2013 Research Report to the

Agricultural Research Foundation

and the

Oregon Processed Vegetable Commission

TITLE: **Integrated strategies to improve weed control in beet crop rotations in the Willamette Valley**

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Summary

The objective of this research was to determine best use patterns for Upbeet herbicide considering factors of preemergence herbicide and cultivation, and how these affect optimum timing for Upbeet applied with or without Spin-Aid for control of weeds such as nightshade and lambsquarters.

EXPERIMENT 1 - At the OSU Vegetable Research Farm in Corvallis, weed control at harvest was influenced primarily by whether Dual Magnum and Nortron were applied PRE. Weed control was a primary determinant of yield. The second most important factor influencing weed control at harvest was cultivation, which on average improved weed control from 70 to 88% when used with PRE herbicide.

UpBeet applied at the 4-leaf beet stage controlled weeds better than when applied at the 2-leaf stage (88 vs. 70 % control), but did not significantly improve yield. When Spin-Aid was tankmixed with UpBeet, it also controlled weeds better at the 4-leaf stage than the 2-leaf stage (86 vs. 75% control). Cultivation at 2-leaf provided better weed control than at 4-leaf when PRE herbicides were used. Late cultivation (4-leaf) may have actually disrupted the control provided by the PRE herbicide. The best weed control was with PRE herbicide followed by UpBeet at 2-leaf followed one day later by a 2-leaf cultivation, and this treatment also yielded the most beets.

EXPERIMENT 2. At the on-farm site near St. Louis, all POST treatments improved weed control compared to Ro-Neet alone. Ro-Neet followed by (fb) Dual Magnum + Nortron PRE stunted beet growth by as much as 40% one month after planting but did not affect yield. UpBeet applied at the 2-leaf stage controlled weeds and provided the greatest yield.

UpBeet herbicide may fill an important niche in weed control programs in table beets, but successful performance will be tied to when the application is made relative to beet and weed growth stage, and whether it is used in concert with cultivation and Spin-Aid.

Background

This project is developing and evaluating new strategies for weed control in table beets. The introduction of glyphosate resistant sugar beets is threatening to undo weed control programs in table beets. Because growers are able to apply glyphosate selectively in sugar beets, the need for products such as cycloate (Ro-Neet), phenmedipham (Spin-Aid), phenmedipham + desmedipham (Betamix), and pyrazon (Pyramin) has diminished. Bayer has divested in the herbicide SpinAid and will no longer produce Betamix. However, Spin-Aid is now available through another registrant. Pyramin, albeit expensive, has been the most effective control for hairy nightshade, but is no longer available in the US. ,.

Despite the past availability of several herbicides for beets, weeds always have been a problem. The soil applied herbicides are short lived, must be used at low rates because of potential crop injury, and do not provide season long control. The postemergence herbicides such as Spin-Aid are marginally effective, depending on air temperature. Integrated strategies that use cultivation are usually required to control late

emerging weeds that escape PRE and POST herbicides. However, production efficiency (maximizing yield) and harvesting equipment require that beets be grown on beds in rows 14 to 18 inches apart. This greatly restricts the proportion of a field that can be cultivated, and hand removal is often needed, greatly increasing the cost of weed control.

We have tested combinations of s-metolachlor (Dual Magnum) and ethofumesate (Nortron) and developed use patterns for this tankmix for growers struggling to manage hairy nightshade, a particularly troublesome weed in beets. Hairy nightshade tangles in harvesting equipment as beets are pulled from the ground. If used as a standalone treatment, however, other measures will be needed because other important species such as smartweed may escape. A recent registration for UpBeet herbicide may improve weed control in beets. This herbicide is a sulfonylurea with very little soil activity. It must be applied when weeds are small. Weeds controlled include the nightshades, mustards, pigweed, lambsquarters, and smartweed, all weeds that can escape the s-metolachlor + ethofumesate treatments. Efficacy is complemented by tank mixing this herbicide with Spin-Aid.

The objective of this research was to determine best use patterns for UpBeet herbicide considering factors of preemergence herbicide and cultivation, and how these affect optimum timing for when UpBeet is applied with or without Spin-Aid for control of weeds such as nightshade and lambsquarters.

