NITROGEN CONTRIBUTION TO ORGANIC BROCCOLI FROM A MIXED LEGUME/CERIAL COVER CROP

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ABSTRACT

Two trials were conducted to evaluate the contribution of nitrogen (N) from a mixed legume/cereal cover crop to the successive organic broccoli crop. Trial No. 1 was conducted at the Center for Agroecology and Sustainable Food System organic farm at the University of California Santa Cruz and Trial No. 2 at the Hartnell East Campus Research Facility in Salinas. Cover crops were grown over the winter and incorporated into the soil in the spring of 2006. A randomized block design or a split plot design was utilized with cover crop and no cover crop as the main plots and 0, 84, 168 and 252 kg-N/ha of commercial organic fertilizer(s) as the other main plots (Trial No. 1) or the split plot treatment (Trial No. 2). Broccoli was grown to maturity. Mineral N in the top 30cm of soil was measured over the season, N in above-ground biomass (broccoli-N) was measured at midgrowth and at harvest, and harvest evaluations were conducted. Broccoli yield was significantly increased by both cover crop and organic N fertilizer applications. The cover crop in Trial No. 1 contained 179 kg-N/ha. N-uptake by broccoli indicated 42 kg more broccoli-N in the cover crop treatments at harvest. The cover crop in Trial No. 2 contained 218 kg-N/ha. 300 mm of rain fell between incorporation of the cover crop and planting of the broccoli. A sizeable portion of mineralized N from the cover crop was assumed to be lost to nitrate leaching. Evaluations of N uptake indicated 30 kg more broccoli-N in the cover crop treatments at harvest. These results showed that 14 to 23% of cover crop N was utilized by the successive broccoli crop. Further, incorporated cover crops increased broccoli-N in a manner similar to 71 to 92 kg-N/ha of applied organic fertilizer.

INTRODUCTION

Nitrogen (N) is the most common limiting plant nutrient, and N fertility management is therefore an important but costly part of organic vegetable production. Nitrogen for organic production is available from a number of sources: mineralization of N from soil organic matter, compost, recently incorporated crop and cover crop residues, and organic fertilizers. Cover crops provide an inexpensive source of nitrogen for crop production.

The process of mineralization of N from cover crop residue is regulated by adequate soil moisture and temperatures (i.e. > 10° C). It is difficult to achieve a precise understanding of the release characteristics of mineral nitrogen from cover crops. This is because nitrogen release from organic residues is mediated by soil microorganisms that utilize carbon from the cover crop as an energy source and nitrogen as a basic protein building block for growth. They release nitrate and ammonium to the pool of mineral nitrogen in the soil after their immediate needs for N are satisfied.

The rate of mineralization of available N from a low C:N (<20) cover crop typically increases over a three- to six-week period following incorporation, and then returns to pre-incorporation levels by week 6-8 (Gaskell 2004). Therefore a cover crop can be a valuable source of short term N but longer season vegetable crops following a cover crop rotation may require supplemental applications of fertilizer N to supply late season N.

Nitrogen added to the soil from cover crops may stay in the soil microbial biomass and organic matter fraction of the soil and be available for subsequent cash crop growth many months after incorporation in to the soil. For instance, the recovery of nitrogen from a cover crop may only be in the range of 10 - 30% for the first cash crop following incorporation; however one study using N15 showed that up to 73% of cover crop nitrogen was recovered in the five subsequent crops following incorporation of the cover crop (Crews and Peoples 2005). Therefore, cover crops provide nitrogen for immediate cash crop growth, but can be retained in the soil organic matter/microbial biomass fraction of the soil for release for crop growth in subsequent years. The effectiveness of cover crop residue in providing N for subsequent crop growth largely depends upon the synchrony of release of nitrogen from the cover crop with N crop demand by the subsequent cash crop.

GOAL

- To examine the role of a legume/cereal mix cover crops in supplying nitrogen for broccoli nutrition in the first season following cover crop incorporation.

METHODS

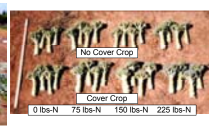
Trial No. 1 was conducted at the Center for Agroecology and Sustainable Food System organic farm in University of California Santa Cruz and Trial No. 2 at the Hartnell East Campus Research Facility in Salinas.

