Aerial Seeding of Winter Cover Crops in the Mid-Atlantic USA

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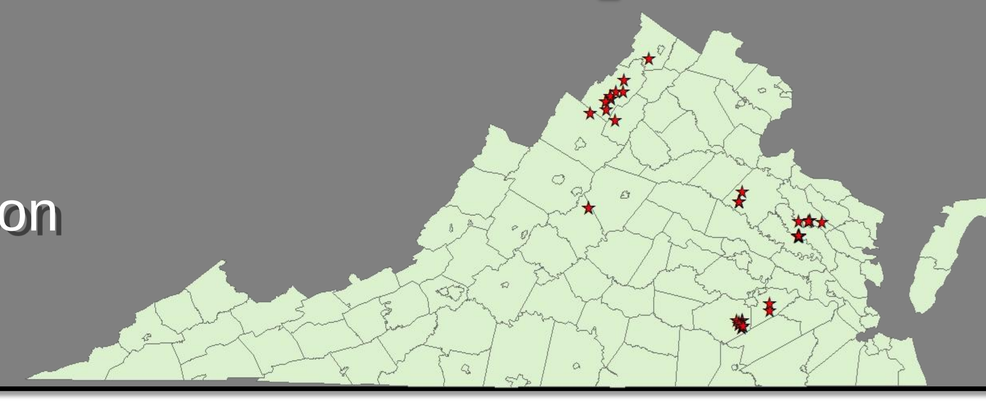

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Abstract

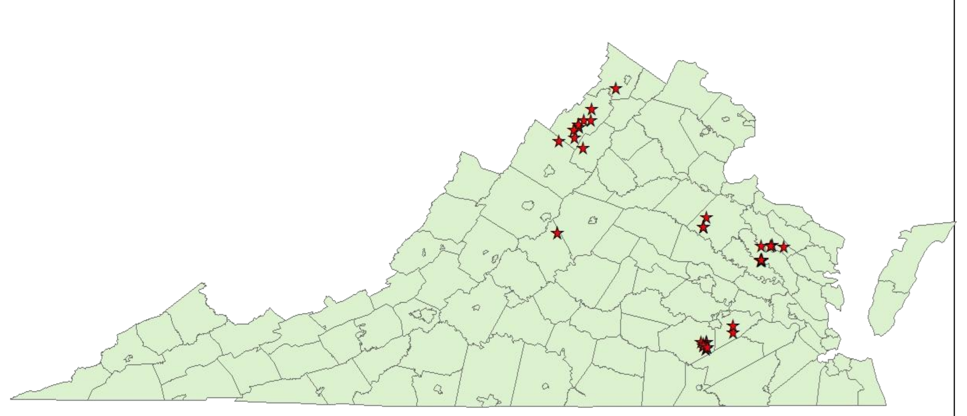
Winter annual cover crops have the potential to reduce the impact of agricultural production on the surrounding ecosystem, including the Chesapeake Bay. Cover crops are one of the main tools that will be relied upon in the coming years to help meet water quality goals, and acreage needs to expand by over 50,000 ha of cover crop annually over the next five years to meet the agreed upon goals. Seasonality of cash crop harvest is one major issue slowing the expansion of cover crop adoption. While corn silage, tobacco, and corn for grain are typically harvested in time to successfully plant a winter annual crop, harvest is always delayed on some of these acres. Similarly, harvest dates for some crops, cotton or full-season soybeans for example, are often too late for conventional seeding of winter annuals. In these cases, the most feasible approach is to broadcast seed into the standing cash crop well before harvest. This facilitates seeding at earlier dates and greater likelihood of accumulating the heat units necessary to give a winter annual cover a head start, but also increases the risk of failure. The objective of this work was to evaluate aerial cover crop seeding techniques and timing on cover crop success and performance. Thirty seven and twenty one fields that were planted to various combinations of cover crops and timings in fall 2010 and 2011, respectively, were sampled in winter and spring. In general, early seeding date was the most important factor in achieving acceptable levels of cover crop biomass by December. Seeding hairy vetch (*Vicia vilosa*) or clover (*Trifolium* sp.) alone did not typically produce adequate fall/winter biomass to provide adequate groundcover or the capacity to capture excess nutrients, and should be combined with a small grain when feasible. A successful cover crop stand was not achieved in approximately 15% of the monitored fields and were designated as failures.