Exp. I (OSU Research Farm)

Methods. Beets were seeded on May 16 on 26 inch rows with 3 rows to a bed, and beds were on 10 ft centers to facilitate equipment movement. The soil type was a Chehalis silty clay loam and the soil test revealed a pH of 6.20, OM of 3.67% and CEC of 24 meq/100 g soil. PRE herbicides were applied on May 16 with 8003 nozzles on 20 in. centers at 30 PSI immediately after planting, and activated with ½ in. irrigation. A rainy period of 12 days followed. POST treatments of Spin-Aid and UpBeet were applied at 2-leaf on June 7 and 4-6 leaf on June 14. Cultivation was applied one day after each POST application, with the rationale that weeds in the beet row are the most troublesome. If cultivation had been applied before plots were sprayed, soil may have covered many of the weeds in the row. The cultivation system used was Bezzerides spyders set at approx. 30° to pull soil from the row, and torsion weeders set just below the soil surface to push soil back into the row and cover small weeds. The spyders were set to leave approx. 3.5 to 4 in. of soil in the row undisturbed. Weed control was evaluated on July 12 and again at harvest. Beets were harvested from 10 ft of the middle row on August 20 and graded according to industry standards.

Table 1. Herbicide application data for Corvallis, 2013.

Date	May 16, 2013	June 07, 2013	June 14, 2013
Crop stage		2-leaf	4 to 6-leaf
Herbicide/treatment	DualMag and Nortron	UpBeet, Spin-Aid	UpBeet Spin-Aid 4-6
Application timing	PES	EPOST	LPOST
Start/end time	6:30- 7 PM	2:30-3:37 PM	11:30-12:15 PM
Air temp/soil temp (2")/surface	57/65/63	86/92/94	74/74/85
Rel humidity	64%	39%	49%
Wind direction/velocity	W 1.9 to 6.7	W 3 to 10	W 3 to 5
Cloud cover	100	0	0
Soil moisture	Very dry	Dry	Dry
Plant moisture	-	Dry	Dry
Sprayer/PSI	BP CO2 25 PSI	BP CO2 25 PSI	BP CO2 25 PSI
Mix size	3 gal/A	3 gal/A	3 gal/A
Gallons H20/acre	20	20	20
Nozzle type	5-XR8003	5-XR8003	4-XR8003
Nozzle spacing and height	20/24	20/24	20/24
Soil inc. method/implement	Irrigation + 12 days of rain	Cultivated June 8	Cultivated June 15

Results (Corvallis)

Analysis of the data indicated that PRE herbicides, cultivation, and EPOST herbicides all had major effects on weed control and ultimately yield. There was no evidence of a major interaction between factors tested, meaning that the effect of each main factor such as PRE herbicide, cultivation, and EPOST UpBeet and Spin-Aid was relatively consistent across the other three practices. A few highlights are listed below:

- Weed control at harvest was influenced primarily by whether Dual Magnum and Nortron were applied PRE (Table 2).
- The 2nd most important factor influencing weed control at harvest was cultivation, which on average improved weed control from 70 to 88% when used with PRE herbicide. Cultivation improved weed control to 60% (compared to the untreated check) when used without PRE herbicides.
- UpBeet applied at the 4-leaf beet stage controlled weeds better than when applied at the 2-leaf stage (88 vs. 70 % control), but did not significantly improve yield.
- When Spin-Aid was tankmixed with UpBeet, it also controlled weeds better at the 4-leaf stage than the 2-leaf stage (86 vs. 75% control).
- Weed control was a primary determinant of yield (Figure 1).

Despite the trends listed above, a few individual treatments stood out. Cultivation at 2-leaf provided better weed control than at 4-leaf when PRE herbicide were used. Late cultivation (4-leaf) may have actually disrupted the control provided by the PRE herbicide (tr.1 vs 6). Cultivation timing did not have a major influence on weed control when PRE herbicides were not applied (tr. 9 vs 14). The best weed control was with PRE herbicide fb UpBeet at 2-leaf followed one day later by a 2-leaf cultivation (tr 2), and PRE herbicide followed one day later by a 2-leaf cultivation fb UpBeet at 4-leaf (tr 4). These two treatments also yielded the most beets.

Table 2. Weed and crop response to main effects applied to table beets.

Source	Composite weed rating at harvest	Yield
	Pr > F	*Pr > F*
PRE herbicide	<0.0001	<0.0001
Cultivation	<.0001	0.001
UpBeet	0.002	0.03
Spin-Aid	ns	ns
2lf UpBeet vs. 4lf UpBeet	0.002	ns
2f Spin-Aid vs. 4lf Spin-Aid	0.08	ns

Figure 1. Effect of weed control level at harvest on beet yield.

