# Optimizing Mulch and Fertilizer Use in Organic Blueberries
## Final Report to the OFRF

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INTRODUCTION
Demand for organic blueberries is relatively strong, but less that 0.1% of the 20,000 acres of blueberries in Michigan are certified organic. An issue consistently identified by our organic blueberry growers is how to manage fertility when mulches, nutrient sources and soil types all can dramatically affect nitrogen (N) availability. Growth and profitable production require an adequate supply of N during the late spring and early summer when the demand by bushes is high. Nitrogen can be a two-edged sword for blueberries because excessive late season levels tend to promote late growth that is prone to winter injury.

Organic blueberry producers use a variety of nutrient sources (composted manures, feather meal, commercial organic fertilizers) and many also utilize surface-applied or pre-plant incorporated mulches (bark, wood chips, straw, leaves, peat). The choice of nutrient sources and mulch materials is based largely on what is available locally an economical. However, mulch materials interact with nutrient sources to affect the availability of N and other nutrients. These interactions are also expected to depend on the soil type. Organic blueberries in Michigan are currently grown on soils that range in texture from sands to mucks.

The goal of this project is to describe how different nutrient sources and mulches affect N availability so that producers can devise programs that meet the nutrient requirements of bushes under their specific conditions. Studies included field trials on commercial organic farms and an MSU research station, and also the use of soil columns where conditions were controlled more closely.

ON-FARM TRIALS

Eight field trials were conducted over three years on several organically certified Michigan farms. Treatments were designed after consulting growers and typically included nutrient materials they had on hand. In each trial, materials were spread in a 2-3 foot-wide band beneath bushes. To monitor available nutrient levels, soil samples were collected at intervals through the season. Samples were composites of eight 8 inch-deep cores taken from random locations within each plot. Soils were dried, homogenized, extracted with 1 M KCl, and analyzed for $NO_3$-N and $NH_4$-N by colorimetric methods. Composite samples of 25 leaves per plot were collected in between late July and late August. These were dried, ground, and analyzed for total N. Trial sites (Table 1) and treatments (Table 2) are described below.

| Table 1. On-farm field trials conducted in 2009, 2010 and 2011 to test fertilization methods for organic blueberries. | | | | |
|---|---|---|---|---|
| Trial | County | Soil texture | Cultivar, plant age (yrs) | Experimental design |
| | 2009 | | | |
| 1 | Van Buren | Loamy sand | ‘Elliott’, 4 | RCB, 4 replications, 11 bushes per plot |
| 2 | Van Buren | Sandy loam | ‘Liberty’, 2 | RCB, 4 replications, 11 bushes per plot |
| 3 | Ottawa | Sandy loam | ‘Duke’, 12 | RCB, 3 replications, 8 bushes per plot |
| | 2010 | | | |
| 4 | Van Buren | Loamy sand | ‘Elliott’, 5 | RCB, 3 replications, 8 bushes per plot |
| 5 | Van Buren | Loamy sand | ‘Elliott’, 5 | RCB, 4 replications, 4 bushes per plot |
| 6 | Ottawa | Sandy loam | ‘Jersey’, 30 | RCB, 3 replications, 4 bushes per plot |
| | 2011 | | | |
| 7 | Van Buren | Loamy sand | ‘Elliott’, 6 | RCB, 4 replications, 4 bushes per plot |
| 8 | Ottawa | Sandy loam | ‘Jersey’, 30 | RCB, 3 replications, 4 bushes per plot |

| Table 2. Treatments applied on certified organic farms, 2009-2011. | |
|---|---|
| Trial | Treatments |
| 1 | 1. Nature-Safe 13-0-0, 500 lb per acre, 23 April, 2009<br>2. Aged bark compost (N:P:K of 0.7-0.6-0.7, C:N ratio 42:1), 10,000 lb/acre, 23 April, 2009 |
| 2 | 1. Nature-Safe 13-0-0, 900 lb per acre, 23 April<br>2. Aged bark compost (N:P:K of 0.7-0.6-0.7, C:N ratio 42:1), 10,000 lb/acre, 23 April, 2009 |
| 3 | 1. Control (no fertilizer)<br>2. Nature-Safe 13-0-0 at 550 lb/acre on 30 April, 2009<br>3. Nature-Safe 13-0-0 at 550 lb/acre + Nature-Safe 8-5-5 at 1,100 lb on 30 April, 2009 |
| 4 | 1. Nature-Safe 13-0-0 organic fertilizer at 600 lb/acre, 6 April, 2010<br>2. Dairy compost (C:N 8.1:1) at 5,800 lb/acre, 6 April, 2010<br>3. Nature-Safe 13-0-0 at 300 lb/acre + dairy compost at 2,900 lb/acre, 6 April, 2010 |
| 5 | 1. Control (non-treated)<br>2. Nature-Safe 13-0-0 at 1,100 lb/acre, 12 April, 2010<br>3. Nature-Safe (13-0-0) at 1,100 lb/acre applied on top of three inches wood chips. |
| 6 | 1. Control (non-treated)<br>2. McGearies 8-1-1 at 720 lb/acre on 19 May, 2010<br>3. McGearies 8-1-1 at 1,440 lb/acre, on May 19, 2010 |
| 7, 8 | 1. Control (non-treated)<br>2. McGearies 8-1-1 at 1,250 lb/acre on 10 April, 2011<br>3. McGearies 8-1-1 at 1,250 lb/acre, on 17 May, 2011 |

