Project Report to the
Oregon Processed Vegetable Commission

Nitrogen Contribution of Winter Annual Cover Crops to Sweet Corn Production in Western Oregon

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Introduction and Justification

There is an increasing interest among Oregon vegetable producers in the use of cover crops to improve soil quality, provide biologically fixed nitrogen to reduce fertilizer inputs, and reduce ground water contamination. Because of the cost associated with cover crop establishment and spring incorporation ($25-40/acre), the ability to account for N contribution from the cover crop and reduce fertilizer inputs could help offset the cover crop costs. Although there is an extensive scientific literature documenting the N contribution of legume cover crops to succeeding cash crops (Hoyt 1987; Mangan 1991; Sharphol et al. 1987; Shennan 1992; Knavel and Herron, 1986), there are several problems associated with making this information useful to vegetable growers in the maritime Pacific Northwest, including:

- Most of the reported work has been in field crops (e. g. corn and sorghum) and has been conducted in the eastern and southeastern United States. Geoclimatic conditions of the Pacific Northwest are unique for cover crop production, as are the nutrient requirements and management considerations for vegetable crops. There is a critical need for regional data generated under a variety of weather conditions, soils and cropping systems.

- Much of the reported work on developing N fertilizer equivalencies for cover crops (how much N fertilizer value a cover crop contributes) has been conducted growing crops following cover crops without any supplemental N fertilizer. Frye and Blevins (1989), however, report highest crop yields and highest net economic return following cover crops plus optimum rates of N fertilizer. For high N-use vegetable crops such as broccoli and sweet corn, data are needed to give growers confidence in reducing N fertilizer application rates when used in conjunction with cover crops. Without reliable information, growers will likely continue to use their normal rates of N fertilizer which could potentially exacerbate non-point source ground water contamination from excessive soil nitrogen.

- Most of the reported work on N fertilizer replacement values for cover crops has been for single species. Considerable interest exists among growers, Extension personnel and researchers on the role mixtures of legumes with grasses or grains in reducing winter N -leaching as well as maximizing biomass production for soil tilth improvement. Grasses and grains, because of their ability to become quickly established in the fall and establish an extensive root system, have been shown to be more efficient than legumes at capturing soil nitrate and preventing late fall and winter leaching to the ground water (Meisinger et al. 1990; Muller et al. 1987). Legumes, however, because of their symbiotic ability to fix atmospheric N, consistently contribute more N to the succeeding crop than grass or grain cover crops (Ebelhar et al 1984; Shennan 1992; Sullivan et al. 1990), with the grasses and grains frequently reducing succeeding crop yields due to N immobilization (Sullivan et al. 1990; Reeves and Touchton 1991). Legume and grain mixtures may offer the "best of both worlds" in terms of achieving multiple benefits which would not be provided by a single cover crop species. Because of the typical growth habits of the grain/legume mixtures in western Oregon, in which the grain grows rapidly in the fall and winter, (capturing soil nitrate) and the legume grows rapidly in the spring (fixing atmospheric nitrogen), these mixtures appear compatible for accomplishing multiple goals.

Objectives

The goal of this work is enhance vegetable producers' ability to optimize N fertilizer application rates for crops following winter annual cover crops. Specific objectives of this project include:

1. To evaluate relative growth rates, biomass production, and nitrogen accumulation of selected cover crops species and mixtures.

2. Evaluate the nitrogen contribution of winter annual cover crops to sweet corn production.

Procedures

This experiment was designed as a partially replicated strip plot experiment. Ten mixtures of grain and legume mixtures were planted in unreplicated strip plots 48 x 270 ft on Oct. 13, 1993 at the Grover Farm , near Keizer, OR (Table 1). The soil series is a Claquato silt loam; previous crops were sweet corn in 1993 and onions in 1992., The cover crop mixtures were drilled using a 12' John Deere grain drill after seedbed preparation with a subsoiler and disk harrow. Cover crop above-ground biomass was sampled on three dates in the spring of 1994 by clipping cover crops at the soil level in 0.25 m^2 quadrats at 6 locations randomly selected within each plot. Grain and legume components of the mixtures were separated as they were clipped. Samples were returned to the laboratory and air dried at 100^{o}F for 24-48 hours. Dried plant tissue was then ground and digested for N analysis using the Kjeldahl process. Nitrogen analysis was performed by the OSU Central Analytical Laboratory.