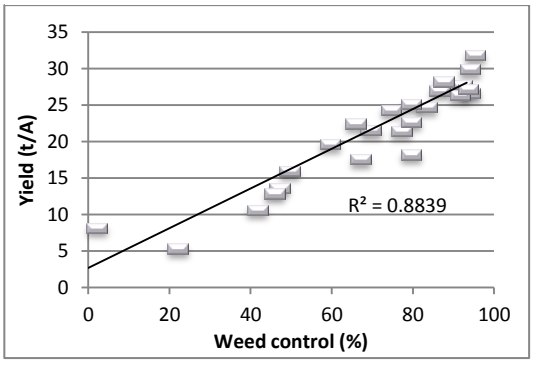

Table 3. Weed and crop response to PRE herbicides, cultivation timing, and EPOST herbicides, Corvallis, 2013.

	PRE Treatments	Timing of:			Crop injury (June 15)		Weed control (June 15)					Weed control (July 13)					
		Cultivation	UpBeet	Spin-Aid	Phyto	Stunting	Pigweed	Hairy nightshade	Lambsquarters	Shepherd's-purse	Composite rating	Pigweed	Hairy nightshade	Lambsquarters	Common purslane	Shepherd's-purse	Composite rating
					0-10		%										
1	DMag+Nortron	2lf	-		0	10	99	95	98	55	93	100	91	95	100	94	93
2	DMag+Nortron	2lf	2lf		0	13	100	99	100	100	99	100	100	100	100	100	99
3	DMag+Nortron	2lf	2lf	2lf	0	19	100	100	100	100	100	100	100	100	97	100	99
4	DMag+Nortron	2lf	4lf		0	13	100	93	74	93	92	100	100	98	100	100	98
5	DMag+Nortron	2lf	4lf	4lf	0	0	98	86	65	98	89	100	100	100	100	100	99
6	DMag+Nortron	4lf	-		0	5	99	84	67	55	89	98	95	83	100	100	85
7	DMag+Nortron	4lf	4lf		0	13	100	95	88	77	92	100	93	98	98	98	94
8	DMag+Nortron	4lf	4lf	4lf	0	5	100	79	100	75	89	100	77	100	99	100	99
9	-	2lf	-		0	0	25	25	19	25	25	55	43	73	75	60	49
10	-	2lf	2lf		0	18	88	81	66	91	76	90	89	93	75	100	83
11	-	2lf	2lf	2lf	0	18	95	85	100	100	88	53	93	98	93	100	81
12	-	2lf	4lf		0	19	80	61	80	45	71	75	93	100	80	100	84
13	-	2lf	4lf	4lf	0	10	75	65	55	60	68	97	97	88	70	100	95
14	-	4lf	-		0	5	0	0	0	0	0	91	53	63	93	100	58
15	-	4lf	4lf		0	3	3	5	5	5	5	84	97	98	96	100	89
16	-	4lf	4lf	4lf	0	5	3	3	3	3	3	78	97	95	100	93	86
17	DMag+Nortron	-	-		0	8	100	93	73	91	90	92	75	80	93	99	71
18	DMag+Nortron	-	2lf		0	10	99	91	79	95	87	94	81	69	100	100	66
19	DMag+Nortron	-	2lf	2lf	0	8	100	97	100	100	97	98	93	100	100	100	93
20	DMag+Nortron	-	4lf		0	8	100	80	88	93	86	99	93	90	100	100	91
21	DMag+Nortron	-	4lf	4lf	0	5	100	80	80	96	88	99	98	98	100	100	96
22	Nontreated	-	-	-	0	0	0	0	0	0	0	30	18	68	40	48	18
23	Handweeded	-	-	-	0	3	0	0	0	0	0	95	61	99	74	100	61
24	Nontreated	-	-	-	0	0	0	0	0	0	0	35	21	35	49	45	29
	FPLSD (0.05)				0	11	13	15	32	25	13	25	26	30	36	26	23

Table 4. Weed control and beet yield in response to PRE herbicides, cultivation timing, and EPOST herbicides, Corvallis, 2013.