Effects of farm trial treatments on soil inorganic N concentrations are illustrated in Fig. 1-5. In Trials 1 and 2 (Fig 1), Nature-Safe 13-1-1 fertilizer (primarily feather, meat and blood meal) maintained higher soil N levels than compost (aged) bark. The bark product in these trials was very low in N (C:N ration 42:1). Even though rates of 13-1-1 and the aged bark were adjusted to supply comparable amounts of total N, the lower levels of inorganic N in bark treated soil reflects the high carbon content of this material. This illustrates that growers using high carbon (low N) composts or amendments will not generally increase available N. these trails were conducted for just one year. If the treatments were continued for several years, more of the N tied to the bark product may have eventually become available to the plants. Leaf N levels were higher in plants treated with Nature-Safe (1.78 % N) than those receiving aged bark (1.50 % N) in Trial 1, but treatments did not affect leaf N levels in Trial 2 (mean 1.8%). Long-lived perennial plants like blueberries often do not respond immediately to N treatments, so limited effects on leaf N levels after one year of treatments is to be expected.

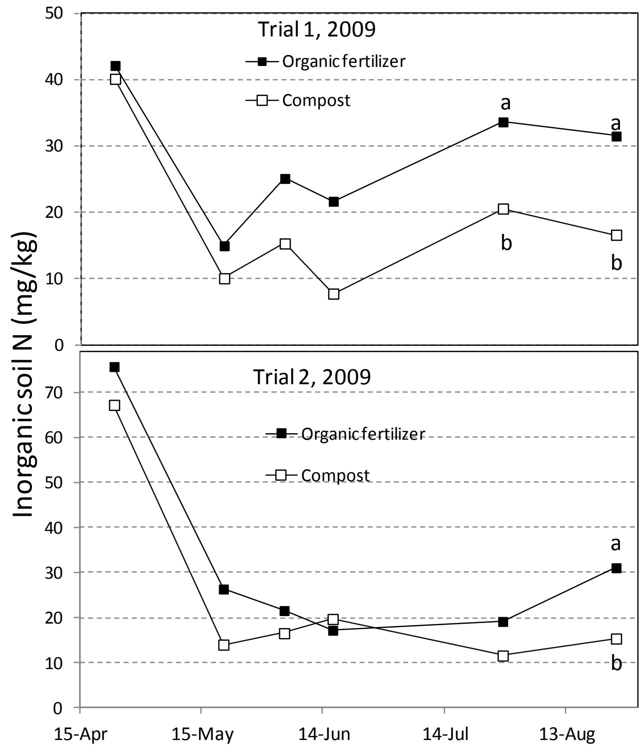


Fig 1. Effect of organic fertilizer (Nature-Safe 13-0-0) and composted bark (N:P:K of 0.7-0.6-0.7, C:N ratio 42:1) applied on 23 April, 2009 on inorganic soil N (nitrate + ammonium).

Results from Trial 3 (Fig. 2) illustrated that the levels of available soil N generally reflected 13-1-1 rates. Available soil N was elevated just a few days after applications, suggesting that mineralization of fertilizer N began rapidly. The 13-1-1 fertilizer appeared to maintain elevated soil N levels through June and July when demand by blueberries is high, and levels tended to diminish in August. These patterns appear suited for blueberries, because abundant available N in the late summer and fall can promote late growth and inhibit hardening of plants for the winter. Leaf N levels were not affected by treatments in Trial 2 (mean 1.80 %) or Trial 2 (1.66 %).

