Field evaluation of early maturing oilseed sunflower double-cropped after winter camelina

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Introduction

In the northern Great Plains and upper Midwest, incorporation of winter-hardy cover crops as components of integrated weed management systems is gaining popularity as an approach for managing the spread of herbicide resistant weeds. Recently, winter camelina (*Camelina sativa*), has been used as a freeze-hardy oilseed cover crop. Winter camelina provides excellent weed suppressing ability with up to 87% control of early summer weeds, including some such as water hemp (*Amarathus tuberculatus*) that are herbicide resistant (Hoerning et al. 2020). Used as a cover crop, winter camelina also has similar benefits to other popular freeze-hardy covers such as winter cereal rye (*Secale cereale*) (Weyers et al. 2019).

Sunflower growers across the Northern Plains are continually looking for new crops and management strategies to bolster the economic and environmental sustainability of their cropping systems and enhance sunflower production. Previous research demonstrated that winter camelina can be harvested early enough during the summer in western Minnesota to allow production of a second short-season summer annual crop (Gesch and Archer 2013). Indeed, one of the crops that worked relatively well following winter camelina was sunflower. However, the yield of double-cropped sunflower was about 28% lower than its full-season counterpart (Gesch and Archer 2013). Since that study, shorter season (i.e., early maturing) sunflower hybrids have been identified that may work even better in a double-cropping scenario with winter camelina. Moreover, the markets for camelina seed, a relatively new oilseed to the US, are beginning to expand, which could make double-cropping with sunflower a more attractive system. The following study was conducted over two growing seasons between 2017 and 2019 to evaluate the feasibility and productivity of double cropping early maturing sunflower hybrids with winter camelina and measure water use of the system. Double-cropping can be limited by soil moisture as generally more water is required to grow two crops in a single season.

Material and Methods

The experiment was conducted over two growing seasons between fall 2017 and summer of 2019 at the Swan Lake Research Farm near Morris, Minnesota. The soil was a Barnes Loam and the previous crop both years was spring wheat. Winter camelina (cv. Joelle) was planted with a

no-till drill on 19 cm spaced rows at a rate of 7 kg seed ha^{-1} in mid- to late September in 2017 and 2018. Control (i.e., full-season) sunflowers were planted June 7 in 2018 and May 31 in 2019 with a John Deere MaxEmerg planter to give a seed population of 61,750 ha^{-1} (i.e., 25,000 $acre^{-1}$). The four oil hybrids used in the study consisted of Crop 549CL (Croplan), Falcon (Nuseed America), MY 8H456CL (Mycogen), and Honeycomb (semi-dwarf early maturing; provided by Dr. Brent Hulke). The control sunflowers were fertilized with 112-34-34 kg ha^{-1} N-P-K and the fertilizer along with Prowl (pendimethalin) herbicide was incorporated into the soil before planting.

Winter camelina was harvested on July 11 in 2018 and July 15 in 2019 and the double-cropped sunflower was planted within the same day. The double-cropped sunflower was managed the same way as the controls after harvesting camelina. In both years of the study, the control sunflowers were harvested from mid-September until the first week of October, with Honeycomb (early maturing hybrid) maturing the earliest. The double crop sunflowers were harvested in October 16 in 2018 after an early killing frost on October 4. In 2019, the double-cropped sunflowers were harvested October 18 to 23 after reaching physiological maturity. Both winter camelina and sunflower were combine-harvested, the seeds were cleaned and dried before determining yield. Oil content of camelina seed was determined by nuclear magnetic resonance (NMR) at the ARS unit in Morris, and sunflower seed oil content and composition was determined by NMR and gas chromatography (GC) at the ARS unit in Fargo. During both seasons, soil moisture was measured to a depth of 1 m with a Delta T PR-2 probe, in the control and double-crop treatments of Honeycomb and Croplan 549CL, between the first week of June until final sunflower harvest.

Results and Discussion

Winter camelina seed yield and oil content were quite low in 2018 averaging just 423 kg ha^{-1} and 35%, respectively. In 2019, however, camelina yielded on average 1848 kg ha^{-1} with a mean oil content of 41%. The poor camelina performance in 2018 was likely due to a combination of late seeding in the fall of 2017 followed by a very wet cold spring. Waterlogging stress of camelina has been cited as detrimental to yield (Gesch and Cermak 2011).

