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Straw amendment as a double-edge sword controlling N losses and immobilization over winter cooling

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Nitrogen (N) lost from the agricultural field as leachate and nitrous oxide (N_2O) gas causes water pollution, accelerates global warming and decreases agricultural N use efficiency. Soil amendments with straw and nitrification inhibitors are used to combat these problems by increasing microbial N immobilization and suppressing nitrification, respectively. The potential N competition between soil microorganisms and subsequent crops under the incorporation of pre-crop straw can be moderated by seasonal temperature variation, but this interfering factor is insufficiently studied. A 99-days mesocosm experiment that simulated the seasonal temperature variation was conducted, to investigate the effects of wheat straw amendment (WSA) and nitrification inhibitor (NI) on the competition for soil N between soil microbes and winter barley under three N fertilization levels (N0 as control, N1 as low N fertilizer, N2 as high N fertilizer), and N lost from soil as N_2O and leachate. Strong mineralization was detected after the cooling-warming cycle, which happens in early spring frequently in Germany. Soil NH_4^+ of all treatments were increased by 34-138 % and soil NO_3^- of N2 levels were increased by 42-133 % during this process, providing mineral N for barley growth but also imposing the risk of N losses. Straw incorporation stimulated immobilization of N by soil microorganisms, increased soil microbial biomass C and N by 45-123 % till the end of experiment, thus decreased the total N lost by 41 % on average by decreasing N leaching (43-91 %), NI mitigated N_2O emission by 40 % in N2 levels, the combination of WSA and NI could mitigate N losses and global warming. However, the immobilized N under WSA was not remineralized timely during barley growth, therefore, barley shoot biomass (by 23-34 %) and N (by 28-46 %) decreased in N0 and N1 fertilizer levels, the shoot

nitrogen use efficiency (NUE) decreased in N1 (by 53 %) and N2 (by 30 %) fertilizer levels. Considering the strong (long term) N immobilization induced by straw, we suggest applying straw and N fertilizer separately to avoid N competition between soil microorganisms and crops.