ACCOMPLISHMENT REPORT
Northwest Regional Biomass Research Center
October 2017-September 2018

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Incorporating Brassica oilseed crops into dryland wheat production may reduce reliance on fossil fuels. Oilseed crops are expected to become an increasingly important feedstock for production of renewable jet. Scientists in Pendleton, OR and colleagues with Michigan Technological University determined the life cycle energy and greenhouse gas (GHG) emissions of 2- and 3-year rotations with cereals and oilseeds in a low precipitation environment of the Columbia Plateau of the state of Oregon, USA. The purpose was to ascertain whether cropping intensification could improve energy efficiency and reduce GHG emissions. A life cycle assessment (LCA) was carried out to evaluate the fossil energy and carbon footprint of nine cropping systems characterized by different inputs applied to spring carinata (*Brassica carinata*) and winter canola (*B. napus*) in rotation with wheat and other cereal crops. Grain yield and field activity data from cropping systems were acquired from a field experiment over a 5-yr period. Gas emissions were measured weekly over two years using static chamber methodology and laboratory gas chromatography. Inputs for the LCA regarding fertilizers, machinery fuel use, and pesticides were from the field trials and literature for fuel use. Emission results of winter wheat (WW) rotations were between 300-400 g CO_2 eq. kg^{-1} WW, in the range for U.S. average WW cropping emissions (i.e., 300-600 g CO_2 eq. kg^{-1} WW). The best oilseed result was 660 g CO_2 eq. kg^{-1} for canola following reduced tillage fallow (RTF). Highest yields were observed when cereal or oilseed crops were planted following RTF. From a trade-off plot of GHG emissions versus total crop sales over six years per hectare, WW-summer fallow (SF) rotation and winter oilseed (WO)-RTF-WW-RTF were the most promising with low emissions and high sales. Efficiency in terms of Energy Return on Energy Investment was 3.85 for winter oilseed yields 1,338.9 kg ha^{-1} and 1.6 for spring oilseed yields 552.2 kg ha^{-1}. Compared to WW-SF, bioenergy oilseed cultivation may increase CO_2 equivalent emissions in 3-yr cereal-based rotations due to increased fallow-substitution cultivation inputs. Fossil energy inputs required to produce oilseed crops were smaller than the total energy in final seed and thus oilseeds have the potential to reduce reliance on fossil fuels. Improving energy efficiency and encouraging adoption by growers will depend on ability to enhance agronomic performance with higher yielding, drought and cold tolerant oilseed varieties. **Citation:** Ankathi, S., D. Long, H. Gollany, P. Das, and D. Shonnard. 2018. Life cycle assessment of oilseed crops produced in rotation with dryland cereals in the inland Pacific Northwest. The International Journal of Life Cycle Assessment. 24:627-641.

Cover crops replace fallow in semi-arid durum cropping systems. The traditional 2-yr rotation of spring wheat followed by summer fallow helps decrease the risk of crop failure in the short term, but long-term consequences include soil C depletion, formation of saline-seeps, degraded environment for soil microbiology, loss of habitat for fauna including pollinating insects, reduced soil water holding capacity, and inefficient precipitation storage during fallow with about 60 to 85% of precipitation lost to surface evaporation. However, little is known about replacing the fallow phase in wheat-fallow rotations, for example with a multispecies crop harvested for forage with regrowth left to serve as a standing cover crop. ARS researchers in Sidney, MT initiated a 6-yr study to investigate the production potential of a 10 species crop mix (buckwheat, canola, cowpea, flax, lentil, millet, pea, radish, sorghum, turnip) in place of fallow in 2-yr durum rotations. Results from the first 3-yr period of the study indicate planting a multispecies crop mix in place of fallow provided on average 3.1 Mg ha-1 (59% of which was radish and pea) of high-quality forage harvested in early summer and an additional 5.4 Mg ha-1 (50% of which was sorghum and millet) unharvested biomass at killing frost left for standing cover to increase ecosystem services compared to fallow.

Wide spacing of energycane reduced cost of planting and sustain biomass. Energycane, a hybrid of commercial sugarcane, wild sugarcanes, and related grassy species, has been emerged as a potential lignocellulosic crop for second generation ethanol production due to high biomass production instead of high sucrose content. It can be grown in warm climates, including southeastern USA. Some of the advantages of growing energycane are that (1) it can be grown in nutrient-poor marginal and eroded lands not suited for growing food crops and (2) it is more cost-effective for producing ethanol compared to annual crops. Little is known about its population density that can reduce seeding cost and produce sustainable biomass. We examined the effect of three intra- (1.2 m, 1.5 m and 1.8 m) and two inter- (0.6 m and 0.9 m) row spacing on aboveground growth characteristics and biomass of energycane from 2013 to 2015 in southeastern USA. Plant height was greater with 1.2 × 0.6 m than 1.8 × 0.9 m spacing from August to September 2013, but the trend reversed from July to September 2014 and 2015. Tiller and leaf numbers were greater with 1.8 × 0.9 m than other spacing from August to November, 2013 to 2015. Leaf area index was greater with 1.2 × 0.6 m than 1.5 × 0.9 m from August to September 2013 and August to November 2015 and greater with 1.5 × 0.6 m than 1.8 × 0.6 m from August to October 2014. Net photosynthesis rate was greater with 1.8 × 0.9 m and 1.5 × 0.9 m than 1.2 × 0.6 m from July to August 2013 and from July to September 2014. Chlorophyll content varied with spacing at various dates. Biomass yield did not vary among spacing and years. Wide spacing increased tiller and leaf numbers and photosynthesis, but reduced leaf area index compared with narrow spacing. Although reduced leaf size, energycane can be planted at wide compared to narrow spacing to reduce the cost of seeding and produce sustainable biomass yield.
Citation: Chiluwal, A., Singh, B.P., Sainju, U.M., Whitehead, W.F, and Singh, B.P. 2018. Spacing effects on energycane growth, physiology, and biomass yield. Crop Science. 58:1371-1384. doi: 10.2135/cropsci2017.08.0513.