Objectives

- Our hypothesis is that winter annual cover crops can contribute to achieving water quality goals for the Chesapeake Bay and that (1) alternative species, (2) adaptable cover crop systems, and (3) non-traditional seeding techniques will broaden the appeal and adoption of cover crops in Virginia.
- Our specific aim was to evaluate the growth and nitrogen (N) uptake of various aerial-seeded cover crops over diverse locations and field conditions.

Materials and Methods

- Nine cover crop species in twenty two different mixes/rates were seeded at thirty seven and twenty one sites throughout Virginia in fall 2010 and 2011, respectively. Seeding rates and cover crops used are listed in Table 2.
- Fields were aerially seeded to cover crops by plane or helicopter in all cases. Field size was at least 7 ha in all cases. In each location, three to five replications of each species or cover crop mixture were seeded in fall 2010 or 2011 (Table 2).
- In early winter and spring, percent ground cover was estimated from all plots using the line:point method. Aboveground biomass was hand clipped from a 0.5 m^{-2} area in multiple locations in each field at this time and crop samples dried in a forced air oven and dry matter yield determined. Digital photographs were taken from each treatment at this time for inclusion in presentations and fact sheets as well as analysis via VegMeasurement software.
- Crop samples were dried in a forced air oven at 60° C for 48 hr and then ground to pass a 2 mm screen using a Wiley (Thomas Scientific, Swedesboro, NJ) sample mill and total C and N determined by dry combustion (Leco Corp., St. Joseph, MI). Nitrogen uptake was determined as the product of dry matter yield and tissue N concentration.
- Analysis of variance was performed using the GLM procedure available from SAS for individual experimental locations. Mean comparisons using a protected LSD test were made to separate yield data when F-tests indicated that significant differences existed ($P<0.05$). Regression analysis was performed by cover crop type over locations and years to evaluate response trends.



Distribution of sites throughout Virginia

Table 1. Listing of cover crop species used in aerial seeding studies

Cover Crop	
Common Name	Scientific Name
Alsike Clover	*Trifolium hybridum*
Canola	*Brassica napus*
Crimson Clover	*Trifolium incarnatum*
Dwarf Essex Rape	*Brassica rapa*
Forage Radish	*Raphanus sativus*
Hairy Vetch	*Vicia villosa*
Oats	*Avena sativa*
Red Clover	*Trifolium pratense*
Rye	*Secale cereale*

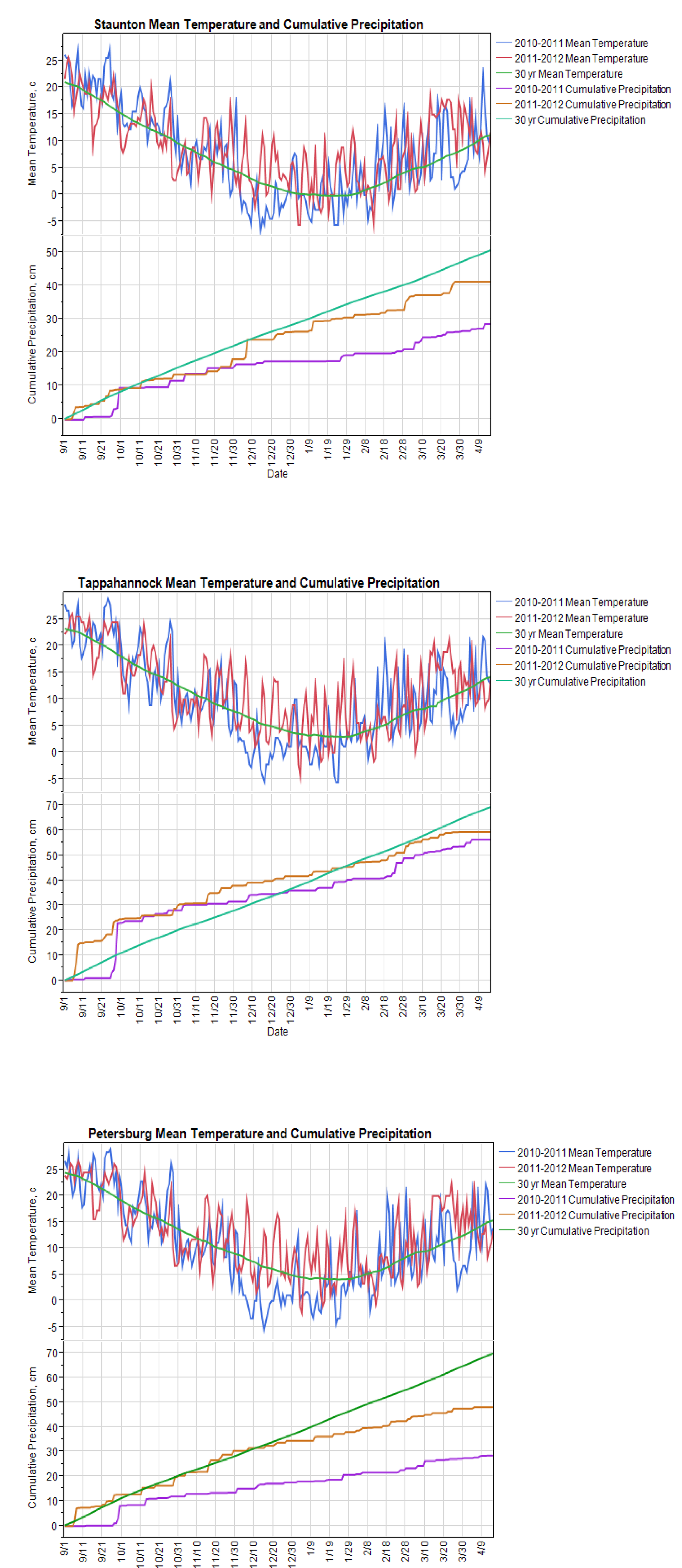
Table 2. Seeding rate by component, planting date and GDD from planting for 58 aerial-seeded fields, 2010-11 and 2011-12

