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Soil tillage and fertilization affect durum wheat and weeds interactions in Mediterranean environment

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Introduction

Although soil tillage offers several advantages to crop plants, it is one of the main causes of soil compaction, structure modification, and organic matter mineralization, especially with plowing practice adoption. Besides, the use of powerful machinery requires more fossil fuels causing more greenhouse gas emissions. On the other hand, there are different tillage practices that only work along with the soil profile, producing crumbling of clods or, in the case of spading machine, a mixing of the soil. Conservation practices, mainly based on reduced soil disturbance and diversification of plant species over seasons, aim to improve the biodiversity and natural biological processes and contribute to greater use efficiency of water and nutrients supporting crop production. Mineral fertilization has an excellent effect on crop production, even if heavy applications negatively affect the agroecosystems stability, favor specific weeds, reduce soil fertility, and influence the environment. On the other hand, organic fertilizers bring directly and indirectly benefits to soil fertility by increasing the organic matter, improving soil structure and stability, and promoting more balanced biological components. Weeds can have an important role in the agroecosystem, as long as they have not become a crop production obstacle. Therefore, it is essential to adopt a sustainable approach for their management to satisfy the agro-ecological objectives. In case of conservation agriculture, the optimal plant diversity will be the one without truly dominant species, combined with a low overall density. This study hypothesized that the soil tillage and fertilization practices could affect durum wheat production and weeds, therefore, the main objective of this study was to evaluate the potential role of different soil tillage and fertilization sources on durum wheat yield and weed relative weed interactions.

Materials and Methods

The field trial was realized at the "Nello Lupori" experimental farm of the University of Tuscia located in Viterbo (Central Italy - 45°25'N, 12°04'E, Alt. 310 m a.s.l.). The average soil characteristics in the 0 - 30 soil layer are: 63% sand, 22% silt and 15% clay. Moreover, the total organic carbon and nitrogen are 1.07% and 0.12%, respectively, while the pH is 7.1. The climate of the area is Mediterranean typical of Central Italy, with cold, wet winters and hot, dry summers. The weather conditions, measured in an automating weather station located near the field experiment, were similar to that observed in the long term period (30-year). The experimental treatments were: (i) two fertilization types [mineral fertilizers (M); organic fertilizer (O) (composted urban organic waste)]; (ii) three tillage methods at a depth of 30 cm [plowing tillage (P), sub-soiling tillage (R), and spading tillage (S)]. The experiment was conducted using a complete randomized block design with three replications. The plot size was 50 m^2 (10 x 5 m). The experiment was carried out in a field where the previous year was cultivated with barley. After the barley harvest, residues were finely chopped and uniformly distributed on the soil surface. In September, the soil was tilled following the above-mentioned treatments and, then, it was harrowed in order to break soil clods for the seed bed preparation. The organic fertilizer (15 t ha^{-1}) was distributed in one application before the harrowing. Mineral fertilizers were applied according to the practices adopted in the study area by distributing the phosphorus (80 kg of P_2O_5 ha^{-1}) before the harrowing, and the nitrogen at the beginning of tilling stage (20 kg of N ha^{-1}), at the end of the tilling stage (30 of N kg ha^{-1}) and at the beginning of stem elongation (50 kg of N ha^{-1}). Durum wheat var. Colosseo was sown on November 27th, 2013 and November 25th, 2014, harvested on July 3rd, 2014 and June 26th, 2015. Wheat Biomass, Wheat biomass and yield components, and weeds were collected from a 1 m^2 quadrant randomly placed in the middle of each plot. Data obtained from the experimental trials were statistically analyzed by analysis of variance (ANOVA) using JMP statistical software package version 4. Fisher's protected least significant differences (LSD) test at the 0.05 probability level ($P < 0.05$) to compare the effects was used.

