# EFFECTS OF SHADE ON BLACK CURRANT PHYSIOLOGY AND PRODUCTIVITY

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## Abstract

Multifunctional Woody Polycultures have been proposed as a more ecological-friendly system of production agriculture that relies on woody perennials grown within a mix of other perennial crop species. However, little research has been conducted on productive shade tolerant crops that can fill the understory niche in these systems. An experiment was conducted on *Ribes nigrum* L. cv 'Consort' to measure the yield response to various levels (0, 35%, 45%, 65%, and 85%) of artificial shade. The study was located at the University of Illinois Urbana-Champaign. This 2-year experiment was initiated in 2016 on 4-year-old black currants. In 2016, there was a 5% reduction in yield from 65% shade, with 85% shade reducing yield by 28%. In 2017, yield was reduced 11% at 65% shade and 57% at 85% shade. Based upon these results, black currants can produce excellent yields under partial shading making them a potentially valuable edible understory crop.

**Keywords:** shade tolerance; black currant; *Ribes nigrum*; understory; multifunctional woody polycultures

## Introduction

Multifunctional woody polyculture is a potential alternative to current agricultural production system. The benefits of MWP systems include reduced soil erosion and nutrient runoff, carbon sequestration instead of carbon emission, resiliency to climate fluctuations, and increased biodiversity (Jordan and Warner 2010). Agricultural landscapes can be designed to produce an agricultural product while also providing net ecosystem services and functionality (Lovell and Johnston 2009). In a side-by-side study, Davis et al. (2012) found that the combined yield and ecosystem benefits from a diverse cropping system could meet or exceed the same performance of a less diverse cropping system while using less synthetic agrichemical inputs.

A major limiting factor in a multi-species system is the availability of light due to intercrop competition, which results in a distinct overstory and understory niche. Black currants (*Ribes nigrum*) have the potential to produce a valuable product in the shaded understory niche. The quick growth to maturity, three to five years, makes this perennial crop a good choice in the [illegible] rants naturally occur in understory environments and are known to produce and grow well under shaded conditions (Bratsch and Williams 2009; Djordjevik et al. 2014; Harmat et al. 1990; Šavikin et al. 2013; and Toldam-Andersen and Hansen 1993). However, empirical research has been limited in determining the agricultural potential of black currants grown under the shade of an over-story of larger-sized fruit and nut trees.



An effective multifunctional woody polyculture system will require crops that produce adequate yield under partial shade. Black currants have potential as an understory crop, with healthy, marketable, good-yielding fruit and shade tolerance. However, there is a paucity of research on the effects of shade on black currant physiology and agricultural potential in the Midwestern US. The objectives of our research were to study the impact of shade on black currant growth and yield.

## Materials and methods

This study was conducted in 2016 and 2017 on the Woody Perennial Polyculture project site at the University of Illinois Fruit Farm in Urbana, Illinois. Soil types present are a Flanagan series (fine, smectitic, mesic Aquic Argiudolls) and a Thorp series (fine-silty, mixed, superactive, mesic Argiaquic Argialbolls). The existing site had east-west orientation with 4-year old Ribes nigrum L. cv 'Consort' set at 1.2 m spacing between plants and 4.8 m spacing between rows. Plants were fertilized in spring 2016 with urea at a rate of 112 kg N/ha and in spring 2017 with poultry manure at a rate of 112 kg N/ha, because the site is being converted to organic production. Disease was treated with applications of mineral oil (Ultra-Pure, BASF Corporation, NC, USA) applied as needed from mid-May until mid-August. Weeds were removed in a 1.2 meter band around plants using glyphosate, dicamba, and light tillage in 2016 and with light-tillage only in 2017. Pruning was done during dormancy to select roughly four 1-year stems, four 2-year stems, and four 3-year stems for an average of 10-12 stems per plant post-pruning.

Four artificial shade treatments were used with one open control. Shade netting at stated levels of 20% white, 30% black, 50% black, and 70% black (Dewitt Company, Sikeston, Missouri, USA) were placed over six currant plants. Shade cloth PAR values were measured at 37%, 45%, 65%, and 83% respectively and are reported as 35%, 45%, 65%, and 85%. Metal conduit was used to create a gothic frame structure 3 m wide and 1.8 m high in the center and slanting down to 0.9 m at the edges. The shade structure extended past the end plants by 0.9 m. A 90% black shade netting treatment was initially installed in 2016 but was replaced with 37% white shade netting three months after February and before full flower bloom.