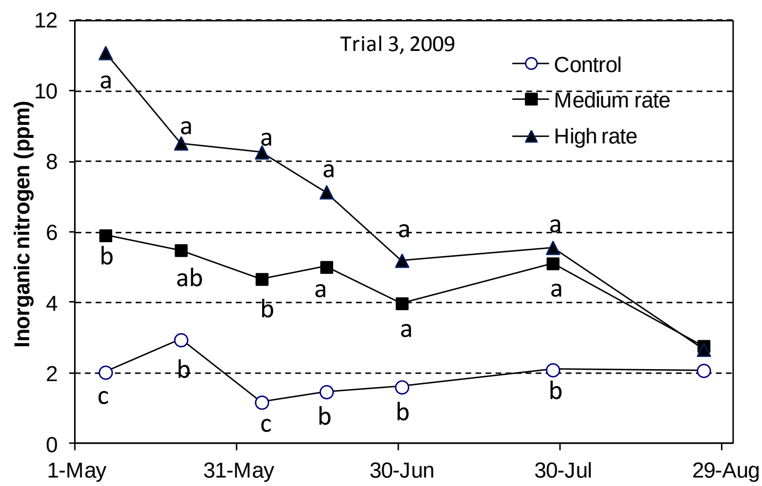


Fig. 2. Effect of no N, medium N (4 lb per plot Nature-Safe 13-0-0, and high N (4 lb per plot of Nature-Safe 13-0-0 plus 8 lb Nature-Safe 8-5-5) applied on 30 April, 2009 on inorganic soil N levels (nitrate + ammonium).

The cooperating grower in Trial 4 was interested in learning whether a combination of a 13-0-0 and dairy-based compost fortified with feather meal (C:N 8.1:1) might provide more available N than 13-0-0 alone. Results (Fig. 3) indicate that 13-0-0 alone provided more N than a half rate combined with compost. Results again indicated that N is released from 13-0-0 soon after application and soil N levels remain elevated for about two months. Interestingly, soil N levels were quite high with all treatments in September. Leaf N levels in Trial 4 were not affected by treatments, ranging from 1.90 to 1.95 %.

Trial 5 compared 13-0-0 on top of the soil or on top of a 3 inch layer of fresh wood chips. The expectation was that wood chips high C:N ratio would tie up N released from the fertilizer, and reduce soil levels. Surprisingly, the highest soil N levels were observed under the wood chips. One explanation is that the granular fertilizer was washed through the wood chip layer quickly, so that little was tied up. Leaf N levels were affected by treatments in a similar way; 13-0-0 + mulch resulting in the highest levels (2.00%), followed by 13-0-0 alone (1.85%) and the control (1.69%).

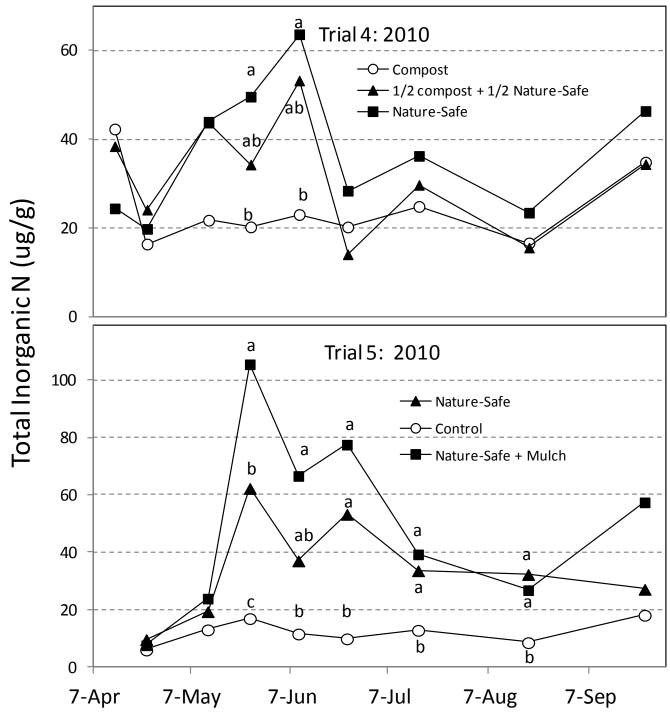


Fig. 3. Effect of organic fertilizer (Nature-Safe 13-0-0) and compost applied on 6 April, 2010 (top) and Nature-Safe with or without wood chip mulch applied on 12 April, 2010 (bottom) on inorganic soil N (nitrate + ammonium).