	PRE Treatments	Timing of:			Weed control (At harvest, August 19)							Harvest (August 19)						
		Cultivation	UpBeet	Spin-Aid	Pigweed	Hairy nightshade	Lambsquarters	Common purslane	Shepherd's-purse	Barnyardgrass	Composite rating	Root harvested	Avg. root wt.	Grade 1	Grade 2	Grade 3	> Grade 3	Total yield
						---------- %----------						*/8.2ft of row*	*g*	---------- % ----------				*t/A*
1	DMag+Nortron	2lf	-		89	89	94	100	100	100	85	58	175	5	37	46	12	27.0
2	**DMag+Nortron**	**2lf**	**2lf**		**93**	**93**	**99**	**100**	**100**	**100**	**93**	**70**	**170**	**5**	**43**	**40**	**12**	**31.8**
3	DMag+Nortron	2lf	2lf	2lf	89	95	100	100	98	100	90	59	190	3	35	44	18	27.7
4	**DMag+Nortron**	**2lf**	**4lf**		**93**	**95**	**98**	**100**	**100**	**100**	**92**	**64**	**178**	**4**	**37**	**49**	**9**	**29.9**
5	DMag+Nortron	2lf	4lf	4lf	97	94	96	100	98	100	92	62	163	4	35	47	15	26.6
6	DMag+Nortron	4lf	-		96	75	80	100	100	100	68	58	131	16	37	38	9	21.5
7	DMag+Nortron	4lf	4lf		96	85	94	100	99	100	90	59	175	6	34	40	18	26.3
8	DMag+Nortron	4lf	4lf	4lf	96	89	100	100	97	100	92	62	174	4	37	51	7	27.2
9	-	2lf	-		73	43	91	75	75	73	45	56	93	18	48	21	5	13.6
10	-	2lf	2lf		81	64	80	100	100	93	58	57	129	10	40	42	6	19.6
11	-	2lf	2lf	2lf	70	67	93	100	100	99	64	55	152	7	45	33	13	22.5
12	-	2lf	4lf		70	80	100	100	100	96	75	53	157	5	34	44	17	21.4
13	-	2lf	4lf	4lf	84	86	91	100	100	95	81	59	163	5	43	44	7	24.7
14	-	4lf	-		86	49	58	100	100	100	40	59	61	33	45	11	6	10.6
15	-	4lf	4lf		74	88	94	100	98	100	78	62	144	7	40	41	11	22.7
16	-	4lf	4lf	4lf	71	76	95	100	100	100	78	57	116	10	43	43	3	18.2
17	DMag+Nortron	-	-		88	64	81	94	100	100	65	68	87	24	43	24	2	17.5
18	DMag+Nortron	-	2lf		88	61	76	100	100	100	48	57	89	15	50	23	6	15.9
19	DMag+Nortron	-	2lf	2lf	93	70	96	100	100	100	73	71	128	9	38	45	8	24.3
20	DMag+Nortron	-	4lf		96	83	85	100	100	100	78	75	124	8	48	39	4	25.1
21	**DMag+Nortron**	**-**	**4lf**	**4lf**	**93**	**91**	**91**	**100**	**100**	**100**	**86**	**67**	**161**	**5**	**35**	**43**	**16**	**28.2**
22	Nontreated	-	-	-	38	10	45	50	50	50	20	46	35	37	27	4	0	5.3
23	Handweeded	-	-	-	74	35	90	100	100	95	44	51	86	20	60	10	9	12.8
24	Nontreated	-	-	-	0	0	0	0	0	0	0	42	53	32	41	7	4	8.1
	FPLSD (0.05)				18	22	25	22	22	21	22	ns	62	15	ns	17	ns	8.3

