EVALUATION OF SUNN HEMP PRODUCTIVITY AFTER WHEAT UNDER NO TILLAGE CONDITIONS

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ABSTRACT: Enhancing the multitasking of traditional agriculture is a key strategy to fulfil the Horizon 2020 targets. Sunn hemp, cultivated as an energy crop within the traditional rotations gap, represents an ambitious challenge for the coexistence of food and non-food crops without competition. The short time available for soil tillage between consecutive crops in rotation could be extended through quicker and more economical seedbed preparation. Three soil management practices were compared in this study: no- (NT), minimum (MT) and conventional (CT) tillage. Even though the non-statistical differences in the average dry biomass, the NT treatment resulted 27% higher than the CT. Furthermore crop yield and architectural components of the plants such as emergence rate, number of plants, canopy cover, and plant height increased by 25%, 33%, 32%, and 20%, respectively under NT conditions in comparison to CT. Moreover branching rate was reduced by two to six times. Besides generating a better plant performance since the emergence stage, the better biometric canopy characteristic of the NT treatment offer improved agronomic harvest characteristic without a yield reduction.
Keywords: no-tillage; cropping system; sunn hemp; wheat; advanced biofuel.

1 INTRODUCTION

Enhancing the multitasking of traditional agriculture is a key strategy to fulfil the Horizon 2020 targets. In general traditional rotations leave the soil bare for lengthy periods, hence there is the chance to intensify the Land Equivalent Ratio (i.e. increase of the intensified cropping system yield compared to the sole-crop yield) by introducing fast growing, high biomass yielding crops. Sunn hemp (*Crotalaria juncea*) is a fast growing and high yielding lignocellulosic legume crop with a great potential as a feedstock for advanced biofuels. Grown as a cover crop in Alabama sunn hemp yielded 7.5 Mg ha^{-1} of dry matter in approximately 100 days [1], whereas in Florida in 120 days yielded up to 11.6 Mg ha^{-1} [2]. Even though its tropical origin, sunn hemp could be cultivated in the temperate climates of Europe thanks to its high growth rate, low input requirement, adaptations to a wide range of soils and tolerance to water stress (after the establishment) [3,4]. Such characteristics eases its cultivation alongside traditional crop rotations gaps as a summer crop [5], while avoiding any competition with food crops. Besides that, sunn hemp could increase crop diversification and soil fertility (N fixed into the soils) [6]. However, the precondition for the feasibility of such new ambitious integrated cropping systems, combining food and energy production, is the development of fast, easy to adopt, and economical practices. Direct sowing could be one of such practices, nevertheless, in European temperate climates, sunn hemp's studies on that regard are scarce, in fact there is no information about its cultivation in a rotational system under NT conditions.

The objective of the study was to test the feasibility of sunn hemp in a wheat - sunn hemp sequential cropping system under no tillage conditions.

2 MATERIALS AND METHODS

A field trial was carried out in 2017 at the Cadriano experimental farm of the University of Bologna, (32 a.s.l., 44° 33' N, 11° 21' E). The experimental set up was a completely randomized block design with four replications and three different seedbed preparation methods: direct sowing (NT, no tillage); minimum tillage (MT, rotary harrowing); Conventional tillage (CT, disc and rotary harrowing). In each case, the dimension of the plots (324 m^2) allowed a complete mechanization of the soil preparation practices. No fertilizer were applied after wheat harvesting. Weed control was carried out four weeks after sowing using a teeth cultivator.

'Crescent sunn', a well know sunn hemp variety, was sown at a density of 50 seeds m^{-2}, with a 0.45 m row distance. Sowing was carried out with a pneumatic seeder on 26th June, five days after wheat harvesting. Emergence rate was evaluated several times during the first two weeks after sowing, whereas phenology (flowering, number of leaves and branches) and canopy photosynthetic active radiation (PAR) interception were measured approximately every two weeks. PAR interception was measured through an EMS 7/L ceptometer.

On 10th October 2017, on an area of 12 m^2 per treatment dry biomass yield, plants height, number of leaves and branches were measured. Hence, the economic effectiveness of the three systems was assessed dividing the soil preparation cost by the related biomass yield.
All measured parameters were subjected to the analysis of variance and post hoc LSD test was performed.

3 RESULTS

The NT treatment recorded the highest average biomass yield in comparison to the CT and MT treatments (Table I). Such biomass production performance was determined by the plant components; that is when compared to the CT, the NT treatment resulted in a 25%, 33%, 32%, and 20% increase in the emergence rate percentage, number of plants m^2, canopy cover (PAR interception), and final plant height, respectively. The MT showed intermediate values to these extremes but statistically similar to the CT (Table I).