In Trial 6 (Fig. 4), a second organic fertilizer (McGeary 8-1-1) was tested at two rates. Nitrogen in this product is primarily from blood and soy meal. Soil N concentrations were proportional to the rate applied, and the release period for 8-1-1 (Fig. 4) was very similar to that of 13-0-0 (Fig. 2). When a high fertilizer rate was used (200 lb), available N remained high even in late September.

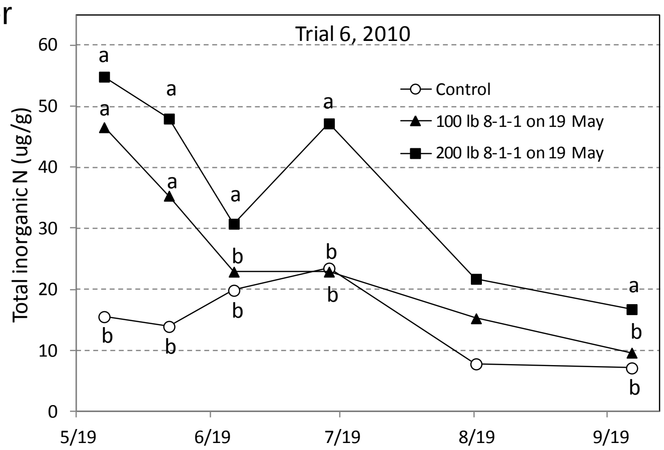


Fig. 4. Effect of no N (control) or 8-1-1 organic fertilizer at 100 lb or 200 lb per acre applied on 19 May, 2010 on inorganic soil N levels (nitrate + ammonium).

Trials 7 and 8 (Fig. 5) compared the same rate of 8-1-1 applied either on 10 April or 17 May. The early application enhanced early season N levels whereas the later application tended to extend N availability later into the season. Leaf N levels were not affected at either site (mean 1.87 % in Trial 7, 1.48 % in Trial 8).

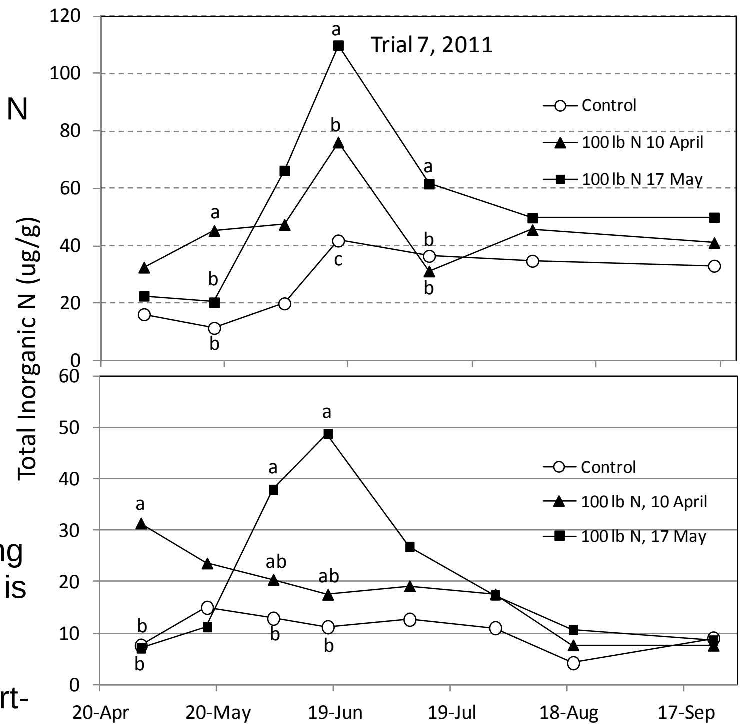

Fig. 5. Effect of no N (control) or 100 lb N per acre applied as 8-1-1 organic fertilizer on 10 April or 17 May, 2011, on inorganic soil N levels (nitrate + ammonium).

Several general conclusions can be drawn from these field trials. First, N is released fairly soon after 13-0-0 or 8-1-1 are applied, and soil levels tend to be elevated for 2-3 months after applications. Some growers apply these materials in March, well before plant demand begins, assuming that N release from organic fertilizers is slow. These trials suggest that this is not necessary. Elevated soil N levels late in the season is a concern in short-season cold regions like Michigan because plants may not harden off in time for winter cold.

These trials also suggest that the C:N ratios of composts or other organic amendments should be known, since materials high in C:N tend to reduce available soil N levels.

