EVALUATING COVER CROPS FOR NITROGEN MANAGEMENT IN A WALNUT ORCHARD

Diana Zapata[1], Kerri Steenwerth[2], William Horwath[1], Xia Zhu-Barker[1]
[1]Department of Land, Air & Water Resource, University of California, Davis, CA 95616
[2]USDA-ARS, Crops Pathology and Genetics Research Unit, Davis, CA 95616

ABSTRACT

Cover crops provide numerous benefits in agricultural systems. From increasing soil water storage to reducing fertilizer inputs, quantify cover crops benefits is crucial in nutrient management, crop productivity, environmental sustainability, and adoption by growers. The goal of this study was to quantifying nitrogen (N) and carbon (C) inputs in a walnut (*Juglans regia* L. 'Chandler') orchard that implemented three cover crop mixtures. The study site was a 5-year-old walnut orchard located in Knight Landing, California. Cover crops treatments were planted in November 2019 and included clover mix, grass-clover mix, and commercial blend (Bell beans, peas, vetch, and oats). The control treatment consisted of resident vegetation. Soil cores (0-15 cm, 15-30 cm, 30-60 cm, and 60-90 cm depth) were collected before cover crop planting and after walnut harvest. Additionally, five in-season soil samplings were performed during the walnut growing period (0-15 cm, 15-30 cm depth). Soil samples were analyzed for ammonium (NH_4^+), nitrate (NO_3^-), and total C and N. Aboveground dry matter was measured before cover crop termination and analyzed for C and N content. The C and N inputs were compared among treatments. Dry matter production and C inputs differed among species. The average aboveground biomass was 3.37 Mg ha^{-1} in the clover, 3.31 Mg ha^{-1} in the grass-clover, 5.45 Mg ha^{-1} in the multiplex, and 3.33 Mg ha^{-1} in the resident vegetation. Cover crops significantly increased inorganic N ($NH_4^+ + NO_3^-$) availability in the top 30cm of soil profile during the walnut growing season compared to the control. Average inorganic N at the top 30 cm soil layer was 12.95 mg N kg^{-1} in the resident vegetation, 17 mg N kg^{-1} in the multiplex, 17.42 mg N kg^{-1} in the grass-clover, and 19.98 mg N kg^{-1} in the clover. The findings from this study are essential in developing N management guidelines for walnut orchards.

OBJECTIVE

1. Quantify C and N inputs from cover crops implemented in a young walnut orchard.

METHODS

Site Description

This study was conducted at the River Garden Farms, Knight Landing, California (38°55'23.88", 121°50'50.28", m.a.s.l. 8) in an established walnut orchard planted in 2015. The soils at the orchard are classified as Grandbend loam, Mollisols, OM 1.5% at the north side and Tyndall sandy loam, Inceptisols, 1.5% OM at the south side. The mean annual temperature is 16.62°C and the annual rainfall is 49.6 mm.

Cover Crop Treatments

Three cover crops mixes were planted on 18 November 2019 and included clover mix, grass-clover mix, and commercial blend commonly used in the region. A control with residential vegetation was included. The clover treatment incorporated a mixture of three Subterranean clovers (*T. subterraneum* L.) with different maturity times at a seeding rate of 28 kg ha^{-1}. The grass-clover treatment included a mixture of the previously describe Subterranean clovers and bromegrass at a seeding rate of 28 kg ha^{-1}. The commercial blend included bell bean, peas, vetch, and oats (Multiplex Max 90 kg ha^{-1}) in addition to a mix of brassicas at a very low seeding rate. Treatments were replicated four times. Mechanical termination through mowing varied among treatments due to different maturity times. Multiplex and resident vegetation treatments were terminated on 14 April 2020, and the grass and legume mixtures on 13 June 2020.

Carbon and Nitrogen Inputs

Aboveground biomass was clipped from four 1 x 1 m^2 quadrants in each cover crop treatment before cover crop termination. Cover crop and weeds biomass were separated and dried in the oven to obtain dry weights. Total carbon (C) and nitrogen (N) contents of plant tissues were measured using an elemental analyzer (Costech EAS 4010, Valencia, CA). The C and N inputs from implementing cover crops were calculated, multiplying biomass production by nutrient content.