Hairy vetch and rye mixed cover crops improves soil carbon and nitrogen under forage sorghum. Bioenergy crops, such as forage sorghum, have the potential to produce large cellulosic feedstock that can address the shortage of the biofuel demand because of their high aboveground biomass yields. Extensive removal of aboveground biomass for bioenergy, however, can reduce soil and environmental quality. Information is limited about the effect of

crop residue removal on soil carbon and nitrogen storage and nitrogen leaching under bioenergy crops. We evaluated the effects of cover crops (hairy vetch, rye, hairy vetch/rye mixture, and the control [no cover crop]) and N fertilization rates (0 and 90 kg N ha^{-1}) on soil organic carbon, total N, ammonium-nitrogen, and nitrate-nitrogen at the 0- to 30-cm depth from 2010 to 2014 in the southeastern USA. Cover crop biomass yield and carbon and nitrogen contents were greater with vetch/rye than rye and the control in 2013 and 2014. At 0-5 and 0-30 cm, soil organic carbon was greater with vetch/rye than rye and vetch and soil total nitrogen greater with vetch and vetch/rye than the control at 0 kg N ha^{-1}. At 0-30 cm, soil organic carbon increased at 2.62 Mg C ha^{-1} yr^{-1} and soil total N at 0.35 Mg N ha^{-1} yr^{-1} with vetch/rye compared to nonsignificant increases with other cover crops from 2010 to 2014. The ammonium-nitrogen at 5-15 cm was greater with rye than other cover crops in 2012 and nitrate-nitrogen content at 5-15 and 0-30 cm was greater with vetch and vetch/rye than rye and the control in 2011 and 2012. Because of increased carbon and nitrogen inputs, soil organic carbon, total nitrogen, and nitrate-nitrogen contents increased with vetch/rye and vetch than rye and the control, but nitrogen fertilization had little effect on soil carbon and nitrogen under forage sorghum. As a result, hairy vetch/rye mixture cover crop can be used to enhance soil carbon and nitrogen stocks and both hairy vetch and hairy vetch/rye can be used to optimize nitrogen availability to forage sorghum.
Citation: Sainju, U.M., Singh, H.P., and Singh, B.P., Whitehead, W.F., Chiluwal, W., and Paudel, R. 2018. Soil carbon and nitrogen under bioenergy forage sorghum influenced by cover crop and nitrogen fertilization. Agrosystems, Geosciences, and Environment. 1:180004 doi:10.2134/age2018.03.0004.

Cover crop mixture enhances soil carbon and nitrogen under sweet sorghum. Sweet sorghum is a promising bioenergy crop because of its high sugar content and its multiple uses of lignocellulose, starch, and bagasse for ethanol production. Extensive removal of aboveground biomass for bioenergy production, however, can affect soil and environmental quality. Winter cover crops and nitrogen fertilization can provide additional crop residues and carbon and nitrogen inputs that may help to protect soil and environmental quality. The effect of winter cover crops (hairy vetch, rye, hairy vetch/rye mixture, and the control [no cover crop]) and nitrogen fertilization rates (0 and 90 kg N ha^{-1}) were evaluated on soil organic carbon, total nitrogen, ammonium-nitrogen, and nitrate-nitrogen contents at the 0- to 30-cm depth from 2010 to 2014 in the southeastern USA. Cover crop biomass yield and carbon content were greater with vetch/rye than vetch and the control and N content greater with vetch and vetch/rye than the control in 2013 and 2014. Soil organic carbon and total nitrogen at 0 to 5 cm were greater with vetch/rye than the control and at 15 to 30 cm were greater with vetch than vetch/rye. At 0 to 5 cm, soil organic carbon increased at 0.55 Mg C ha^{-1} yr^{-1} and total nitrogen at 0.06 Mg C ha^{-1} yr^{-1}, regardless of treatments. At most depths, ammonium-nitrogen content was greater with rye than the control and greater with 0 than 90 kg N ha^{-1}, but nitrate-nitrogen was greater with vetch/rye than rye. Because of greater cover crop carbon and nitrogen inputs, soil organic carbon, total nitrogen, and nitrate-nitrogen contents increased with vetch/rye and vetch than rye and the control, but ammonium-nitrogen content increased with rye. Soil carbon and nitrogen stocks can be enhanced and nitrogen availability can be optimized by growing hairy vetch and hairy vetch and rye mixture compared with other cover crops under bioenergy sweet sorghum.

Citation: Sainju, U.M.**,** Singh, H.P., Singh, B.P., Whitehead, W.F., Chiluwal, A., and Paudel, R. 2018. Cover crop and nitrogen fertilization influence soil carbon and nitrogen under bioenergy sweet sorghum. Agronomy Journal 110:463-471. doi:10.2134/agronj2017.05.0253.