LONG-TERM MULCH STUDY

This trial was initiated in 2008 at the MSU Horticulture Teaching and Research Center (HTRC) in East Lansing, MI. Planting occurred in May and nine mulch treatments were imposed on plots of five bushes in a randomized complete block design with four replications. Mulches included a control, perforated white plastic, woven black weed barrier, burlap sacks (used coffee bean sacks), fresh pine wood chips, pine bark nuggets, spoiled grass hay, wheat straw, and shredded wood/bark. Plastic mulches burlap bags were 3 ft wide and pinned along the edges. Straw and hay were initially applied about 8 inches deep, and later settled to about 4 inches. Wood products were applied 3 inches thick. In 2010 the plots were re- This was sprinkled over the top of the organic mulches, but underneath the weed barrier products. The fresh pine wood chips, spoiled grass hay, wheat straw, and wood/bark were re-applied to maintain a layer at least two inches thick. The old perforated white plastic weed barrier were taken off of the plots and replaced with new material. New burlap sacks were laid over the old ones that were decomposing. The pine bark nuggets did not need to be reapplied. Plants were fertilized each spring by spreading 2 lb of McGeary 8-1-1 fertilizer over the top of mulches. This was applied beneath the plastic mulches.

Soils were sampled in 2010 and 2011. Plots were weeded three times per season and total minutes per plot were recorded, then extrapolated to a per acre basis. Soil and leaf samples were collected in 2010 and 2011.

Soil N levels were highly variable in 2010 and no clear treatment effects were apparent (Fig 7). Leaf N levels ranged from 1.75 to 2.15%, and also were not affected by treatments. In 2011, soil N levels were often higher in plots mulched with straw, but differences between other treatments were not consistent. Leaf N levels were not affected by treatments (mean 1.88 %).  Why soil N levels were so variable and not consistently affected by mulches is not clear. Up until June, 2010, we relied on a single trickle line for irrigation. Later in 2010, we switched to overhead sprinklers and used these through 2011. The sprinklers likely retained more uniform soil moisture levels throughout the plots. They may also have increased the downward movement of fertilizer N. This may explain partly why soil N levels were generally lower and more uniform in 2011 than 2010. It is also important to consider that if these treatments were continued for a few additional seasons, treatment differences may have become more apparent. Continued use of mulch materials with high C:N ratios (pine chips, bark nuggets) would eventually result in a lower C:C organic matter pool, which might contribute available N at certain times. Use of low C:N mulches (spoiled hay) clearly increased available N by 2011 (Fig. 6), and would be expected to do so in future years.

