Perennial leys for dairy cows: soil and plant attributes, yield and botanical composition with long-term low and high N input

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Soil chemical properties, plant nutrient concentrations, yields and botanical composition were studied in a high (mimicking conventional) and low nitrogen (N) input (mimicking self-sufficient organic) farming system over 7 years in a field experiment in Tingvoll, Norway. The two-factor experiment consisted of two organic fertilizer types (digested and undigested manure from organically managed dairy cows) and two fertilizer application rates, 110 and 220 kg total N ha^{-1} yr^{-1}. All, treatments and control, were cultivated with perennial grass-clover ley, re-established once during the study period. There was no significant difference between the average values of the above-mentioned characteristics evaluated for the digested and undigested manure, expect for K concentration in the ley (2018). Thus, results of treatments with high N input were combined to represent conventional farming systems, while low N input treatments represent organic farming systems. As expected, after 7 years, AL-extractable phosphorous (P) and potassium (K) concentrations in soil were significantly ($p=0.002$) higher in the conventional treatments than in the organic treatments. Despite the double amount of manure, cumulative ley yield (2011-18) was only 17% higher ($p<0.001$) in the conventional than in the organic treatments. In 2018, concentration of P in the aboveground plant material was significantly higher in all fertilised treatments than in the control ($p=0.041$), and significantly higher in the conventional than in the organic treatments ($p<0.001$). N use efficiency (NUE%) was calculated as NUE% = N removed (in ley yields) / N applied (manure) x 100. NUE(%)ranged from 102-163% for the organic treatments, suggesting that more N was removed by ley yields than it was applied with manure. This N may derive from soil or biological N fixation. Conventional treatments had a NUE between 59 and 96%. Low NUE% indicates excessive use of fertiliser that may cause environmental pollution. Botanical composition of the grass-clover ley (2015) was affected by N application rates, with significantly less clover ($p=0.008$) and more grass ($p=0.003$) in the high N input treatments. Overall, our findings indicate that in the long-term high N input farming systems do not necessary translate in significant gains of ley yield production when comparing to low N input systems. NUE and clover content of the ley will be reduced with higher N input.