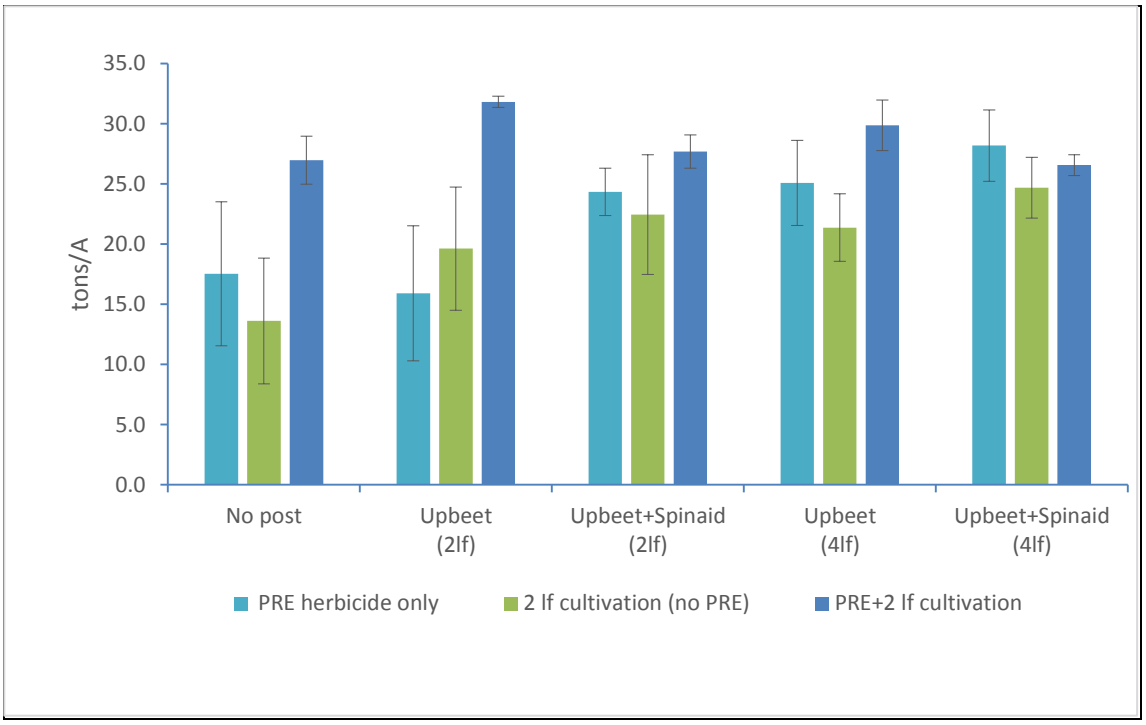

Figure 2. Effect of PRE herbicide and cultivation on UpBeet and Spin-Aid efficacy.

Exp. 2 (St. Louis)

Methods. A second experiment was placed on a grower field near St. Louis to test the efficacy and crop safety of Upbeet and Spin-Aid tank mix combinations. The soil type was Woodburn silt loam with a soil test of pH 6.70, 4.54 % OM (LOI), and CEC of 18.6 meq/100 gr soil. Ro-Neet was applied by the grower to the entire field, including the plot area. Dual Magnum (2/3 pt/A) and Nortron (16 oz/A) were applied to specified plots after planting on June 6 and incorporated with irrigation from a big gun. Spin-Aid and UpBeet were applied to 2-leaf (June 27) and 4-leaf (July 3) beets. All treatments were applied with 8003 nozzles on 20 in. centers at 30 PSI in 20 gal/A water. Weed control and crop injury were evaluated on July 11, and again at harvest on August 14.

Table 5. Herbicide application data, St. Louis.

Date	June 06, 2013	June 27, 2013	July 3, 2013
Crop stage		coty to 2-leaf max, highly variable	4-leaf
Herbicide/treatment	PPS	2-leaf	4-leaf
Application timing	PPS	2-leaf	4-leaf
Start/end time	3:15 to 3:30 PM	7:45 to 8:15 AM	8:30 to 9 AM
Air temp/soil temp (2")/surface	88/84/95	69/-/69	67/73/78
Rel humidity	37%	73%	47
Wind direction/velocity	0-3 NE	0	NE 0-2
Cloud cover	0	100	0
Soil moisture	0	Very wet, had rained for last 4 days	Wet on plots 101-103, drier on 104- 108
Plant moisture	-	Dry	Damp on rows 1-3
Sprayer/PSI	BP CO2 25 PSI	BP CO2 25 PSI	BP CO2 25 PSI
Mix size	3 gal	2100 mls	2100 mls
Gallons H20/acre	20	20	20
Nozzle type	5-XR8003	5-XR8003	5-XR8003
Nozzle spacing and height	20/24	20/24	20/24
Soil inc. method/implement	irrigation on June 7 with big gun	-	-

Results (St. Louis)

- All POST treatments improved weed control compared to Ro-Neet alone.
- Ro-Neet + Dual Magnum + Nortron (Tr. 1) caused a 40% reduction in growth compared to Ro-Neet only (Tr. 8) one month after planting, but yield was greater in Tr. 1 than Tr. 8 because of improved weed control.
- At the 2-leaf stage, UpBeet was sufficient to control weeds and maintain yield. At the 4-leaf stage, UpBeet + Spin-Aid produced the greatest yield.
- Crop injury was greatest when POST treatments were applied at the 2-leaf stage.
- A sprayer skip near the experimental plots indicated that Ro-Neet provided very good weed control.
- Beet growth in the grower portion of the field (Ro-Neet + Dual Magnum+ Nortron 32 oz/A) was significantly stunted compared to beet growth in the same treatment in the experimental plot where only 16 oz/A Nortron was applied (Ro-Neet + Dual Magnum+ Nortron 16 oz/A).