Mixed cover crops were grown over the winter and incorporated into the soil in the spring. A randomized block design or a split plot design with four replicates was utilized with cover crop and no cover crop as the main plots and 0, 84, 168 and 252 kg-N/ha as the other main plots (Trial No. 1) or the split plot treatment (Trial No. 2). Broccoli was grown to maturity and mineral nitrogen (N) in the top 30cm of soil was measured over the season, tissue nitrogen was measured at midgrowth and at harvest, and harvest evaluations were conducted. See below for detail cultural practices for each trial.

Trial 1

A mixed legume cover crop was planted to the entire plot at the rate of 199 kg/ha on November 17, 2005. The proportion of the different varieties was the following: 4% 'Cayuse' oats (*Avena sativa*); 48% Bell beans (*Vicia faba*); and 48% 'Lana' wooly pod vetch (*Vicia villosa* spp. dasycarpa). The cover crops were mowed on May 8, 2006. Mowed cover crop residue (above ground shoots) was removed manually with rakes and a blower from the "No cover crop" plots on May 10. Biomass and total nitrogen content of the cover crop were measured prior to incorporation. All plots were tilled with a mechanical spader on May 15. Feather meal (12-0-0) was manually broadcast on the beds as a preplant N on June 15. The fertilizer was applied at four rates: 0, 56, 112 and 168 kg-N/ha, and was rototilled into the beds immediately after application. After reshaping the beds, broccoli of the variety BOS 1095 was direct seeded at a 7.5cm spacing (double lines per bed) using Stanhay precision seeders on June 21. Broccoli plants were thinned to 22.5cm spacing on July 10 and 11 and then high flow drip tape (single line per bed) was laid out and used for irrigation for the duration of the cropping cycle. Blood meal (12-0-0) was applied on July 25 as a supplemental N at four rates: 0, 28, 56 and 84 kg-N/ha, making total application rates to 0, 84, 168, and 252 kg-N/ha. Broccoli shoots were sampled for biomass and N uptake evaluation on July 25, August 16, and September 18. Harvest evaluation was conducted on September 19, 2006.



Trial 2

A legume mix cover crop was planted on the winter cover crop plots at the rate of 123 kg/ha on October 11, 2005. The proportion of the different varieties was the following: 18% 'Cayuse' oats; 38% Bell beans; 20% 'Lana' wooly pod vetch; and 25% 'Magnus' pea (*Pisum sativum*). The non-cover cropped plots were rototilled twice during the winter to control weeds. The cover crops was mowed and rototilled into the soil on February 14, 2006. Biomass and total nitrogen content of the cover crop were measured prior to incorporation. Beds were listed on March 24 and the cover crop plots were divided into four fertilizer subplots that were four beds wide by 12 meter long. Feather meal (12-0-0) was shanked into the beds (two shanks per bed and the depth of application was level with the furrow bottom) with a small plot fertilizer applicator on April 20. The fertilizer was applied at four rates: 0, 84, 168 and 252 kg-N/ha and the beds were power mulched with a Marvin bed mulcher immediately following. Broccoli transplants of the variety Marathon were planted by hand on April 21 (54 day old plants). Broccoli shoots were sampled for biomass and N uptake evaluation on May 23 and July 5. Harvest evaluation was conducted on June 30 and July 5, 2006.




RESULTS AND DISCUSSION

In both trials, yield of broccoli was significantly increased by cover crop application and the rate of organic fertilizer N (Table 1). The cover crop in Trial No. 1 contained 179 kg-N/ha. N uptake by broccoli indicates 9 and 42 kg more N broccoli biomass in the cover crop treatments at midgrowth and at harvest, respectively (Fig. 1-Trial 1). The cover crop in Trial No. 2 contained 218 kg-N/ha. 300 mm of rain fell between incorporation of the cover crop and planting the broccoli and it is assumed that a sizeable portion of mineralized N from the cover crop was lost to nitrate leaching (Fig. 1-Trial 2). Evaluations of N uptake indicate 22 and 30 kg more N broccoli biomass in the cover crop treatments at midgrowth and at harvest, respectively (Fig. 1-Trial 2). Increase of broccoli biomass N at harvest in cover crop plots was approximately equivalent to the increase brought about by 71 (Trial 2) or 92 kg-N/ha (Trial 1) of organic fertilizer application (Fig. 2). It also indicated that 14% (Trial 2) to 23% (Trial 1) of cover crop N was used by successive broccoli crop, which agrees to the range suggested by Crews and Peoples (2005) (see introduction).