Control sunflowers grew well at Morris in 2018 ranging in yields from 3065 kg ha^{-1} for Falcon to 3897 kg ha^{-1} for Croplan 549CL (Fig. 1A). These relatively high yields were likely due to a lack of disease and insect pest pressure. A relatively early killing frost occurred during 2018 (Oct. 4). Because of this, the only double-cropped sunflower that reached physiological maturity by the time of the killing frost was the early semi-dwarf hybrid Honeycomb, which did yield 1705 kg ha^{-1} while the other hybrids were much lower (Fig. 1A). The oil content of the double-cropped Honeycomb seed (36%) was 3% lower than its full-season counterpart planted in early June and lower than its known full potential. Due to a combination of factors including bird and insect damage, control sunflower hybrids did not yield as high in 2019 (Fig. 1B) ranging between 1344 kg ha^{-1} for MY 8H456CL to 2161 kg ha^{-1} for Croplan 548CL. The double-cropped Honeycomb yielded 1214 kg ha^{-1}, which was just 19% less than the full-season control (Fig. 1B).

During the 2018 growing season, the total seed yields for the double-crop treatments (i.e., sunflower plus camelina seed yields) were not as great as that of the monocrop full season sunflower (Fig. 2). However, results were very different in 2019, where the total seed yield of the double crop treatments averaged 2786 kg ha^{-1} compared with monocrop sunflower yield, which across all hybrids averaged 1728 kg ha^{-1} (Fig. 2).

Having sufficient soil water throughout the growing season to successfully produce two crops in a single season can be one of the most limiting factors for double cropping. In 2018, the soil moisture was lower in the double-crop treatments compared with the control, full season sunflower (Fig. 3). Although the volumetric soil moisture on average was about 6 to 7% lower in the Honeycomb double-crop treatments compared with the control (Fig. 3), it was not low enough to cause any noticeable drought stress symptoms such as leaf wilting. Precipitation was well distributed throughout both growing seasons and was relatively high (data not shown). Consequently, soil moisture during the study may have somewhat limited the growth and yield of the double-crop sunflower, but was likely not a major factor.

Conclusion

This study demonstrated that using an early maturing semi-dwarf hybrid, sunflower can be double-cropped following winter camelina as far north as west central Minnesota. Despite the challenges of unusually short growing seasons, in both years of the study, Honeycomb reached physiological maturity before exposure to a killing frost. Total seed yield of double-cropping camelina and sunflower was less than that of mono-cropped sunflower in 2018. However, in 2019, total seed yields for double-cropping camelina and sunflower were substantially greater than monocrop full season sunflower. Evidence indicated that double-cropping did use more soil moisture than the monocrop sunflower, but due to ample precipitation in both years of the study, it may not have been the most yield limiting factor. Double-cropping winter camelina and sunflower has the potential to add economic value while providing environmental benefits by using a winter cover crop. Further research is needed to evaluate more sunflower hybrids and locations across the Great Plains and upper Midwest for double cropping.

References:

Gesch RW, Cermak SC (2011) Sowing date and tillage effects on fall-seeded camelina in the northern Corn Belt. Agron. J. 103:980-987.

Gesch RW, Archer DW (2013) Double-cropping with winter camelina in the northern Corn Belt to produce fuel and food. Ind. Crops Prod. 44:718-725.

Hoerning CA, Wyse DL, Wells MS, Gesch RW, Forcella F (2020) Yield tradeoffs and weed suppression in a winter annual oilseed relay-cropping system. Agron. J. doi: 10.1002/agj2.20160

Weyers SL, Thom MD, Forcella F, Eberle CA, Matthees HL, Gesch RW, Ott M, Feyereisen GW, Strock JS, Wyse D (2019) Potential for nutrient loss reduction in winter oilseed cover cropped systems in the Upper Midwest. J. Environ. Qual. 48:660-669.

