-24.4	23.7	-2.5	4	0.97	6.2	-4.7	-13.9	2	1
S	Non	Po	W	2	-1.1	5.86	24.8	94	-106	-5148	-4.6	6.1	2.3	-8.4	0	-2.7	2	0.71	1	-3.5	-13.9	-2	1
S	Non	Po	CA	2	-0.7	6.07	24.2	382	-103	-4897	-3.5	9.1	0.2	-9.3	0	-2.6	0	0.36	0.5	-3	-14	-3	3
S	Non	Po	N	2	-0.9	5.95	19.6	55	-151	-5461	-4.5	5	-0.9	-4.1	0	-3.1	-1	0.38	0.7	-5.5	-14.2	-3	-2
S	Non	Po	CT	2	-1.1	5.85	18	-29	-158	-5798	-5.2	4.6	0.2	-4.8	0	-2.9	0	0.66	1.9	-6	-14	-3	-1