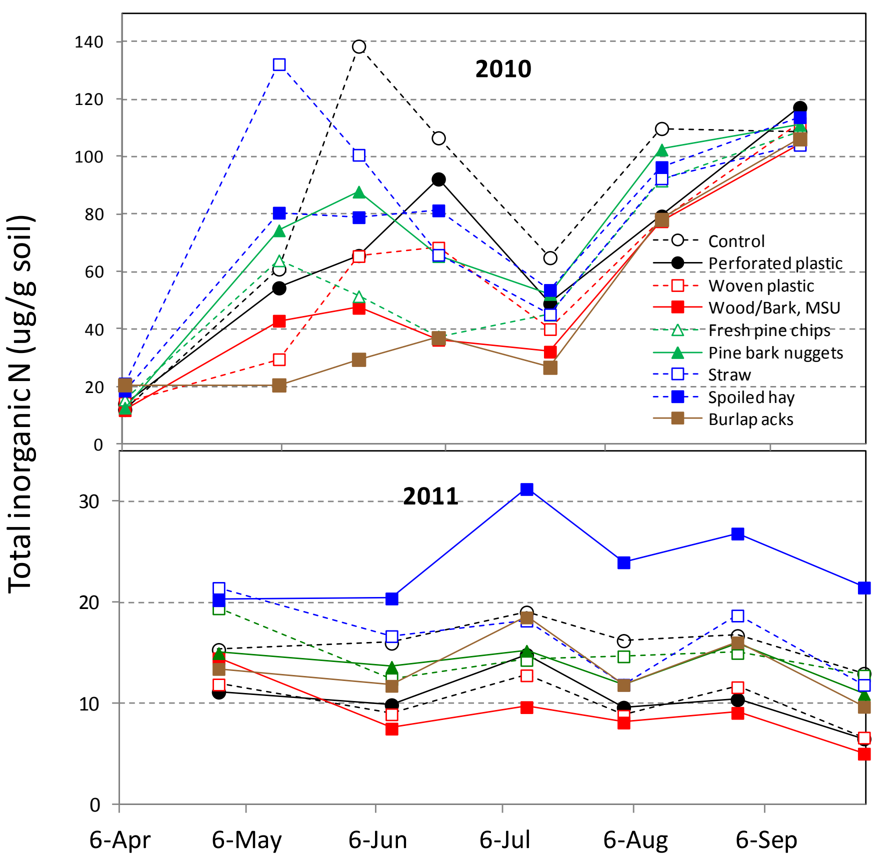


Fig. 6. Effect of surface mulch treatments on soil inorganic N (nitrate + ammonium) in a blueberry planting. E. Lansing, MI, 2010 and 2011.

The mulch plots were weeded by hand 2-4 times during each season and time requirement was recorded. Mulches have had clear effects on hand weeding times (Table 3). Annual weeds dominated in 2008 and 2009, but perennial species such as quackgrass, dandelion, yellow nutsedge, and curly dock became more prevalent in later years. Over the four years of the experiment, all mulches reduced weeding times by comparable amounts relative to the non-mulched control. A surprise was the high weeding times where perforated plastic and woven weed barrier plastic were used. The time required here was primarily to remove weeds coming up within the plant hole. Some growers place wood chips or bark in the hole and this tends to suppress weeds and reduce the need for weeding.

Hand weeding can be very disruptive to blueberry root systems. If weeds are not removed when they are small, blueberry roots are damaged and exposed when large weeds are pulled from around plants. This disturbance resulted in considerable plant injury and loss of 5-8 % of plants over the four years of this study. Workers should be cautioned to weed young plants carefully. After two or three years, growers may consider mowing and weed whacking close to the plants, and pulling only weeds growing directly within the plants. This management approach is less labor intensive, but may require more frequent irrigation and nutrient additions.

Table 3. Effect of mulch treatments on hand weeding times, HTRC.

| Mulch treatment | Weeding time (hr/acre) | | | | |
|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | Mean |
| Control | 64 | 290 | 202 | 32 | 147 |
| Perforated white plastic | 21 | 63 | 31 | 13 | 32 |
| Woven black weed barrier | 19 | 80 | 21 | 13 | 33 |
| Burlap sacks | 27 | 78 | 54 | 19 | 45 |
| Fresh pine wood chips | 16 | 66 | 110 | 15 | 52 |
| Pine bark nuggets | 16 | 48 | 56 | 11 | 33 |
| Spoiled grass hay | 12 | 73 | 68 | 11 | 41 |
| Wheat straw | 10 | 68 | 66 | 28 | 43 |
| Wood/Bark | 19 | 78 | 130 | 16 | 61 |
| LSD (0.05) | ns | 96 | 76 | ns | 29 |

3-YEAR SOIL COLUMN STUDY

Columns of soil can provide better control of experimental conditions and the potential to test more treatment comparisons than field trials. We conducted a three year study (2009-2011) using columns constructed from 14-inch-long sections of 0.25-inch-thick, 10-inch-diameter polyvinyl chloride pipe (pvc) pipe. A 0.25-inch-screen was secured 2 inches above the bottom. This was covered with a 0.5-inch layer of pea gravel. Columns were then filled with about 11 inches of loamy sand topsoil excavated from between rows of an organic blueberry planting at the MSU HTRC Farm. Soil was collected from several locations throughout the planting and homogenized prior to filling the columns.

Three treatments were replicated in six columns: control (no mulch), 2-inch layer of wood chips, and 2-inch layer of pine bark. Soils and mulches were settled by slowly dripping the equivalent of 2 inches distilled water through each column. This was accomplished by pouring water into a perforated trays on top of each column. After settling, 5 g of organic fertilizer (McGeary 8:1:1) was sprinkled on the surface of each column on 22 May, 2009. The columns were set outside in a shaded location and covered with a tarp suspended 3 feet above the top of the columns to exclude rain but allow for air flow and evaporation. Plastic trays were positioned beneath each column to capture and measure leachate.

Every 1-2 weeks, the equivalent of 1.0 inch of rain (530 ml) was dripped slowly into each column as described previously. Water was applied in the morning and leachate was measured and sampled in the afternoon. Samples were frozen, and later analyzed for ammonium and nitrate. The columns were stored in a 2$^{o}$C cooler each year from October to April and then returned to the outside location. The mulches and fertilizer were re-applied on May, 2010 and 2011, and columns were leached and sampled as in 2009.