Table 1. Effects of Main Treatments on Broccoli Yield[1].

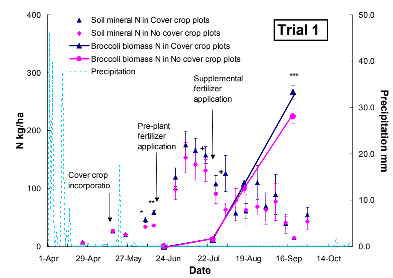
Trial 1

Cover Crop Treatments	Heads No./ha	Heads tons/ha	Mean Head (kg)
No Cover Crop	80,920	20.4 a	0.25 a
Cover Crop	80,464	23.0 b	0.29 b
ANOVA (P)	*0.88*	*0.0036***	*0.011**
Fertilizer Treatments kg-N/ha			
0	79,324	17.0 a	0.22 a
84	78,412	20.3 b	0.26 b
168	80,236	23.6 c	0.30 b
252	84,795	25.7 c	0.31 b
ANOVA (P)	*0.47*	*0.0000****	*0.0001****

Trial 2

Cover Crop Treatments	Heads No./ha	Heads tons/ha	Mean Head (kg)
No Cover Crop	75,520 a	8.88 a	0.12
Cover Crop	96,874 b	12.3 b	0.13
ANOVA (P)	*0.007***	*0.007***	*0.052†*
Fertilizer Treatments kg-N/ha			
0	39,071 a	3.36 a	0.07 a
84	86,459 ab	9.08 a	0.11 ab
168	104,949 b	13.5 b	0.13 b
252	114,312 b	16.5 c	0.15 b
ANOVA (P)	*0.001****	*0.0000****	*0.000****

[1] No significant differences were found in interactions in both trials. Values with the same letter are not significantly different at the 5% of probability according to Tukey's HSD test. †, *, **, ***: Significant at the 10, 5, 1, or 0.1% of probability.



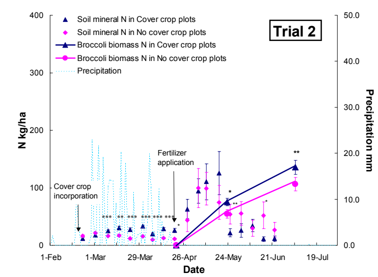
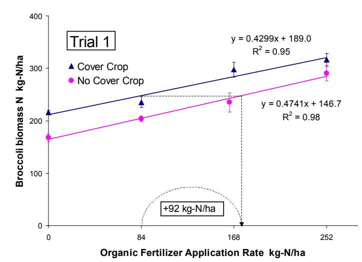


Figure 1. Changes in Soil Mineral N (0-30cm deep), Broccoli Biomass N, and Precipitation Amount during the Broccoli Production Cycle.



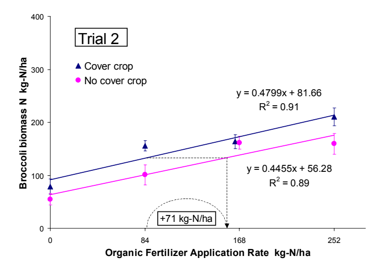


Figure 2. N Content Increase in Broccoli Biomass at Harvest Brought About By Cover Crop Incorporation and Organic N Fertilizer Application.

CONCLUSIONS

- The yield of broccoli was higher in the cover crop treatment in both trials.
- Evaluations of N uptake indicated 30 to 42 kg more broccoli-N in the cover crop treatments at harvest in two trials.
- These results showed that 14 to 23% of cover crop N was utilized by the successive broccoli crop.
- Incorporated cover crops increased broccoli-N in a manner similar to 71 to 92 kg-N/ha of applied organic fertilizer.

LITERATURE CITED

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FOR MORE INFORMATION

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