Different Soil Tillage and Nitrogen Fertilization in Durum Wheat: Effect on Yield and Nitrogen Utilization

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Introduction

More than 50% of durum wheat in Europe is cultivated in the Mediterranean region where farmers usually adopt conventional practises with high input levels. However, the environmental and economic sustainability of this crop are strongly affected by agricultural practises such as soil tillage and nitrogen fertilization, generating interest in low input cropping practices that can reduce the environmental impact and the production cost and at the same time guarantee sustainable yield levels. For these reason, a two-year study was carried out within LIFE+IPNOA Project, to study the effect of soil tillage and nitrogen rate on durum wheat productivity and nitrogen use.

Methods

The IPNOA experimental field trials was located in two representative sites in Tuscany: i) the Centre for Agro-Environmental Research E. Avanzi (CIRAA), located in San Piero a Grado (Pisa) and ii) the Centre for Agricultural Technologies and Extension Services (CATES), located in Cesa (Arezzo). The experiment was conducted during 2013-2014 and 2014-2015 growing seasons. In both sites, a split-plot design with 4 replicates was used. The main plot was assigned to tillage, which consisted in conventional tillage (P) (ploughing, 30 cm depth) and minimum tillage (MT) (10 cm depth). The sub-plot was assigned to N fertilisation, which consisted in three N fertilisation rates: no fertilisation (N_0), 110 kg N ha^{-1} (N_1) and 170 kg N ha^{-1} (N_2). Following each growing season, crop yield (grain and straw) and yield components (N° of spikes per m^2, thousand-seed weight), were assessed on 4m^2per plot, excluding border plants and it was expressed on a dry matter content basis. One sub-sample for each plot was placed in a forced-draft oven at 60 °C until constant weight to determine the nitrogen content using Kjeldahl's method. Grain and straw N uptakes were calculated by multiplying dry yield and N content and their sum represented the above ground N uptake. The following parameters were also calculated: (i) Agronomic Efficiency (A_E) as ratio of (grain yield at N_x– grain yield at N_0) to applied N at N_x; (ii) Nitrogen Utilization Efficiency (N_{UtE}) as ratio of grain yield to above ground N uptakes at harvest; (iii) Nitrogen Harvest Index (N_{HI}) as ratio of grain N uptake to total above ground N uptake at harvest; (iv) Physiologica Efficiency (P_E) as ratio of (grain yield at N_x – grain yield at N_0) to (above ground N uptake at N_x – above ground N uptake at N_0); (v) Apparent Recovery Fraction (RF) as the ratio of (grain N uptake at N_x – N uptake at N_0) to applied N at N_x. The statistical analysis was performed with R software and the lme4 package. Data were analysed using a linear mixed model. Site, soil tillage and nitrogen rate were considered fixed variables, while year was considered a random variable. Significance was determined using the R LMER Convenience Functions package. Tukey's HSD post hoc test was used to reveal significant differences among treatments.

Results

The influence of site, soil tillage and nitrogen rate was significant (Figure 1). The total aboveground biomass was higher in CATES than in CIRAA (+30%) and the same gap was observed also for grain and straw yields. Moreover, the influence of the tillage system was significant with slightly higher values in P (+10%) for both straw and grain yield. Nitrogen fertilization rates had a significant effect on total above ground dry yield: N_1 and N_2achieved no significantly different yield level, while a twofold increase was observed respect to N_0 (+50%). These results agree with those reported by Lòpez-Bellido & Lòpez-Bellido (2001) and Ierna et al., (2016), observing no response to fertilization under Mediterranean