In 2009, N leaching was primarily early in the season and losses were greatest from columns without surface mulches. In 2010, losses tended to be higher later in the season and total losses did not vary greatly between treatments; 46 mg N from control columns, 36 from those with mulch, and 68 from those with bark. In 2011, the largest amount of N leached from non-mulched columns (Table 3), with the highest losses occurring later in the season. This suggests that bark and wood chips can serve to retain N applied to soil systems.

Table 3. Total seasonal leaching volume and nitrogen content from soil columns.

| | Leachate volume (l) | | | Leachate N (mg) | | |
|---|---|---|---|---|---|---|
| Treatment | 2009 | 2010 | 2011 | 2009 | 2010 | 2011 |
| Control | 1.3 | 0.8 | 1.8 | 39 | 47 | 89 |
| Bark mulch | 2.9 | 2.5 | 2.1 | 15 | 68 | 21 |
| Wood chips | 2.6 | 2.3 | 2.8 | 17 | 36 | 43 |

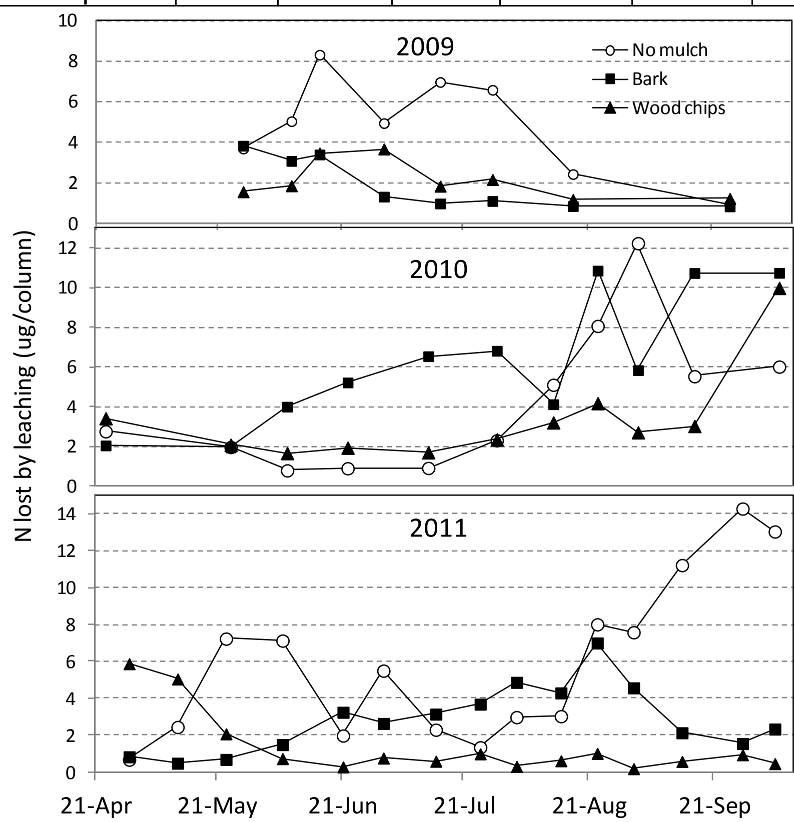


Fig. 6. Nitrogen content of solutions leaching from soil columns over three seasons, as affected by surface mulching with bark mulch or wood chips.

## 1-YEAR COLUMN STUDIES

Smaller 4-inch-diameter PVC columns were used in two one-year studies. These were filled with gravel and soil in the same manner as the larger columns. The following six treatments were applied on 3 June, 2010 to 5 columns each (replications): control (no chips or fertilizer); 2 inch thick layer of wood chips, wood chips + 1.2 g McGearies 8-1-1 fertilizer; wood chips + 2.4 g fertilizer, wood chips + 4.8 g fertilizer; wood chips + 9.6 g fertilizer. Columns were leached approximately every 2 weeks with the equivalent of 1.0 inches rain and leachate was collected and analyzed as described previously.

Results are illustrated in Fig. 7. Fertilizer without organic mulches resulted in the highest leaching losses. Leaching was also relatively high on two dates where compost was applied without mulch. There were not clear differences between the mulch types, although the use of straw resulted in relatively high N losses on the last sampling date. Results suggested that surface mulches had a certain capacity to retain N in the soils system. This is likely the result of the N demand by the microbial community degrading these materials.