Experimental design was a randomized complete block with four blocks. Each shade treatment consisted of six plants, with the outer two plants serving as buffers and data collected from the center four plants. The shade netting was installed in early spring before full leaf out on March 12th in 2016 and removed after leaf fall in late November and was installed in late spring before full flower break on April 13th in 2017.

Treatments were harvested by hand when 95% of the berries were ripe as judged by Brix and visual measurements and before significant berry drop occurred. In 2016, all treatments were harvested on July 5th. In 2017, the control and 35% treatments were harvested on June 27th while the 45%, 65%, and 85% treatments were harvested on July 1st and 2nd. Harvest weight was recorded for each of the plants and averaged across plots.

Analysis of variance was performed using JMP Pro (c13, SAS Institute, Cary, NC, USA). Subsamples were averaged across replications before running the analysis. Means were separated using the Tukey-Kramer multiple comparisons test at a significance level of $\alpha=0.05$. Parameter means plus or minus standard deviation by treatment and year are reported.

## Results

There was a significant year by treatment interaction, so data are reported separately by year. Averaged across all treatments, the yield in 2017 was 1094 grams per bush while the 2016 yield was 694 grams per bush. In 2016, there was no difference in yield amongst any of the treatments, in 2017, the 85% shade treatment had a lower yield than the control (Table 1). Averaged across both years, the 65% treatment reduced yields by only 8%.

Table 1: Total mean yield of black currant (*Ribes nigrum*) by percent shade treatment and percent reduction from the control for the 2016 and 2017 growing season in Urbana, IL in grams per bush ± standard deviation. Different letters within a column indicate significant differences as determined by Tukey-Kramer multiple comparison test at a rejection level of α=0.05 with LSM values shown where significance was found. NS=not significant. *,**,*** Significantly different at the P=0.05, 0.005, or 0.001 probability level, respectively.

| Yield | | | | |
|---|---|---|---|---|
| | 2016 | | 2017 | |
| Treatment | Total (g) | % Reduction | Total (g) | % Reduction |
| Control | 807 ± 277 | - | 1294 ± 256 a | - |
| 35% | 638 ± 197 | 21 | 1278 ± 293 a | 1 |
| 45% | 682 ± 79 | 16 | 1179 ± 297 a | 9 |
| 65% | 768 ± 210 | 5 | 1158 ± 275 a | 11 |
| 85% | 577 ± 98 | 29 | 561 ± 119 b | 57 |
| LSM | NS | | 374.4 *** | |

**Discussion**

For the inclusion of woody understory crops in polycultures, the insignificant yield loss found in up to 65% shading proved to be the most interesting result. In 2017, only the 85% shade treatment reduced yield compared to the control (Table 1). Overall yield in 2016 was lower than 2017. This is most likely due to the 4-year-old plants reaching peak maturity and approaching ceiling yields in 2017. The higher yield in 2017 may also be explained by the addition of a two-year-old variety in the vicinity of the trial that went through flowering and may have served as a pollinizer. Also, warmer temperatures at the end of winter season followed by an extended cool spring may have contributed to increased yields in 2017.

The 65% shade treatment shows the greatest potential with minimal yield reduction in both years. This may be due to increased soil moisture or by the plant maintaining biomass allocation to reproduction immediately after developing shade and into the following year. The low yield in the 85% treatment could be caused both by limited carbon capture under reduced solar irradiance and by an increase in disease prevalence. Our results are consistent with the yield loss found by Toldam-Andersen and Hansen (1993) in black currants grown under 50% shade conditions who also reported an 8% reduction in yield for shaded plants. In a similar study on blueberries, Kim et al. (2011) found that blueberries performed well up to 60% shading, where heavier shading reduced yield significantly. Overall, our research indicates that black currants in the Midwest can maintain acceptable yields with up to 65% shade, but yields will be significantly reduced at shade levels above 65%. While the performance of plants under shade netting does not directly correlate to the performance of plants under a shade tree, these results help strengthen the argument for black currants in an understory environment.

Overall, the results of this study indicate that black currants are an excellent understory crop in light to moderate shade conditions. With a phenotypic plasticity homologous to shade species, currants were able to maintain a substantial yield under shade stress. Further, black currant germplasm could be screened to determine the cultivars having the best shade tolerance. These superior cultivars could then be used in a breeding program to further enhance productivity under shade. Black currants may prove useful in polyculture, providing fruit and nut orchard growers with an additional crop in the system that could increase yield and income without requiring additional land resources.

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