Figures:

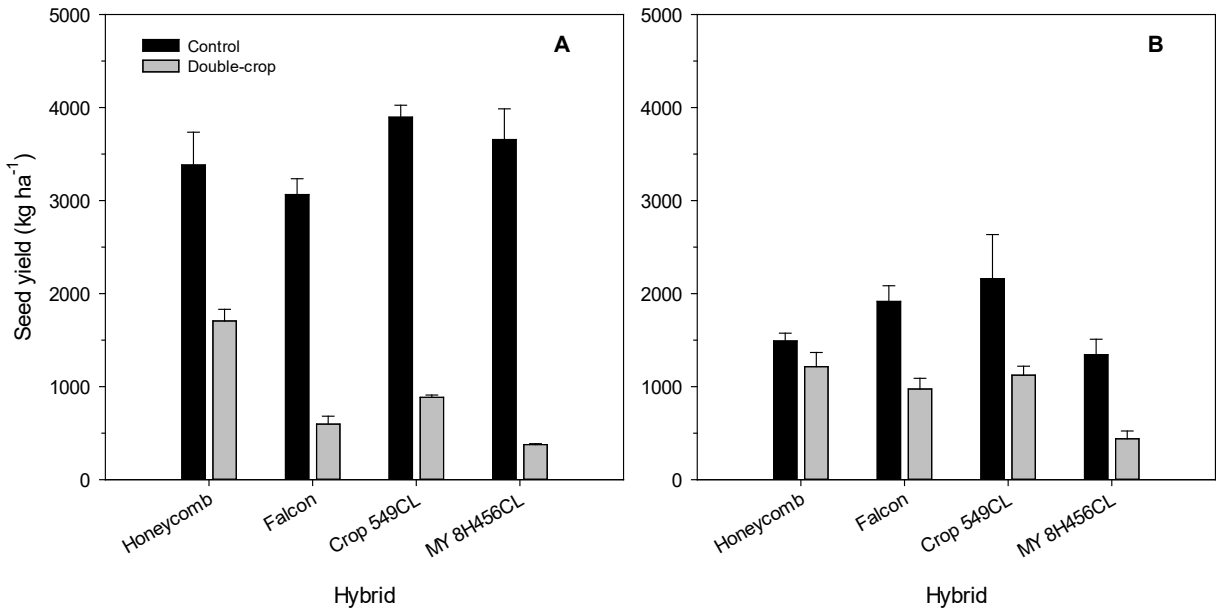


Figure 1. Sunflower seed yields for control (full-season) and double-cropped sunflower in 2018 (A) and 2019 (B).