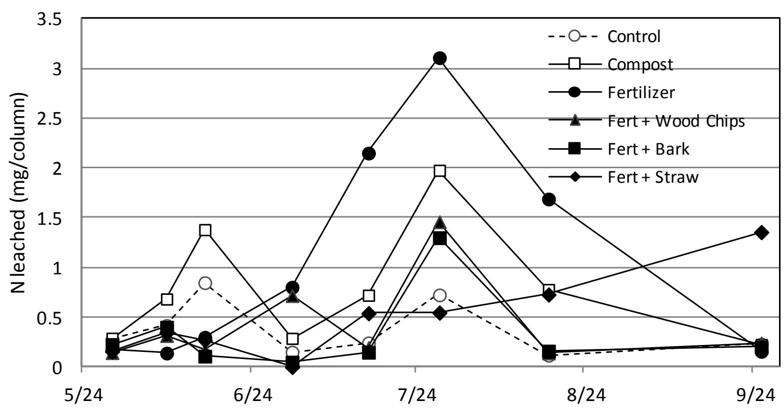


Fig 7. Effect of compost, fertilizer, and mulch types on nitrate- and ammonium-N leaching through soil columns, 2009.

The second study was conducted in 2011 using the same soil columns. Columns were re-filled with soil as previously. Treatments included a non-fertilized or amended control, wood chips without fertilizer, and wood chips with 1.2 to 9.6 g of McGeary 8-1-1 fertilizer. Wood chips were added to a depth of 2 inches, and fertilizer was applied over the top of the chips.

Results (Fig 8) indicated that wood chips tended to retain N in columns, but that high fertilizer rates (4.8 or 9.6 g) appeared to exceed the retention capacity and result in leaching losses.

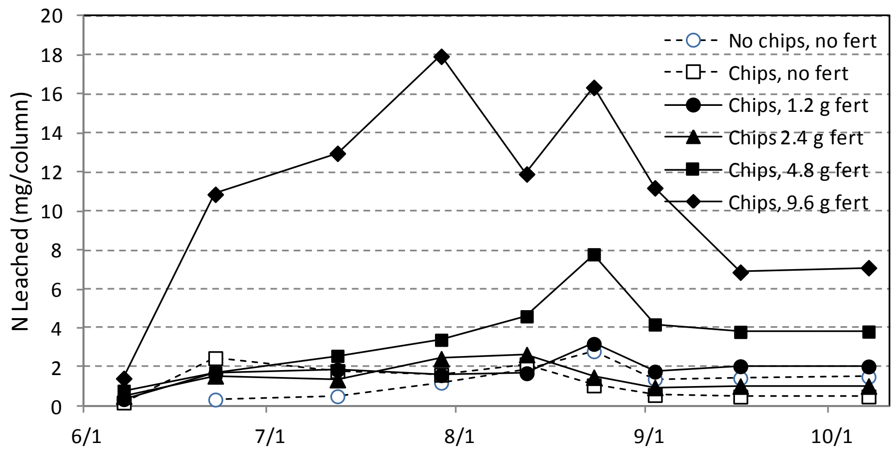


Fig 8. Effects of fertilizer (McGeary 8-1-1) on nitrate- and ammonium- N leaching from soil columns, 2010.

## DISCUSSION AND CONCLUSIONS

1. The two organic fertilizers tested in these studies had N release patterns that matched closely the demand curves of blueberries. Release of N began soon after application indicating they should be applied shortly before blueberries begin growing and needing N. When high rates are applied in the spring, available N may still be elevate in September, which may promote late growth and increase the risk of winter injury.

2. Compost can be a useful N source for organic blueberries, but the C:N ratios of composts should be known in order to predict their impact. We worked with an aged bark, compost mixture produce by one farmer (C:N ratio of 42:1) and a dairy-based compost fortified with feather meal (C:N ratio 11.1:1) The low ratio materials can supply adequate N, whereas compost with high C:N ratios may actually reduce the amount of N available to plants.

3. Surface mulches effectively suppress weeds and reduce hand weeding times. Plant-based mulches with high C:N ratios (straw, bark, wood chips) also tend to reduce available soil N levels, apparently because N is tied up in the decomposer microbe community. Use of mulches such as hay with lower C:N ratios may maintain high levels of available soil N than high C:N materials such as bark and wood chips. Although our studies were of relatively short duration, continual use of mulches is expected to eventually result in a higher organic soil system that might both retain applied N at reduce leaching losses, and supply N to supplement annual fertilizer additions.