SITE ID	Crop Type	Component 1	Component 2	Component 3	Seeding Date	GDD to Sample Date 1	GDD to Sample Date 2
		-----------Seeding Rate kg ha^{-1}-----------					
201101	Rye	112			8-Oct-10	935	1588
201102	Rye	112			8-Oct-10	935	1588
201103	Canola	9			8-Oct-10	935	1588
201104	Rye+Canola	112	9		8-Oct-10	935	1588
201105	Rye+Crimson Clover	112	9		20-Sep-10	1436	2089
201106	Rye	112			20-Sep-10	1436	2089
201107	Rye+Crimson Clover	112	9		20-Sep-10	1436	2089
201108	Rye	112			20-Sep-10	1436	2089
201109	Rye+Radish	112	4.5		19-Sep-10	1155	1566
201110	Rye	112			14-Oct-10	690	1222
201111	Rye	112			14-Oct-10	690	1222
201112	Rye+Radish	112	4.5		14-Oct-10	690	1222
201113	Rye	112			25-Sep-10	997	1407
201114	Rye	112			21-Sep-10	1132	1542
201115	Rye	112			25-Sep-10	997	1407
201116	Rye+Crimson Clover	112	22		25-Sep-10	997	1407
201117	Rye+Radish	112	4.5		25-Sep-10	997	1407
201118	Vetch	28			13-Oct-10	714	1246
201119	Vetch	28			13-Oct-10	714	1246
201120	Rye+Vetch	112	22		24-Sep-10	1180	1712
201121	Vetch+Radish	22	4.5		6-Oct-10	877	1410
201122	Rye	112			6-Oct-10	877	1410
201123	Alsike Clover	9			8-Oct-10	935	1588
201124	Oats+Alsike Clover	81			8-Oct-10	935	1588
201125	Oats	81	4.5		8-Oct-10	935	1588
201126	Red Clover	11			8-Oct-10	935	1588
201127	Oats+Red Clover	81	5.6		8-Oct-10	935	1588
201128	Alsike+Red Clover	9	5.6		8-Oct-10	935	1588
201129	Alsike	9			8-Oct-10	935	1588
201130	Oats	81			8-Oct-10	935	1588
201131	Oats+Alsike Clover	81	4.5		8-Oct-10	935	1588
201132	Red Clover	11			8-Oct-10	935	1588
201133	Oats+Red Clover	81	5.6		8-Oct-10	935	1588
201134	Alsike+Red Clover	9	5.6		8-Oct-10	935	1588
201135	Rye	112			8-Oct-10	935	1588
201136	Rye	112			8-Oct-10	935	1588
201137	Rye	112			8-Oct-10	935	1588
201201	Rye+Radish+Crimson Clover	84	4.5	22	21-Sep-11	1078	1743
201202	Dwarf Essex Rape	17			13-Oct-11	794	1447
201203	Dwarf Essex Rape	17			13-Oct-11	794	1447
201204	Dwarf Essex Rape	17			13-Oct-11	794	1447
201205	Dwarf Essex Rape	17			13-Oct-11	794	1447
201206	Rye	112			26-Sep-11	947	1611
201207	Rye	112			21-Sep-11	1440	2294
201208	Rye	112			25-Sep-11	973	1637
201209	Rye	112			25-Sep-11	973	1637
201210	Rye	112			19-Sep-11	1126	1791
201211	Rye	112			17-Sep-11	1548	2402
201212	Rye	112			22-Sep-11	1404	2258
201213	Rye	112			17-Sep-11	1164	1825
201214	Dwarf Essex Rape	11			10-Oct-11	884	1537
201215	Dwarf Essex Rape	17			10-Oct-11	884	1537
201216	Dwarf Essex Rape	22			10-Oct-11	884	1537
201217	Vetch+Radish	22	4.5		14-Sep-11	1618	2472
201218	Vetch+Radish	22	4.5		14-Sep-11	1618	2472
201219	Vetch+Radish	22	4.5		14-Sep-11	1618	2472
201220	Vetch+Radish	22	4.5		14-Sep-11	1618	2472
201221	Dwarf Essex Rape	11			20-Oct-11	638	1291

