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Inorganic Nitrogen Dynamics in Soil During Sugar Beet Crop Growth

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Nitrogen (N) is the crop nutrient which more directly influences the production and quality of sugar beet (*Beta vulgaris* subsp. *vulgaris* L., SB) root. It is therefore important to accurately estimate the amount of N fertilizer to be supplied to the crop. Soil N excess, besides being detrimental for SB technological quality, may also increase the environmental pollution risk. The aim of this work was to improve our general knowledge of N availability for SB, by monitoring the inorganic N content in the cultivated soil layer during the crop growth season. The N dynamics in soil under SB was compared with that under winter wheat (*Triticum aestivum* L., WW), in the same kind of soil.

Materials and Methods

The experiment was carried out in 2006, at the experimental farm of the CRA-CIN of Rovigo, Eastern Po Valley, Italy (Lat.: 45°04'; Long.: 11°47'), on a clay loam soil. The experimental design was a strip-plot with 2 replicates. Crops (SB, WW) were assigned to the main plots and 3 N fertilizer rates (0, 60 and 120 kg N ha^{-1}) to the sub-plots (sub-plot area: 402 m^2). The preceding crop was WW, for both SB and WW. Wheat straw was removed from the field. Winter wheat (cv. Abusson) was seeded on 20 Oct 2005 and harvested on 3 July 2006. Sugar beet (cv. Dorotea) was seeded on 15 March 2006 and harvested on Aug 15. Nitrogen fertilizer was distributed as urea on March 10, for both crops. The WW and SB cultivation techniques were those typical of the Padana plain (Po Valley). Crop biomass dry matter (DM) and N removal (as Kjeldahl N) were measured on 4 dates for WW (shoots and ears) and on 6 dates for SB (tops, leaves and roots), from mid April to the crop-harvest date. Nitrogen removal was calculated by multiplying each plant part DM by its N concentration. For WW, root N removal was estimated, by assuming the WW root dry weight as equal to 20% of total crop biomass (shoot + root), and its N concentration as equal to the shoot N concentration. Soil samples were collected at 0-0.25 and 0.25-0.50-m soil depth on 6 dates, from mid April to mid August. The soil inorganic N (nitrate + ammonium N) content was measured colorimetrically. Statistical analysis was performed using a mixed model for measurements repeated in time. In a preliminary analysis N removal by WW and SB was compared at common sampling dates. A second analysis was then performed separately, on each crop data set. Soil inorganic N data was log-transformed before statistical treatment.

Results

In the analysis comparing crop N removal at common sampling dates (from April 19 until July 3), N removal by SB was on average higher than N removal by WW ($P<0.05$, data not shown). Highly significant effects of Date of sampling ($P<0.001$) and of Crop x Date of sampling interaction ($P<0.01$) were also detected. In fact, in the April-May sampling dates, N removal by SB was on average lower than that by WW. However, starting from June, N removal by SB was always much higher than that of WW (Tab. 1). Nitrogen fertilizer significantly increased crop N removal only for WW.

Statistical analysis for soil inorganic N content depending on crop, date and depth of sampling, showed highly significant effects for all the main sources of variation and for some first and second order interactions (Data not shown). Despite the SB having removed more N than WW had, throughout the growth period the inorganic N content in soil under SB was on average twice (14.1 mg N kg^{-1} dry soil)

that of soil under WW (7.5 mg N kg^{-1} dry soil) (Tab. 2). As the soil was the same, we concluded that the observed differences in the inorganic soil N content could be due to the crop type.

Table 1. Total N removal (shoot + root) by sugar beet (SB) and winter wheat (WW), in spring-summer 2006, at Rovigo (Italy). Treatments: N0, control; N1, 60 kg N ha^{-1}; N2: 120 kg N ha^{-1}.

Crop	Treatment	Total crop N removal, kg ha^{-1}						
		19/04	16/05	01/06	03/07	18/07	14/08	Means
SB	N0	0.3	55	127	200	175	224	130A
	N1	0.2	48	152	176	208	206	132A
	N2	0.2	52	145	247	287	281	169A
	Means	0.2C	52BC	141AB	208A	223A	237A	
WW	N0	31.9a	43b	27a	70a			43B
	N1	30.7a	73ab	41a	74a			55B
	N2	57.7a	123a	86a	122a			97A
	Means	40.1B	80A	51B	89A			

[1] For each crop, with reference to the significant sources of variation (see text), upper-case letters were used for comparisons of the mean effects, lower-case letters for the comparison of first order interaction effects. The interaction Date x Treatment, when significant, was estimated at each date (comparison between treatments within each column). For each source of variation, means followed by the same letters are not significantly different for $P<0.05$, according to the Tukey-Kramer test for mean comparisons.

Table 2. Inorganic N content in soil cropped with sugar beet (SB) and winter wheat (WW), in spring-summer 2006, at Rovigo (Italy). Treatments: N0, control; N1, 60 kg N ha^{-1}; N2: 120 kg N ha^{-1}.

Crop	Soil depth (m)	Treatment	Inorganic N content (mg N kg^{-1} dry soil) at the dates						
			10/04	16/05	01/06	03/07	18/07	14/08	Means
SB	0-0.25	N0	11.5	7.3	4.8	8.9	8.8	11.9	8.9
		N1	26.9	18.7	12.0	15.1	13.7	23.1	18.3
		N2	29.7	26.7	29.4	22.3	17.2	25.9	25.2
		Means	22.7	17.6	15.4	15.4	13.2	20.3	17.4
	0.25-0.5	N0	10.0	8.1	4.9	5.2	7.2	8.1	7.3
		N1	18.3	13.9	7.1	6.5	8.9	10.5	10.9
		N2	17.8	19.9	17.2	8.3	8.5	13.3	14.2
		Means	15.4	14.0	9.7	6.7	8.2	10.6	10.8
	Means of date for SB		19.0	15.8	12.6	11.1	10.7	15.5	**14.1**
WW	0-0.25	N0	3.8	2.8	3.1	5.7	7.2	6.7	4.9
		N1	16.0	3.5	3.7	7.7	8.2	11.9	8.5
		N2	24.8	4.2	3.9	7.0	7.0	11.6	9.7
		Means	14.9	3.5	3.6	6.8	7.5	10.0	7.7
	0.25-0.5	N0	5.0	2.5	3.4	5.0	5.9	6.5	4.7
		N1	13.3	3.4	3.5	5.9	7.6	9.6	7.2
		N2	26.7	4.3	3.8	6.4	7.1	9.6	9.7
		Means	15.0	3.4	3.6	5.8	6.9	8.6	7.2
	Means of date for WW		14.9	3.4	3.6	6.3	7.2	9.3	**7.5**

Conclusions

Our results suggest the need to estimate the amount of N which may become available to crops during the crop growth season, by taking into account not only the soil potential mineralization but also the crop type.

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