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Nutrient Management in Cover Crop-Based Organic Hemp Production

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Commercial hemp (*Cannabis sativa*) production ceased throughout the United States in the early 1940's due to its close relationship to the marijuana plant. Therefore, little to no research on industrial hemp has been conducted over the past eighty years in the U.S., resulting in knowledge gaps of basic agronomic practices. Considering that the concept of organic farming was virtually unknown until the publication of JI Rodale's Organic Gardening and Farming publication in the late 1940's (Kelly 1992), there is virtually no knowledge about organic hemp production methods, but it is suspected that many farmers producing hemp in the early part of the 20th century utilized natural fertility methods prior to the widespread adoption of synthetic fertilizers during the Green Revolution. Organic systems rely on cover crops as sources of natural plant fertility and biological soil processes to make these nutrients available and thus are less prone to leaching into surface and subsurface water sources. However, such reliance on natural processes can also result in asynchrony between nitrogen availability and crop nitrogen needs. The nutrient availability can also be impacted by crop density as modified by row spacing. In addition, row configuration is part of the cultural weed control strategy. Seed hemp cultivars are usually shorter, earlier maturing and perhaps less competitive with weeds than fiber cultivars and could benefit from the use of higher plant densities. There are mixed results from hemp plant density and row spacing trials on hemp establishment, biomass (fiber type) and seed yield (seed type), and hemp seed quality. We assumed that seed hemp varieties are shorter than fiber varieties, may be less competitive with weeds, and therefore may benefit by planting in higher densities. We also obtained information from previous trial at Kutztown that the hemp establishment could be difficult without fertilizer application.

Figure 1. Seed (short and yellowish in right) and fiber hemp (tall and green in left) grown in Kutztown, PA. Photo: Madhav Dhakal

A plot-scale research trial was conducted at Rodale Institute (Kutztown, Pennsylvania, USA) in 2019 and 2020. The field was planted to barley (*Hordeum vulgare*) in August 2018 and 2019 and harvested as hay in May 2019 and 2020, prior to preparing the field. The entire field was plowed and disked one time in late May each year prior to fertilizer application. Bloodmeal (14-0-0) was applied at a rate of 100 and 200 lb N/acre immediately after preparing soil and incorporated with a Perfecta harrow and packed just prior to

planting. The seed hemp variety Canda (source) was planted at a row spacing of 7.5 in and 15 in. This resulted in a seeding rate of 60 lb ac^{-1} in 7.5-in spacing and 30 lb ac^{-1} in 15-in spacing. Seeds were planted with a John Deere grain drill using the Sorghum setting on June 05 and 08 in 2019 and 2020, respectively. Plants were harvested late August both years. Soil samples were collected prior to planting and after harvesting in each plot from 0-6 in depth using core samplers to determine nutrient contents. Hemp samples were collected in August to determine biomass, plant nitrogen and carbon content, and grain yield. Weeds were collected from 1 m^2 quadrat to determine dry biomass. Nitrogen use efficiency (NUE) was calculated based on soil and plant nitrogen status. Hemp grain protein was calculated by multiplying grain N content with 6.25.

By design, hemp was seeded at high density in narrow spacing and low density in wide spacing treatments. Although the planting rate per unit area was double in narrow spacing, hemp population density did not reflect the planting density, which indicate that there is no point doubling the seed amount (Fig. 2). Growers could plant in narrow rows with the same amount of seed as wide row spacing to save the seed cost. Compost favored establishment of hemp better than bloodmeal and control.

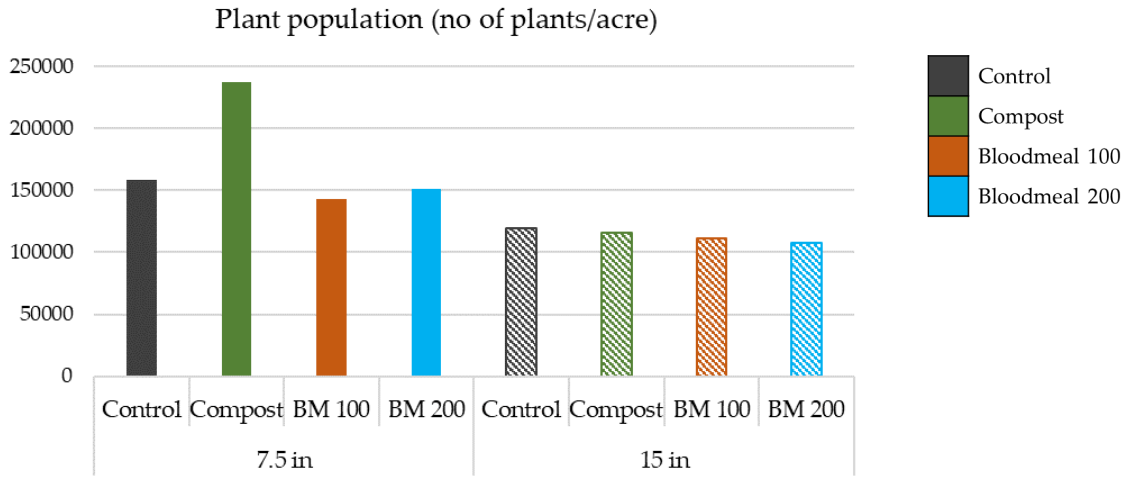

Figure 2. Hemp population density as affected by fertility treatments.

Hemp has ability to suppress broad range of weed species. Narrow row spacing suppressed weeds more than the wide rows (Fig. 3). Narrow row spacing reduced weed biomass by 35% over wide spacing. There was no effect of fertilizer treatments on weed biomass.