Establishment of winter annual cover in corn stover

Above ground biomass determined on Hairy Vetch

Figure 4. Mean annual temperature and cumulative precipitation for three regions in Virginia



Aerial broadcast rye captured on a tarp between corn rows

Aerial broadcast rye caught on soybean leaves

Results and Discussion

- December harvested biomass from all plots with rye only (33 fields) are shown in Figure 5, ranked from highest to lowest yield. Six of the 33 fields had less than 600 kg/ha biomass and had in common very low germination due to lack of rainfall after seeding. The highest biomass was observed when seeding occurred before September 20, followed by those fields seeded by the end of the first week of October.

Figure 5. Rye-only aerial seeded biomass harvested in December

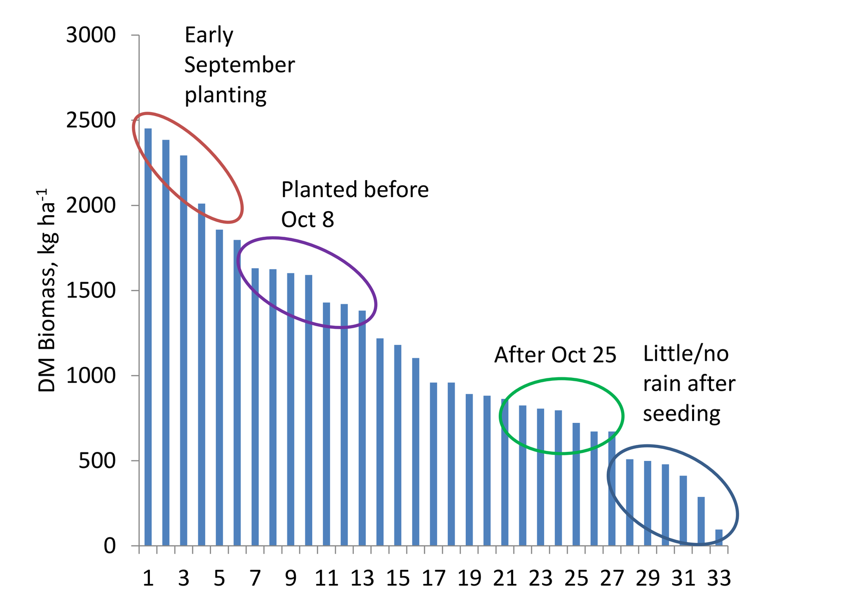
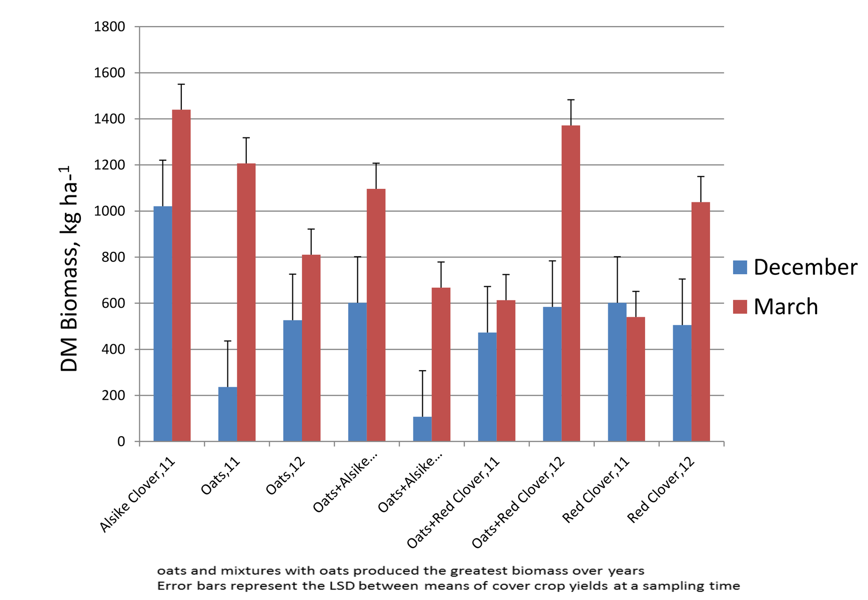
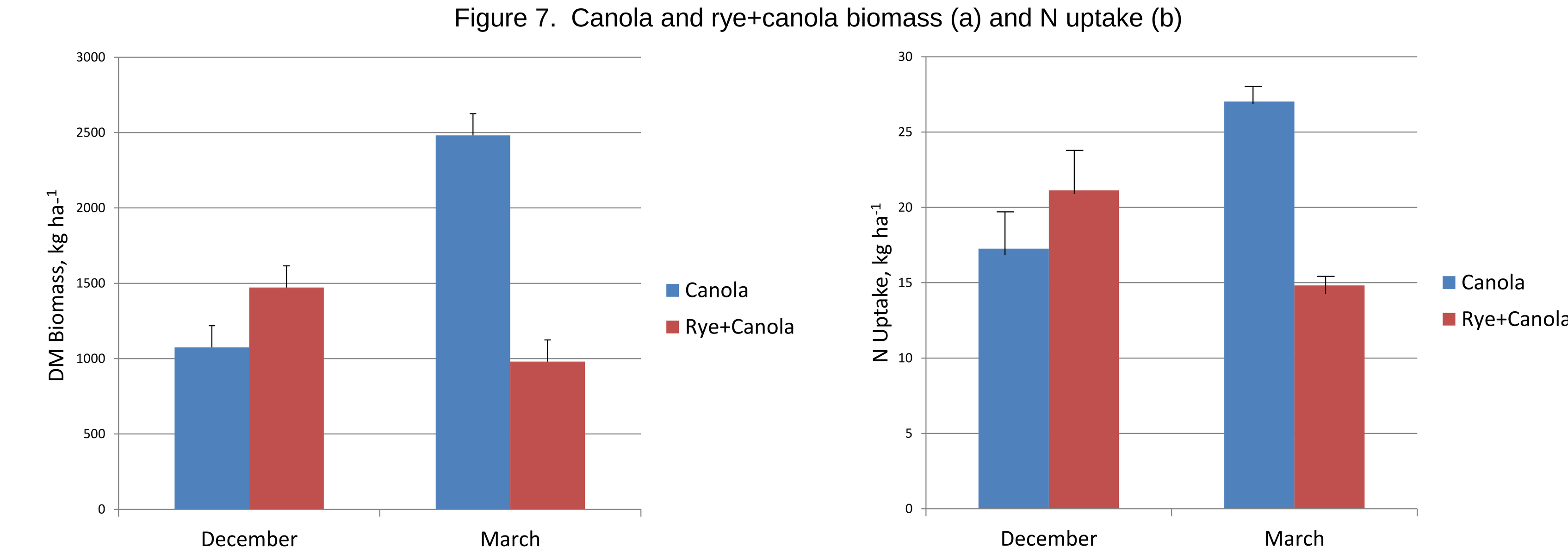


Figure 6. Oats, alsike and red clover biomass in winter and spring



- One study conducted in both 2010-11 and 2011-12 compared oats, alsike clover, and red clover alone and in combination (Figure 6). Red clover is reported to suppress soybean cyst nematode and alsike to do well on slow draining soils. Alsike clover alone and in mixture, along with oats+red clover produced the greatest average spring and winter biomass.
- Canola, alone and in combination with rye, has shown potential as an aerial-seeded cover crop by producing over 1000 kg ha^{-1} by December (Figure 7).