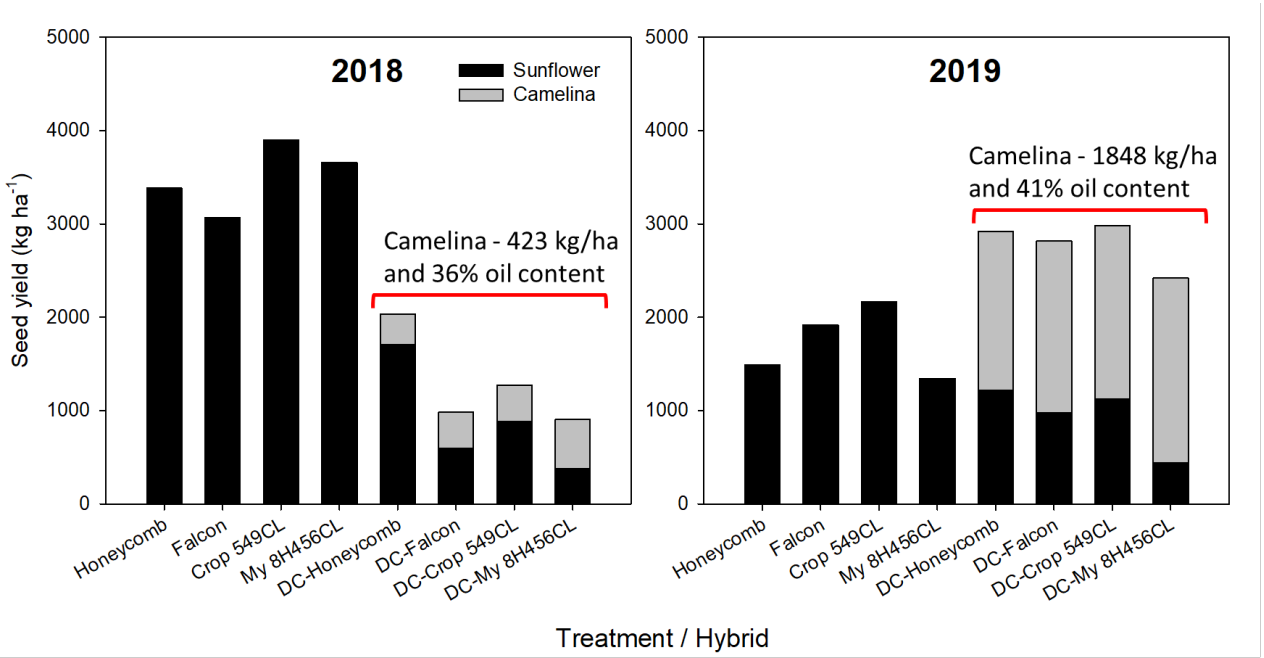


Figure 2. Total seed yield of full season sunflower (left bars in each graph) compared with the combined yield of double-crop sunflower (DC) and winter camelina (bars on right side in each graph) for the 2018 and 2019 growing seasons. The overall average camelina seed yield and oil content are given above the red line.

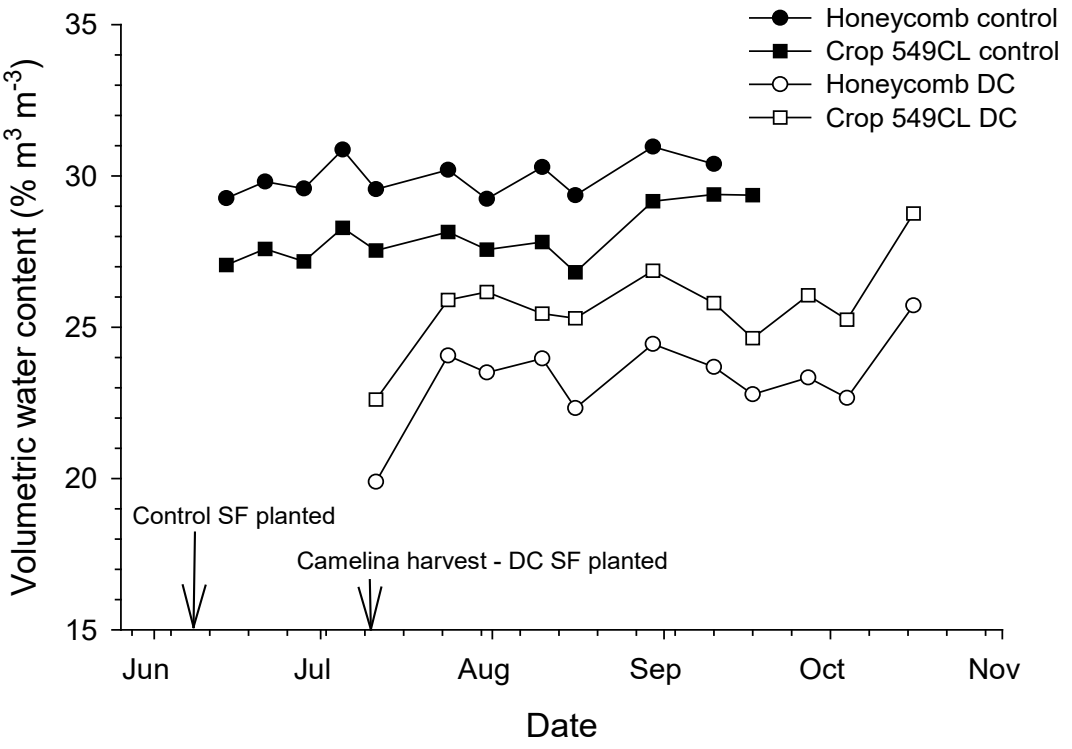


Figure 3. Soil water content between 0-1 m deep for sunflower controls (solid symbols) and double crop (DC) treatments (open symbols) during the 2018 growing season. The arrows on the x-axis denote when the control sunflower (SF) and the double crop sunflower (DC SF) were planted.