Cover crops were soil incorporated on April 22, 1994, using two passes of a disk harrow. Jubilee sweet corn was planted on June 7 on 30" centers, phosphorus and potassium fertilizers were banded at planting at rates typically used for sweet corn on the Grover Farm. No N fertilizers were applied at planting. Within each cover crop strip, a completely randomized design of 4 nitrogen fertilizer rates (0, 60, 120, 180 lbs N/acre) and 3 replications was used. Plots were 6 corn rows x 48 feet. Nitrogen fertilizer (urea, 46-0-0) was applied in a six-inch wide band along one side of the corn on July 13.

Corn in-husk yield was determined on Sept. 16 by hand-harvesting and weighing all ears greater than 7" long in 40 foot sections of the two center rows of each plot . Analysis of variance was used to compare effects of N fertilizer within each cover crop treatment; means were compared using LSD procedures ($p = 0.10$). Because cover crop plots were not replicated, no statistical comparisons could be made among cover crop effects on yield.

Results

Cover Crop Biomass. The rapid spring growth of cover crops is illustrated by the nearly doubling of dry-matter biomass for most cover crops from April 8 to April 21 (Table 1). Since cereal rye is well known for its rapid spring growth, often producing more biomass than can be easily mechanically incorporated into the soil, one of the objectives of this trial was to seek grain cultivars which would be more short-statured and produce a more manageable quantity of biomass in the spring. All cover crop mixtures produced similar biomass on the earlier two sampling dates (March 16 and April 8), but by the final sampling date (April 21) the rye + Austrian field pea (henceforth referred to as "pea") mixture had nearly one ton more biomass than the Hesk barley + pea mixture (Table 1). Mixtures using Hesk barley and Monida oat generally produced less total biomass than the mixtures using cereal rye or Mica barley.

One factor of interest in this research is the relative proportion of grain vs. legume in the cover crop mixtures. A higher proportion of legume at time of incorporation would suggest a greater probability that the N of the cover crop mixture would be rapidly mineralized and made available for uptake by the vegetable crop (since legumes typically have a lower C:N ratio). In this study, the Hesk barley + common vetch (Vicia sativa) and the Monida oat + common vetch mixtures had legume to grain ratios of approximately 2:3, compared to ratios of 1:8 ratios for Mica barley + peas and 1:4 ratios for the rye + pea mixture (Table 1, Fig. 1).

Cover Crop N Content. Total nitrogen contained in the above-ground biomass of the cover crops is shown in Table 2. Cover crop mixtures produced relatively similar total quantities of N by the April 21 sample date (89-124 lbs), however the ratio of N produced by the grains and legumes varied considerably. For example, in the Monida oats + common vetch mixture, the legume to grain N contribution was identical (57 lbs each). In the cereal rye + peas, however, the contribution was 86 and 17 lbs N respectively.

Corn Yield. In-husk corn yield increased in most cover crop treatments with application of N fertilizer (compared to 0 N), although interestingly this response was not statistically detectable in the fallow plot (Fig. 1). Considerable variability in corn yield within similar treatments reduced the ability to statistically distinguish N effects within cover crop treatments (i.e. yield differences of nearly 2 tons were not statistically different in the Monida oat + common vetch mixture.) The data do suggest, however, that some cover crops (for example O + CV) had a more favorable impact on sweet corn yield than mixtures containing cereal rye.

Clearly one of the major problems with this experiment is the ability to compare corn yield means among cover crop treatments because of the lack of replication, and the inability to detect relatively large N fertilizer effects because of yield variation within treatments. In the 1994-95 cover crop trials, which were established on 8 farms in the Willamette Valley in October, 1994, all cover crop treatments have 4 replications. N fertilizer rates in the 1995 sweet corn crop will be replicated within the cover crop trials as in 1994.