Figure 7. Canola and rye+canola biomass (a) and N uptake (b)



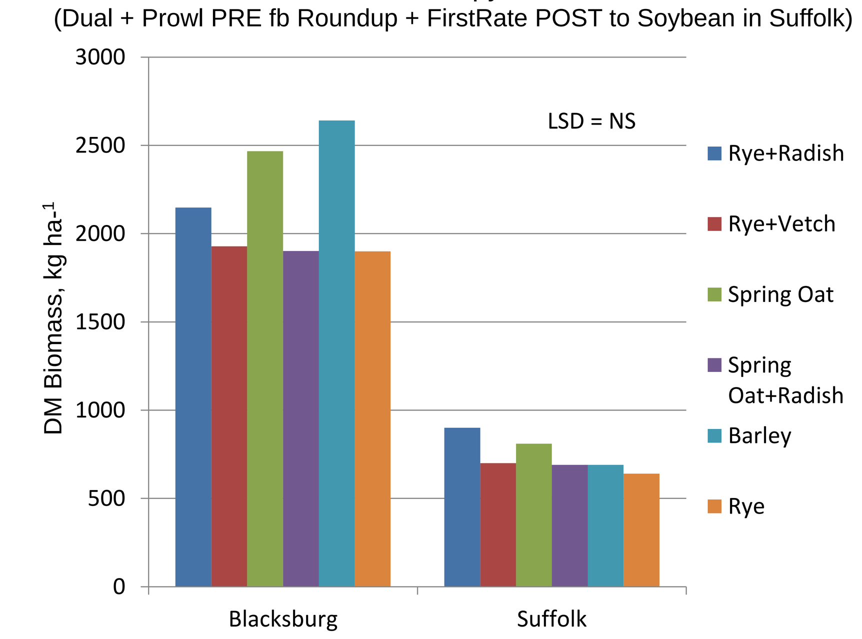
Error bars represent the LSD between means at a sampling date

- Total season biomass, N uptake, and CN ratio measured before cover crop termination in March is presented in Table 3. Rye, mixtures with rye and canola had the highest dry matter yield, averaging over 2000 kg ha^{-1}.

Table 3. March biomass, N uptake and CN ratio, mean over locations and years

	Dry Matter Yield	N uptake	C:N Ratio
	----------kg ha^{-1}----------		
Rye+Crimson Clover	3258	41	21.2
Rye+Vetch	2704	26	10.3
Rye+Radish	2519	41	14.8
Canola	2482	27	28.1
Rye+Radish+Crimson Clover	2368	43	13.1
Vetch+Radish	2326	78	11.3
Vetch	2281	80	11.9
Rye	2181	47	17.3
Oats	1009	17	16.1
Oats+Red Clover	992	23	20.7
Rye+Canola	980	15	26.9
Alsike Clover	884	12	19.9
Oats+Alsike Clover	882	15	20.1
Red Clover	789	14	19.0
Dwarf Essex Rape	757	15	13.8

Figure 8. Cover Crop Species and Broadcast Seeding into Soybean Canopy
(Dual + Prowl PRE fb Roundup + FirstRate POST to Soybean in Suffolk)



- One study was conducted in 2011-12 evaluating multiple cover crop species broadcast seeded into soybeans at two locations (Figure 8). While there were no significant differences between treatments within locations, there was more than twice the average biomass at the Blacksburg site compared to Suffolk. It is believed that residual FirstRate herbicide carryover at Suffolk resulted in suppressed cover crop growth.

Conclusions

- Growing season temperatures in 2010-11 were near the 30-yr mean, but 2011-12 was warmer. Cumulative rainfall was lower than the 30-yr mean at two of three sites that were centrally located near our sampling locations (Figure 4).
- A successful cover crop stand was not achieved in approximately 15% of the monitored fields, and therefore were designated as failures. Lack of adequate and consistent rainfall and moisture were the cause (data not shown).
- Early seeding and thus greater GDD accumulation was the practice most responsible for high levels of fall season rye biomass production.
- Rye or mixtures that contained rye were generally the most productive and had the greatest N uptake when measured over experiments in March of both years.
- Canola shows promise as an aerial seeded cover crop, not least because of small seed size which results in greater efficiency for applicators.
- At these planting dates, vetch alone did not produce adequate fall growth to protect soil or scavenge nutrients (data not shown).
- More information is needed about the effects of residual herbicides on cover crop performance, but in some cases reduced cover crop growth has been observed.