Field Crops Research 223 (2018) 150–154

Contents lists available at ScienceDirect

Field Crops Research

journal homepage: www.elsevier.com/locate/fcr

Impact of a living mulch cover crop on sugarbeet establishment, root yield and sucrose purity

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ARTICLE INFO

Keywords:
Beta vulgaris
Companion crop
Cover crop
Intercropping
Wind erosion

ABSTRACT

Lack of crop rotation diversity and extensive tillage leaves the soil in many sugarbeet-based production systems vulnerable to wind erosion. Intercropping sugarbeet (*Beta vulgaris* L.) with a living mulch is a practice that aims to protect sugarbeet seedlings from blowing soil and provide ecosystem services such as enhancing soil organic matter, reducing sedimentation in surface-irrigated farms, and improving soil biological activity. If managed improperly, nevertheless, the living mulch can compete with sugarbeet and reduce its production. Selection of an appropriate crop species along with timely termination are the two critical points that need to be researched in order to minimize the impact of living mulch on sugarbeet performance while still offering ecosystem services. A 4-yr field experiment was conducted to evaluate the effect of living mulch and its termination time on sugarbeet population, root yield, and purity. Over four years of the study, living mulch terminated at sugarbeet V2 growth stage had no significant effect on sugarbeet yield and quality. However, when living mulch termination was delayed to V4 and V6 growth stages, root yield declined by 17 and 14 Mg ha^{-1}, respectively, compared to 66.4 Mg ha^{-1} yield in the control. Living mulch had a positive impact on root quality traits by increasing sucrose concentration and decreasing root impurities (sodium, potassium, and amino-N concentration in the beet). The results indicated that planting sugarbeet with a living mulch can offer ecosystem services without negatively impacting sugarbeet productivity (recoverable sucrose yield) if terminated no later than V2 growth stage.

1. Introduction

Due to high economic return, crop rotation in sugarbeet growing regions is usually limited and often includes a few crops including grain cereals. Lack of crop diversity, in addition to the extensive soil tillage has made the soil vulnerable to wind erosion, loss of organic matter, and limited soil biological activity which threatens the long-term sustainability of sugarbeet-based cropping systems (Stevens et al., 2010). Additionally, the above ground growth rate of sugarbeet, especially prior to four-leaf stage, is quite slow making it highly prone to wind damage and/or damage from wind-blown soil (Dregseth et al., 2003). The adverse effect of wind damage on sugarbeet establishment and its final yield has been documented previously (Ohnami, 2009).

Early season intercropping of sugarbeet with a companion crop, known as living mulch, is a management practice that has potential to address aforementioned issues. In this system, glyphosate-resistant sugarbeet cultivars grow with a companion crop until the companion crop is terminated by using glyphosate herbicide. Similar to other living mulch systems, the companion crop in sugarbeet production system could provide multiple ecosystem benefits such as improving soil organic matter and soil biological activities (Marinari et al., 2015); providing soil cover thus minimizing soil erosion (Etemadi et al., 2018; Jahanzad et al., 2017; Siller et al., 2016); and reducing runoff and sedimentation (Laloy and Bielders, 2010). Moreover, the living mulch sown earlier than or simultaneously with sugarbeet is expected to establish quicker thus protecting sugarbeet seedlings from wind damage (Yonts et al., 2002). Additionally, if sugarbeet stand fails for any reason such as extreme dry events or highly damaging wind, the companion crop continues growing to partially compensate for the main crop failure. In some regions, such as southern Minnesota, farmers adopt this system in exchange for phosphorus credits in cooperation with the Minnesota Pollution Control Agency (Peters et al., 2015). Peters et al. (2015) estimated that about 49% of the sugarbeet growers in 2015 used spring-seeded living mulch in eastern North Dakota and Minnesota.

Use of living mulch with sugarbeet has also been employed to control pathogens in sugarbeet cropping systems. Dregseth et al. (2003) evaluated the use of oat (*Avena sativa* L.,) living mulch as a cultural tactic to minimize feeding injury from sugarbeet root maggot (*Tetanops*

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https://doi.org/10.1016/j.fcr.2018.04.009
Received 16 February 2018; Received in revised form 12 April 2018; Accepted 17 April 2018
0378-4290/

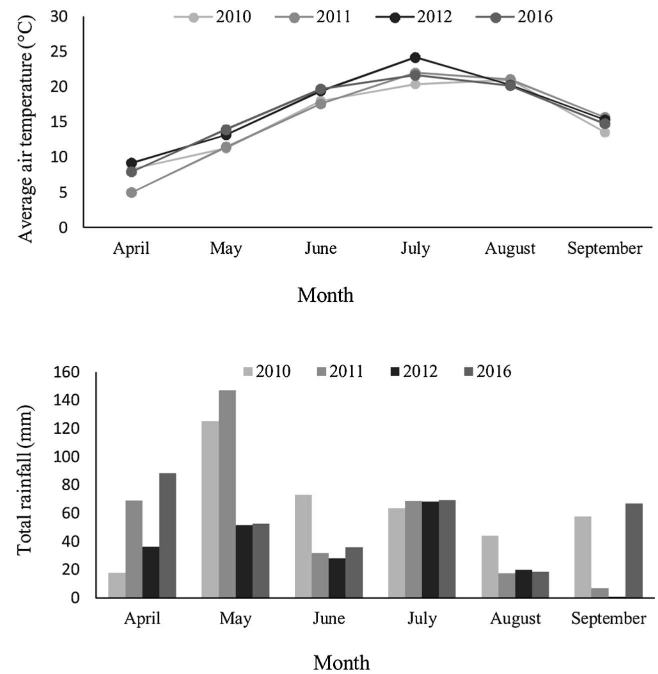

Fig. 1. Average monthly air temperature (a) and total monthly rainfall during sugarbeet growing season in 2010, 2011, 2012, and 2016 in Sidney, Montana. (source: https://ndawn.ndsu.nodak.edu/weather-data-monthly.html).

myopaeformis). Oat mulch reduced maggot feeding injury in the absence of soil insecticide application and increased root yield by 6.8% compared to control without mulch. The authors suggested that beneficial interactions between planting-time, insecticide application, and cereal cover crops are achievable in areas infested by *T. myopaeformis*.