Data on hemp biomass collected in August showed that the yield was responsive to N application, indicated by the highest biomass with bloodmeal @200 lbs N/acre at 15-in spacing. Row spacings didn't have any effect on the biomass yield. Hemp biomass yield suggested that the low seeding rate with minimal amount of N can be as profitable as high N application and high planting density.

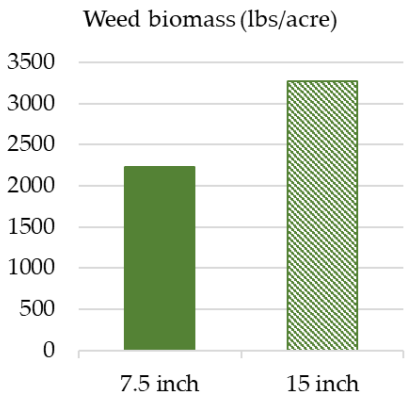

Figure 3. Weed biomass as affected by hemp row spacing/plant density.

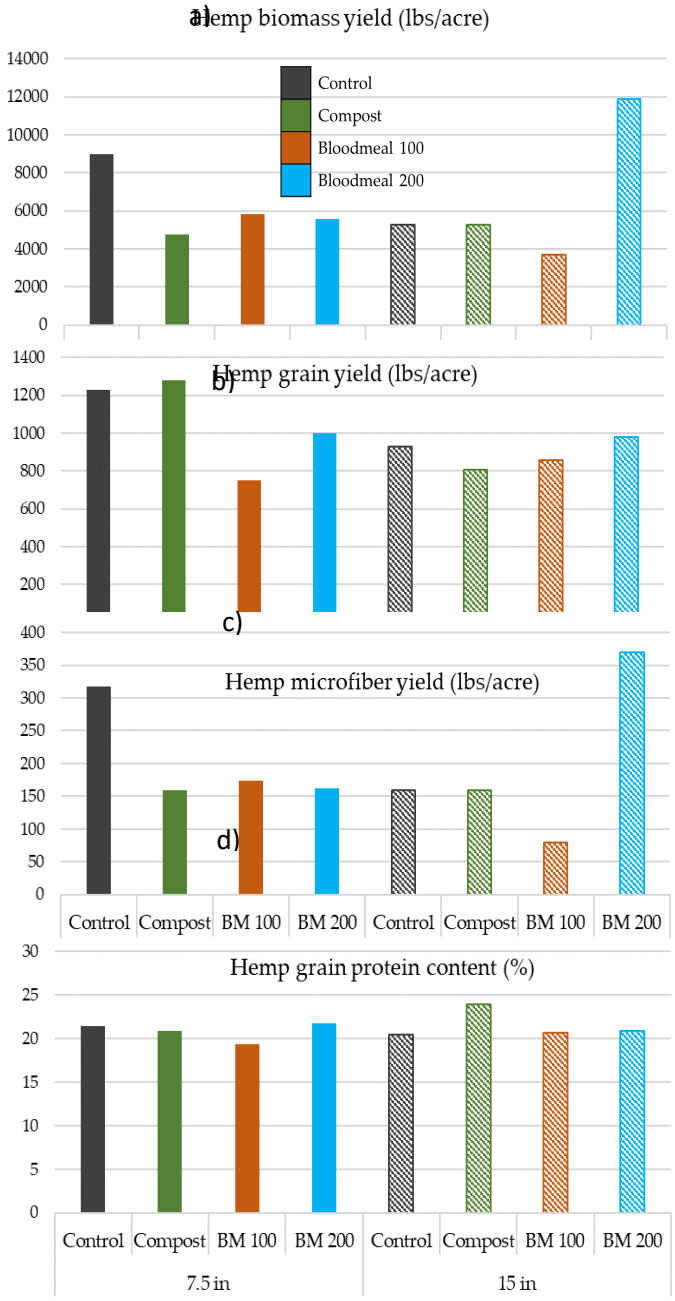

Figure 4. Hemp biomass yield (a), grain yield (b), microfiber yield (c), and grain protein content (d) as affected by row spacings and fertilizer

Hemp grain yield suggested that greater seed yield can be achieved with high density planting of hemp even without supplemental fertilizer as shown by control with narrow row spacing (Fig. 4b). Bloodmeal had moderate seed yield. Seed yield was less varied among treatments at wider rows suggested that substantial yield can be obtained by cutting seeding rate into half.

Hemp microfiber extracted from the bark was not different among row spacings (Fig. 4c). Except for bloodmeal @200 lb N/acre, which had nearly two times the fiber amount of other fertilizer treatments including bloodmeal @100 lb N/acre and compost under both row spacings. Control at high density planting had unexpectedly greater fiber mass than compost and bloodmeal @100 lb N/acre.

The average protein content in hemp seed was 21%, which is more than most of the cereals and pulses. Neither fertilizer nor row spacings had effect on grain protein content. Compost tended to have more protein but that was not statistically different from others.

As hypothesized, seeding hemp at lower density (wide rows), can be considered a viable means to produce industrial hemp in PA with supplemental fertilizers in the summer. Bloodmeal @200 lbs N/acre boosted biomass and microfiber yield at wider row spacing. The only tradeoff with wide row spacing is that it may not be able to suppress weeds as narrow rows. Nevertheless, growers could cut back their seed cost with wider row spacing. Control also showed traits comparable to fertilizer application, which might be due to cover crop terminated before hemp planting that suggest hemp can be grown in cover crop-based systems without additional fertilizers.

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