Table I: Biomass production and biometric parameters of sunn hemp under different tillage systems.

	CT	MT	NT
Emergence rate (%)	76 b	82 ab	91 a
N° of plants at harvest (pt m^{-2})	31 a	31 a	41 a
Canopy cover (%)	63 b	61 b	82 a
Plant height (m)	1.25 b	1.28 b	1.55 a
Aboveground dry matter (Mgha-1)	5.5 a	5.3 a	7.0 a

Furthermore, phenological observations showed that the MT and CT started earlier the branch development than the NT treatment. At about 37 days after sowing, the CT and MT had two and six times more branches than the NT respectively, whereas at harvest time the ratio switched with NT showing 50% more branches than CT and MT which showed similar values (Fig 1).

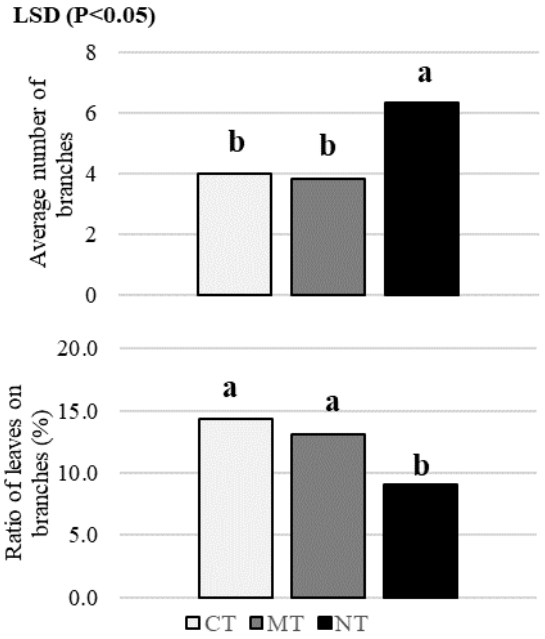

Figure 1: Canopy branching and leaves distribution percentage under different tillage systems, at harvest.

The stem elongation rate of NT resulted 66% and 75% higher than CT at 17 and 43 days after sowing respectively, with intermediate values in the MT treatment. As far as NT flowering occurred earlier the stem elongation rate decreased significantly between 43 and 91 DAS, on the other hand the other two treatments showed a reduction later; that is between 91 and 106 DAS (Fig. 2).

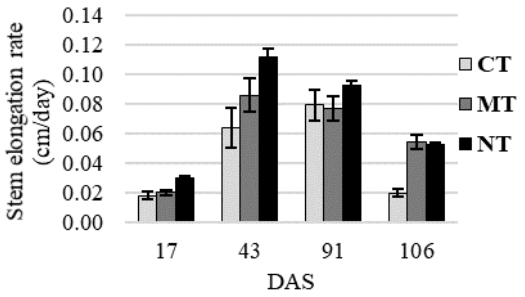

Figure 2: Stem elongation rate from establishment of sunn hemp under different tillage systems.

The soil preparation cost per unit of biomass yielded shows a broad gap between the treatments. NT allowed to save twice as much money than CT (Fig. 3)

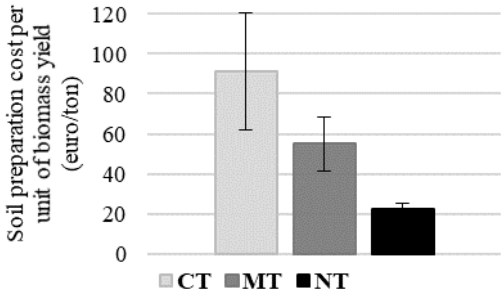

Figure 3: Soil preparation costs per unit of biomass yield of sunn hemp under different tillage systems.

4 DISCUSSION AND CONCLUSIONS

Taking into account of the non-significant difference in the biomass yield between treatments, the biometric parameters evaluated here highlight, besides a better economic performance due to the lower soil preparation costs, a general better agronomic performance of the no tillage practice compared to minimum and/or conventional tillage. In fact, in the no tillage treatment, the plants were straight, less ramified and not lodged, possibly due to the protective effect of the cereal stubble that lead to a higher emergence rate and enhanced apical dominance. The resulting plants structure suggests a better fit (i.e. less losses) to mechanical harvest than the much more ramified plants produced under minimum and conventional tillage. Therefore, sunn hemp in rotation with wheat under no tillage could be a feasible practice in temperate climates as not only do not negatively affect the biomass yield, but at the same time it seems to improve agronomic harvest characteristics of the canopy.

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7 LOGO SPACE