Optimum termination time of the living mulch plays a vital role in the success of this system (Overstreet and Cattanach, 2010). Delaying the termination time often results in a sugarbeet yield penalty. Limited research-based information exists documenting how living mulch systems influence the productivity of sugarbeet. Therefore, a field experiment was conducted over a course of four years to evaluate the effect of living mulch on sugarbeet establishment, yield, and quality. Specific objectives were to determine 1) if the existence of living mulch reduces sugarbeet yield and quality and 2) whether termination date of living mulch affects sugarbeet yield and quality.

2. Materials and methods

Field experiments were conducted at Eastern Agricultural Research Center in Sidney, Montana (47° 43′ 32″N, 104° 9′ 5″W) during four growing seasons (2010, 2011, 2012, and 2016). Soil at this site is deep, well drained, nearly level Savage clay loam (fine, smectitic, frigid Vertic Argiustolls) containing > 20 g kg^{-1} organic matter and pH of ~8.3. Average monthly air temperature and total rainfall during the experiment are shown in Fig. 1.

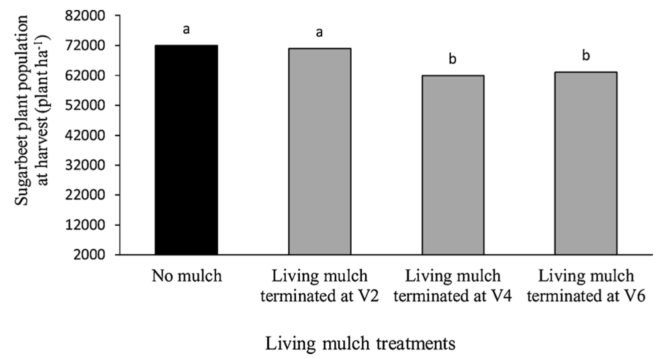

Fig. 2. Effect of living mulch on sugarbeet plant population in 2010–2012 experiment. Means with the same letter are not significantly different based on LSD test at $P = 0.05$.

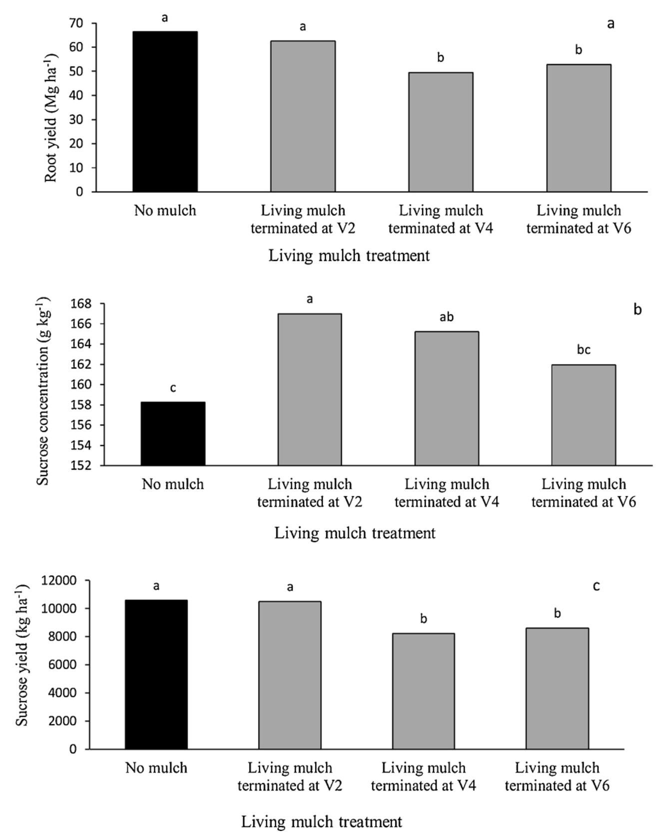

Fig. 3. Effect of living mulch on sugarbeet tuner yield (a), sucrose concentration (b), and sucrose yield (c) in 2010–2012 experiment. Means with the same letter are not significantly different based on LSD test at $P = 0.05$.

Table 1
Description of agronomic management practices for sugarbeet and the living mulch in Sidney, Montana.

Item	2010	2011	2012	2016
Living mulch (barley) seeding date	April 22	May 5	April 22	May 3
Sugarbeet planting date	April 29	May 19	April 23	May 3
Sugarbeet between-row space (cm)	61	61	61	61
Sugarbeet within- row space (cm)	14	14	14	14
Sugarbeet cultivar	ACH 123	VH SV 36944	BTS 47RR31	ACS 360
Initial soil NO_3-N (0-0.12 m)	80 kg ha^{-1}	80 kg ha^{-1}	85 kg ha^{-1}	70 kg ha^{-1}
N-P_2O_5-K_2O application rates (kg ha^{-1})	80–56–0	80–56–0	80–0–0	135–22–22
Sugarbeet harvest date	September 20	September 22	September 19	September 19