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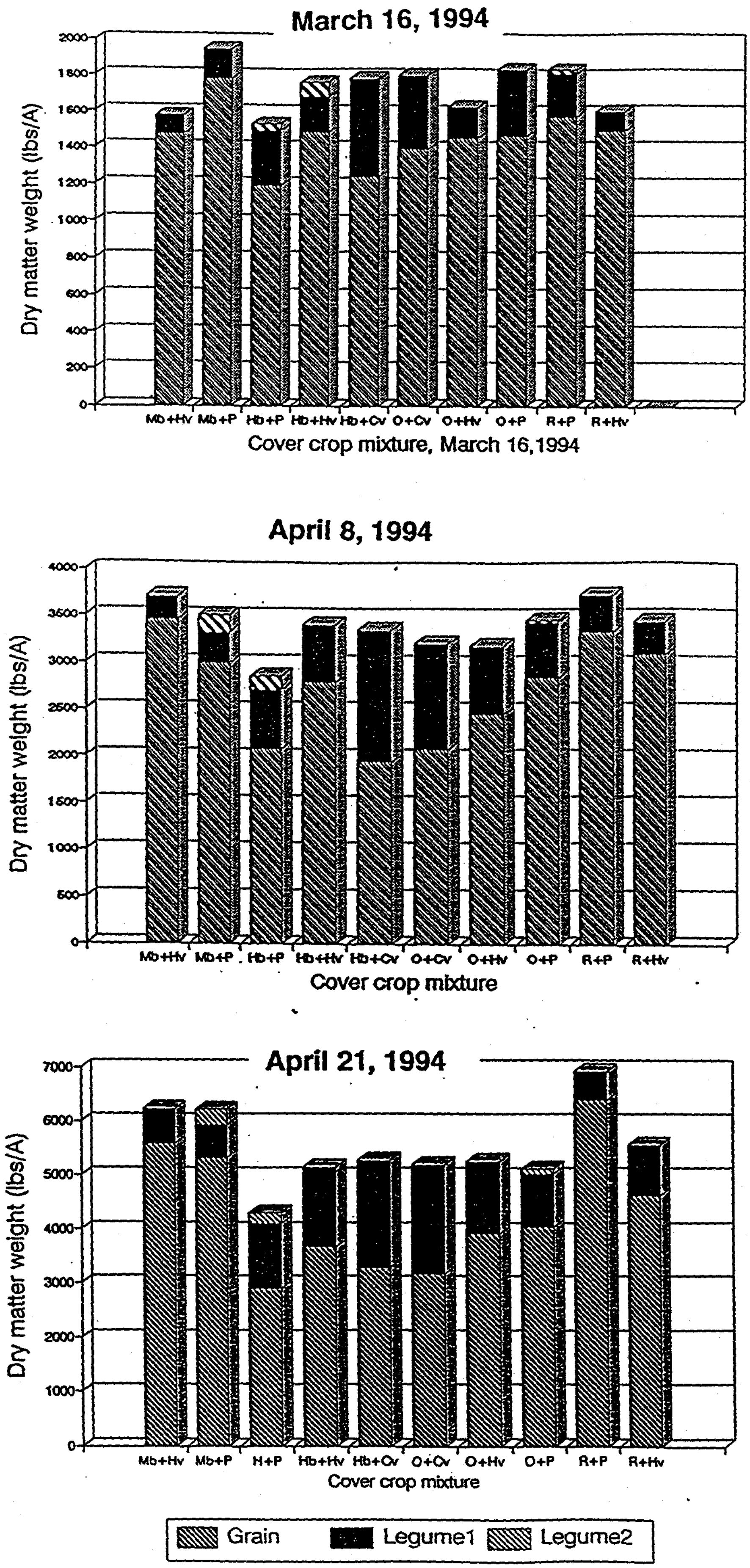
Table 1. Seasonal accumulation of above-ground cover crop biomass at the Grover Farm, Salem, OR, 1994.