Results

The durum wheat production in terms of biomass, harvest index (HI), thousand seeds weight, seed bleaching and specific weight was significantly affected by both soil tillage and fertilization source interacting with year. Durum wheat biomass varied from 1003 to 1289 g m^{-2} of DM and tended to be higher in plowing treatment in both years and using mineral fertilization (M) also in both years (Tab. 1). The weather conditions measured during the growing seasons tended to be different in the two experimental years. The rainfall was higher in the first year compared to the second year in which a high drought level was observed in spring time. The HI and thousand seed weight results favored by sub-soiling and spading tillage practices, even if durum wheat biomass was lower in both years. Generally, under organic fertilization treatment (O), wheat biomass was similar in both years. No significant differences were observed between fertilizer sources for the thousand seeds weight. Generally, the yield components parameters were better in the second year compared to the first year.

Table 1. Durum wheat production and yield components. Values belonging to the same parameter with different letters are statistically different according to LSD ($P < 0.05$).

		Biomass (g m^{-2})	HI	Thousand seeds weight (g)	Bleaching (%)	Specific weight (kg hl^{-1})
2014	P	1289a	0.403ab	47.2ab	88.0b	78.7c
	R	1179b	0.381c	46.9ab	91.5a	78.7c
	S	1110bc	0.396b	52.4a	94.0a	78.6c
2015	P	1215ab	0.392bc	50.2a	26.6c	89.1a
	R	1003c	0.402ab	44.4b	21.8d	87.2b
	S	1073bc	0.412a	48.2ab	22.4d	87.4b
2014	M	1451a	0.409a	50.6a	92.1a	78.6c
	O	934c	0.378b	47.0a	90.2a	78.7c
2015	M	1239b	0.415a	47.5a	25.4b	88.7a
	O	955c	0.389b	47.7a	21.8c	87.1b

The Durum wheat production in terms of biomass resulted to be significantly affected by weed density especially under sub-soiling tillage (R) and spading tillage (S) systems, while the relationship was not significant when plowing tillage is adopted ($P > 0.05$, Fig. 1). Wheat biomass was affected also by weed biomass but only under spading tillage (S). Not relationships was observed concerning the fertilizer sources.

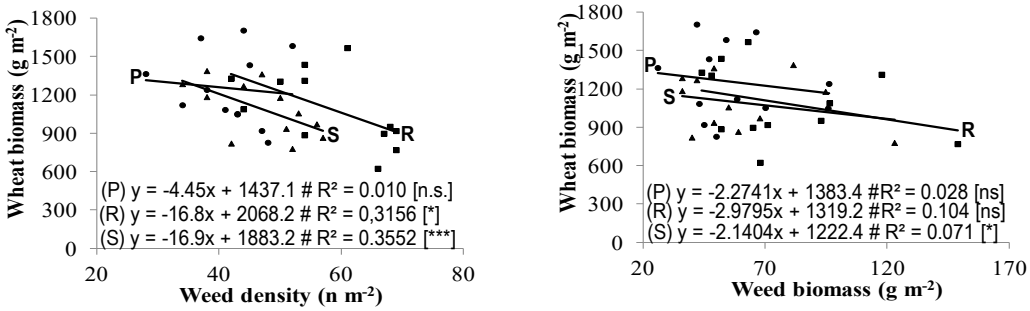

Figure 1. Durum wheat production related to weed density and weed biomass.

Conclusions

This study demonstrated that different soil tillage methods and fertilization sources affect durum wheat production and weeds biomass. Although the durum wheat performed better under conventional tilled soil by means of plowing, the need of the adoption of sustainable agronomical practices such as reduced tillage practices should be stimulated for environmental issues. Therefore, further studies should be addressed to evaluate the weed characteristics and their competition effects to avoid severe yield loss and support environmental-friendly practices. Moreover, detailed studies regarding organic fertilization application should be conduct because the methods and time of application can be relevant for the crop performance.

Literature

Langeroodi A et al. 2020. How Do Intensification Practices Affect Weed Management and Yield in Quinoa (*Chenopodium quinoa* Willd) Crop?. Sustainability 12(15), 6103.