Table 6. Crop injury and weed control at the St. Louis site, 2013.

	PPI/PRE Treatments	POST treatments			Crop injury				Weed control (July 11)						Weed control at harvest					
	(gal/pt/oz)	UpBeet	Spin-Aid	Stinger	July 3		July 11		July 11						August 14					
					Phytotoxicity	Stunting	Phytotoxicity	Stunting	Pigweed	Lambsquarters	Shepherd's-purse	Prickly lettuce	Hairy nightshade	Composite rating	Pigweed	Lambsquarters	Shepherd's-purse	Prickly lettuce	Hairy nightshade	Composite rating
		leaf stage, rate/A			*0-10*	*%*	*0-10*	*%*	*% control*											
1	Roneet2/3+DMag2/3+Nortron16	-	-	-	1.0	40	0	15	100	98	98	98	98	97	100	99	98	100	99	99
2	Roneet2/3+DMag2/3+Nortron16	2-lf, 0.5 oz	-	-	1.3	48	0	23	100	100	100	100	100	100	99	98	100	100	100	99
3	Roneet2/3+DMag2/3+Nortron16	2-lf, 0.5 oz	2-lf, 1.5 pt	-	1.8	53	0	33	100	100	100	100	100	100	100	100	100	100	100	100
4	Roneet2/3+DMag2/3+Nortron16	2-lf, 0.5 oz	2-lf, 1.5 pt	2-lf, 4 oz	3.0	65	0	33	100	100	100	100	100	100	100	100	100	100	100	100
5	Roneet2/3+DMag2/3+Nortron16	4-lf, 1 oz	-	-	0.8	28	0	15	100	100	100	100	100	100	100	100	100	100	100	100
6	Roneet2/3+DMag2/3+Nortron16	4-lf, 1 oz	4-lf, 3 pt	-	0.0	30	0	18	100	100	100	100	100	100	100	100	100	100	100	100
7	Roneet2/3+DMag2/3+Nortron16	4-lf, 1 oz	4-lf, 3 pt	4-lf, 4 oz	0.0	23	0	20	100	100	100	100	100	100	100	100	100	100	100	100
8	Roneet2/3 only (check plot)	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	FPLSD (0.1)				*1.6*	*18*	-	*19*	*0*	*2*	*1*	*1*	*1*	*1*	*1*	*3*	*1*	*0*	*1*	*1*

Table 7. Table beet yield response to treatments, St. Louis, OR 2013.

	Treatments				Total biomass	Root number	Root wt.	Grade 1	Grade 2	Grade 3	Root yield
	PPI/Pre herbicide (gal/pt/oz)	UpBeet	Spin-Aid	Stinger	*kg/plot*	*no./plot*	*kg/plot*	*%*			*Ton/A*
1	Roneet 2/3+DMag 2/3+Nortron16	-	-	-	13.3	74	6.7	12	57	28	23.2
2	Roneet 2/3+DMag 2/3+Nortron16	2-lf, 0.5 oz	-	-	13.5	61	6.8	10	62	26	22.9
3	Roneet 2/3+DMag 2/3+Nortron16	2-lf, 0.5 oz	2-lf, 1.5 pt	-	12.1	60	6.3	9	57	30	22.1
4	Roneet 2/3+DMag 2/3+Nortron16	2-lf, 0.5 oz	2-lf, 1.5 pt	2-lf, 4 oz	12.6	57	6.9	9	43	39	23.5
5	Roneet 2/3+DMag 2/3+Nortron16	4-lf, 1 oz	-	-	11.1	59	5.7	9	56	32	19.6
6	Roneet 2/3+DMag 2/3+Nortron16	4-lf, 1 oz	4-lf, 3 pt	-	14.2	70	7.4	13	47	37	24.2
7	Roneet 2/3+DMag 2/3+Nortron16	4-lf, 1 oz	4-lf, 3 pt	4-lf, 4 oz	12.0	54	6.1	7	52	34	20.6
8	Roneet 2/3 only (check plot)	-	-		11.6	83	5.6	26	65	7	18.2
	FPLSD (0.1)				*ns*	*20*	*1.3*	*10*	*ns*	*16*	4.4