Cover crop mixture (Component species)	Seeding Rate (lbs/acre)	Dry weight (lbs/acre) Above-ground biomass		
		March 16	April 8	April 21
Mica barley + Hairy vetch	**62**	**1,581**	**3,723**	**6,246**
Mica barley	47	1,476	3,454	5,582
Hairy vetch	15	105	269	664
Mica barley + Austrian peas	**112**	**1,993**	**3,514**	**6,231**
Mica barley	61	1,781	2,987	5,329
Austrian peas	51	172	338	610
Common vetch (Seed contaminate with Peas)		40	189	292
Hesk barley + Austrian peas	**100**	**1,580**	**2,862**	**4,317**
Hesk barley	50	1,190	2,073	2,906
Austrian peas	50	307	635	1,202
Common vetch (Seed contaminate with Peas)		83	154	209
Hesk barley + Hairy vetch	**76**	**1,691**	**3,423**	**5,167**
Hesk barley	54	1,487	2,786	3,672
Hairy vetch	22	204	637	1,495
Hesk barley + Common vetch	**92**	**1,790**	**3,368**	**5,294**
Hesk barley	51	1,243	1,945	3,291
Common vetch	41	547	1,423	2,003
Monida oats + Common vetch	**84**	**1,808**	**3,218**	**5,217**
Monida oats	47	1,394	2,075	3,173
Common vetch	37	414	1,143	2,044
Monida oats + Hairy vetch	**63**	**1,630**	**3,193**	**5,285**
Monida oats	45	1,457	2,455	3,934
Hairy vetch	18	173	738	1,351
Monida oats + Austrian peas	**110**	**1,868**	**3,465**	**5,153**
Monida oats	55	1,466	2,835	4,054
Austrian peas	55	377	599	991
Common vetch (Seed contaminate with Peas)		25	31	108
Cereal rye + Austrian peas	**104**	**1,820**	**3,744**	**6,956**
Cereal rye	52	1,575	3,333	6,401
Austrian peas	52	245	411	555
Cereal rye + Hairy vetch	**70**	**1,609**	**3,457**	**5,590**
Cereal rye	50	1,496	3,092	4,635
Hairy vetch	20	113	365	955

Fig. 1. Relative contribution of grain and legume components of dry weight biomass of cover crop mixtures.



Legend:

Mb+Hv = Mica barley + Hairy vetch
Mb+P = Mica barley + Austrian peas (*)
Hb+P = Hesk barley + Austrian peas(*)
Hb+Hv = Hesk barley + Hairy vetch
Hb+Cv = Hesk barley + Common vetch
O+Cv = Monida oats + Common vetch
O+Hv = Monida oats + Hairy vetch
O+P = Monida oats + Austrian peas(*)
R+P = Cereal rye + Austrian peas
R+Hv = Cereal rye + Hairy vetch

* Legume 2 = Common vetch (Seed contaminate w

Table 2. Seasonal accumulation of nitrogen in cover crop mixtures, Grover Farm, 1994.