Soil Measurements

Soil temperature and moisture were monitored weekly during the 2020 walnut growing season using soil sensors installed at 1ft depth in each cover crop treatment (n = 16) (TEROS 11, Meter Group Inc., Pullman, WA). Soil N status was measured after cover crop termination and five times during the walnut growing season. At cover crop termination, soil samples were collected using an ESP soil sampler at six depths (0-15, 15-30, 30-60, and 60-90 cm) in the tree line and cover crop planting area. For the in-season sampling, a composite soil sample was obtained from 0-15 and 15-30 cm depths using a soil auger. Soil samples were analyzed for pH, and inorganic N (ammonium and nitrate).

RESULTS AND DISCUSSION

Cover crop aboveground biomass varied from 3.31 to 5.4 Mg ha^{-1}, with the lowest production found in the grass-clover mix and the highest in the Multiplex blend (Table 1). The average biomass production in the clover mix was 3.37 Mg ha^{-1}. Because cover crops have been implemented only for 1-year (2019-2020), we were not expecting to find differences in weed suppression. However, preliminary data suggested weed biomass was the highest in the resident vegetation, followed by the Multiplex blend, the grass-clover mix, and the clover mix treatment. Clover showed potential in suppressing weeds, most likely due to its mat-forming growth pattern that increases groundcover.

Table 1. Aboveground cover crop biomass in dry weight (Mg ha^{-1}).

Treatment	Species	Biomass (Mg ha^{-1})
Clover mix	Clover	3.37 ± 1.56
	Weeds	0.64 ± 0.49
Grass-clover mix	Clover	1.04 ± 0.73
	Grass	2.27 ± 0.62
	Weeds	0.95 ± 0.59
Multiplex	Bell bean	0.15 ± 0.17
	Brassica	2.04 ± 1.5
	Oats	1.02 ± 1.01
	Peas	0.85 ± 0.68

	Vetch	1.4 ± 1.01
	Weeds	1.49 ± 0.96
Resident vegetation	Weeds	3.34 ± 0.72

During the walnut growing season, the clover mix and grass-clover mix treatments showed the highest soil moisture consistently during the walnut growing season (Figure 1). In contrast, the multiplex and control (resident vegetation) had the lowest moisture content associated with higher weed pressure measured in those treatments (Table 1). Soil temperature did not show apparent differences between cover crop treatments.

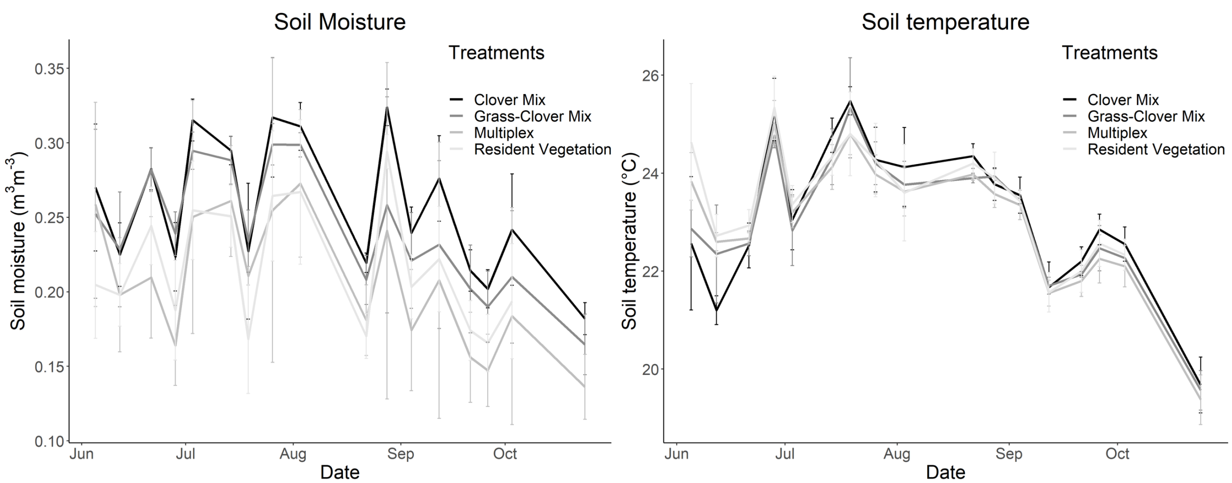

Figure 1. Soil moisture (left) and temperature (right) installed at 1ft depth during the 2020 walnut growing season.