	March 16			April 8			April 21		
Cover Crop Mixture	Total biomass (lb/A)	Percent Nitrogen	Total Nitrogen (lb/A)	Total biomass (lb/A)	Percent Nitrogen	Total Nitrogen (lb/A)	Total biomass (lb/A)	Percent Nitrogen	Total Nitrogen (lb/A)
Mica Barley + Hairy Vetch	**1,581**	**1.58**	**25**	**3,723**	**2.06**	**77**	**6,246**	**1.67**	**104**
Mica Barley	1,476	1.43	21	3,454	1.90	66	5,582	1.49	83
Hairy Vetch	105	4.08	4	269	4.08	11	664	3.14	21
Mica Barley + Austrian Peas	**1,993**	**2.21**	**44**	**3,514**	**2.33**	**82**	**6,231**	**1.75**	**109**
Mica Barley	1,781	2.06	37	2,987	2.01	60	5,329	1.48	79
Austrian Peas	172	3.68 [a]	6	338	4.15	14	610	3.44	21
Common Vetch *	40	3.69 [b]	1	189	4.28	8	292	3.21	9
Hesk Barley + Austrian Peas	**1,580**	**2.78**	**44**	**2,862**	**2.55**	**73**	**4,317**	**2.27**	**98**
Hesk Barley	1,190	2.50	30	2,073	2.02	42	2,906	1.72	50
Austrian Peas	307	3.68 [a]	11	635	4.10	26	1,202	3.43	41
Common Vetch *	83	3.69 [b]	3	154	3.56	5	209	3.32	7
Hesk Barley + Hairy Vetch	**1,691**	**2.66**	**45**	**3,423**	**2.40**	**82**	**5,167**	**2.23**	**115**
Hesk Barley	1,487	2.44	36	2,786	2.02	56	3,672	1.88	69
Hairy Vetch	204	4.30	9	637	4.16	26	1,495	3.10 [c]	46
Hesk Barley + Common Vetch	**1,790**	**2.96**	**53**	**3,368**	**3.06**	**103**	**5,294**	**2.34**	**124**
Hesk Barley	1,243	2.65	33	1,945	2.52	49	3,291	1.78	59
Common Vetch	547	3.69	20	1,423	3.79	54	2,003	3.25	65
Monida Oats + Common Vetch	**1,808**	**2.43**	**44**	**3,218**	**2.56**	**82**	**5,217**	**2.18**	**114**
Monida Oats	1,394	1.79	25	2,075	1.71	35	3,173	1.79	57
Common Vetch	414	4.51	19	1,143	4.09	47	2,044	2.79	57
Monida Oats + Hairy Vetch	**1,630**	**2.02**	**33**	**3,193**	**1.87**	**60**	**5,285**	**2.07**	**109**
Monida Oats	1,457	1.84	27	2,455	1.26	31	3,934	1.48	58
Hairy Vetch	173	3.45	6	738	3.92	29	1,351	3.77	51
Monida Oats + Austrian Peas	**1,868**	**2.30**	**43**	**3,465**	**2.05**	**71**	**5,153**	**1.73**	**89**
Monida Oats	1,466	1.88	28	2,835	1.64	46	4,054	1.31	53
Austrian Peas	377	3.68 [a]	14	599	3.97	24	991	3.33	33
Common Vetch *	25	3.69 [b]	1	31	3.89	1	108	2.89	3
Cereal Rye + Austrian Peas	**1,820**	**2.80**	**51**	**3,744**	**2.44**	**91**	**6,956**	**1.48**	**103**
Cereal Rye	1,575	2.66	42	3,333	2.26	75	6,401	1.35	86
Austrian Peas	245	3.68	9	411	3.91	16	555	2.99	17
Cereal Rye + Hairy Vetch	**1,609**	**2.30**	**37**	**3,457**	**2.37**	**82**	**5,590**	**1.93**	**108**
Cereal Rye	1,496	2.12	32	3,092	2.18	67	4,635	1.70	79
Hairy Vetch	113	4.12	5	365	4.16	15	955	3.05	29

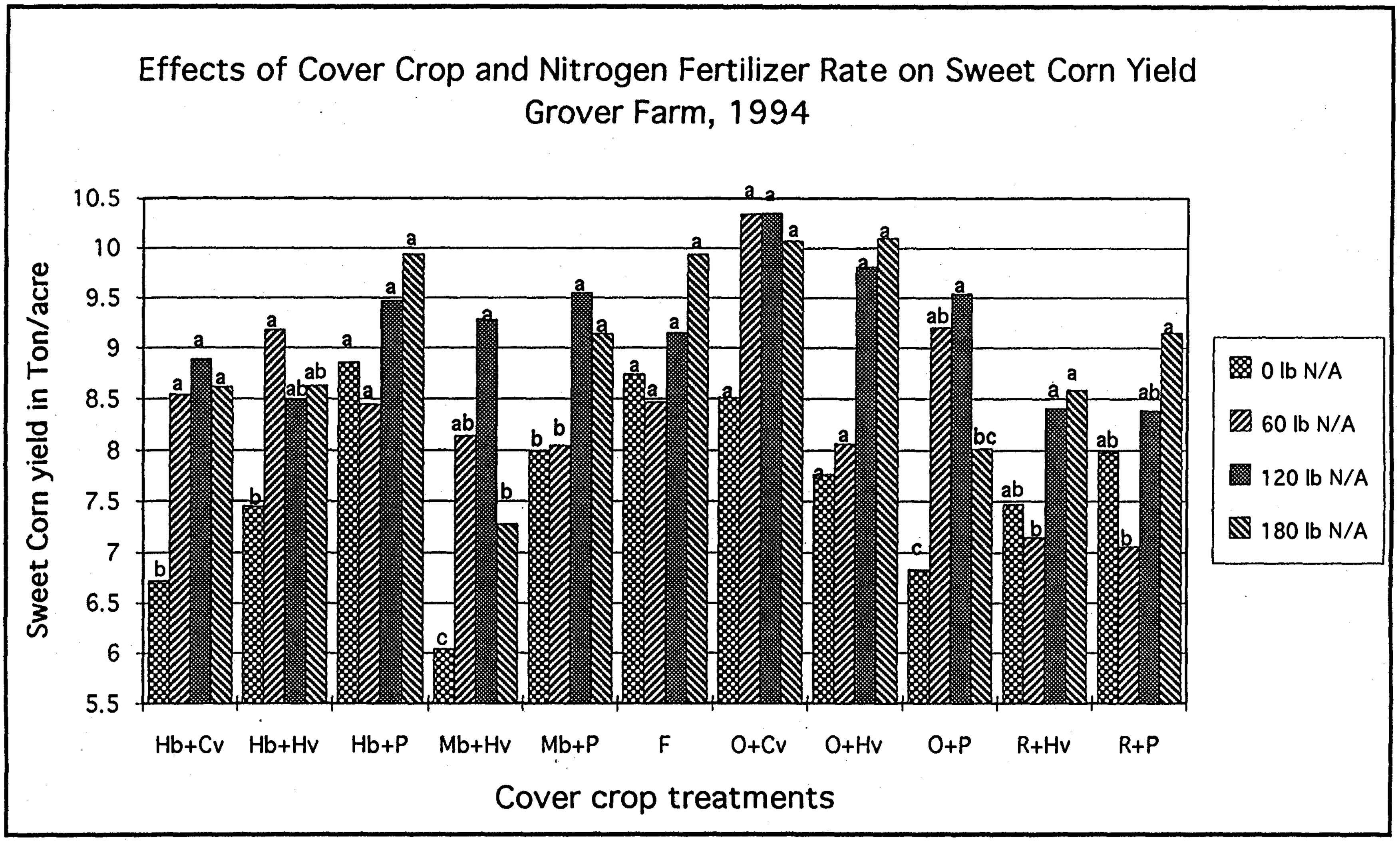
* Common vetch is seed contaminate with Austrian peas.

[a] Data missing for Austrian peas in the Mica barley + Austrian peas, Hesk barley + Austrian peas, and Monida oats + Austrian peas mixtures. Percent nitrogen of Austrian peas is estimated from the Cereal rye + Austrian peas mixture.

[b] Data missing from Common vetch in the Mica barley + Austrian peas, Hesk barley + Austrian peas, and Monida oats + Austrian peas mixtures. Percent nitrogen of Common vetch is estimated from the Hesk barley + Common vetch mixture.

[c] Data missing for hairy vetch in the Hesk barley + hairy vetch mixture. Percent nitrogen of hairy vetch is estimated from the Mica barley + hairy vetch mixture.

Fig. 2. Effects of cover crops and N fertilizer rates on sweet corn in-husk yield, Grover Farm, 1994. Note: similar letters above bars within cover crop treatments indicate no statistically significant differences (p = .10). No statistical comparisons can be made among the cover crop treatments because of lack of replication.



Legend:

Hb+Cv	=	Hesk barley + Common vetch	O+Cv	=	Monida oats + Common vetch
Hb+Hv	=	Hesk barley + Hairy vetch	O+Hv	=	Monida oats + Hairy vetch
Hb+P	=	Hesk barley + Austrian peas	O+P	=	Monida oats + Austrian peas
Mb+Hv	=	Mica barley + Hairy vetch	R+Hv	=	Cereal rye + Hairy vetch
Mb+P	=	Mica barley + Austrian peas	R+P	=	Cereal rye + Austrian peas
F	=	Fallow			