Above and belowground biomass inputs from cover crops increased soil N mineralization compared to the control (resident vegetation) (Figures 2 and 3). At the topsoil 30 cm, clover increased N availability consistently during the walnut growing season with an average of 19.98 mg N kg^{-1}, followed by the grass-clover mix with 17.42 mg N kg^{-1}, and the Multiplex blend with 17 mg N kg^{-1}. Resident vegetation had the lowest soil inorganic N content, with an average of 12.95 mg N kg^{-1}. In summary, preliminary data after 1-year of implementing cover crops suggested that cover crops can increase C and N inputs in walnuts orchards. The highest soil N content was measured during late-July and early-August, with a decline later in the season. The seasonal increase in N availability under cover cropping found in this study occurred around the maximum N uptake in walnut trees. This information can also help growers improve N management in orchards as cover crops can release N in synchrony with crop N demand. Further research will compare current findings with leaf analysis performed in July and harvest yield.

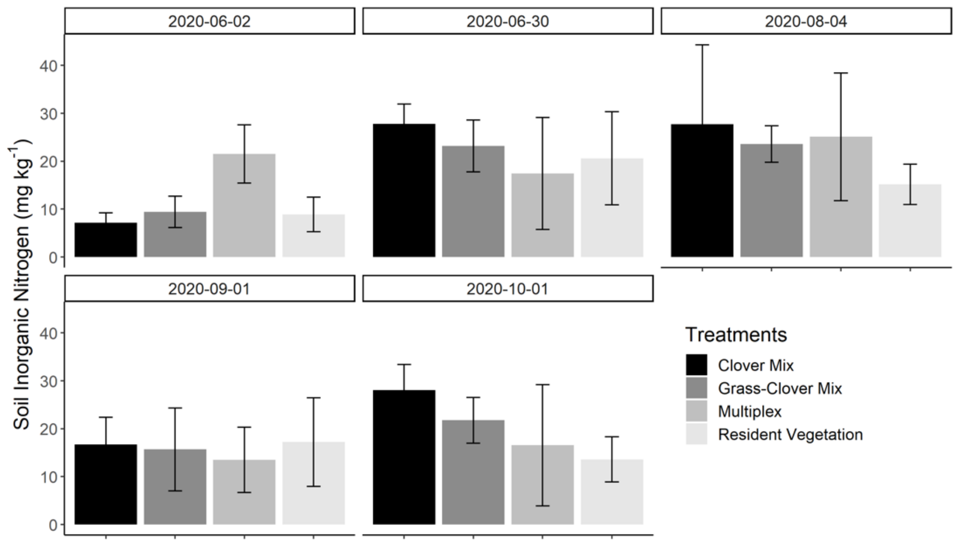

Figure 2. Soil inorganic N measured from 0 to 15 cm depth during the walnut growing season

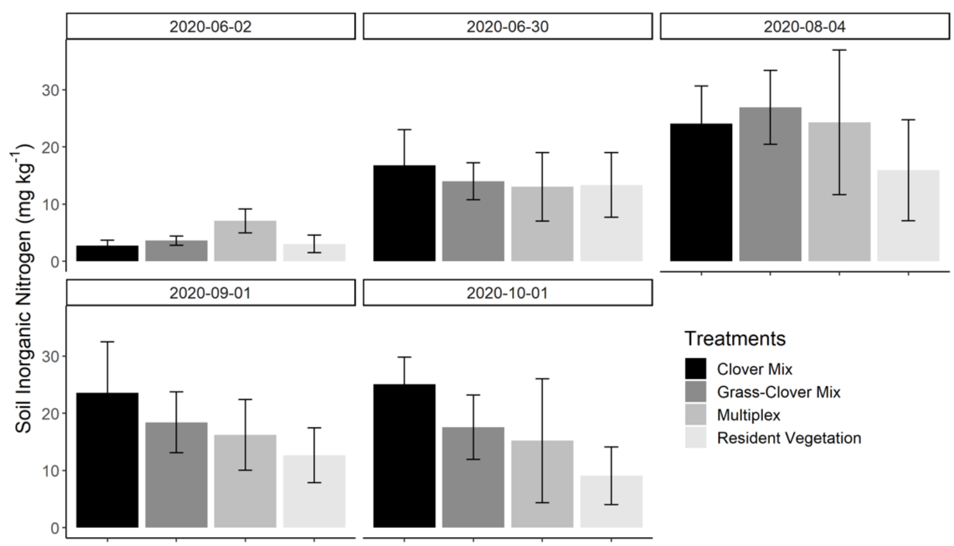

Figure 3. Soil inorganic N measured from 15 to 30 cm depth during the walnut growing season