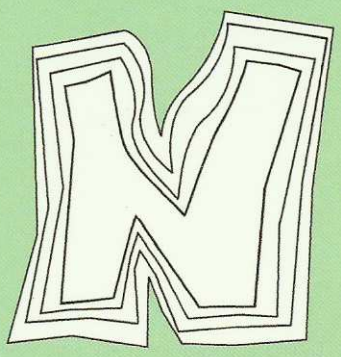

18th NITROGEN WORKSHOP

THE NITROGEN CHALLENGE: BUILDING A BLUEPRINT FOR NITROGEN USE EFFICIENCY AND FOOD SECURITY

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NITROGEN USE EFFICIENCY IN A SOIL AMENDED WITH DIFFERENT ORGANIC RESIDUES

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Background and Objectives

Nitrogen efficient use is important for economic and environmental sustainability of cropping systems. Three examples of fertilization practices considered to be able to contribute to the improvement of N use efficiency are: the use of a waste with higher C/N ratio, such as pulp mill sludge (Kirchmann and Bergström, 2003), specific application time and/or split application of nitrogen fertilizers (Roberts, 2008) and the use of nitrification inhibitors, such as the DCD (Zaman and Blennerhassett, 2010). In present study a field experiment was carried out from May 2006 to May 2008, in central Portugal, to evaluate agronomic nitrogen use efficiency (AE) and apparent N recovery efficiency (ARE), when different organic wastes (cattle slurry, sewage sludge and urban waste compost) were used as N sources in a double-cropping system producing maize and oats forage. The use of a nitrification inhibitor (DCD), the splitting application of residues and the use of an organic residue with high C/N ratio (pulp mill sludge) were evaluated as management practices that could improve N use efficiency.

Materials and Methods

The soil was a Cambisol, with 0.81% organic C, pH (H_2O) 6.2, and high P and K levels (>120 mg kg^{-1}). The 1st year autumn was rainy, and 2nd year one of the year most dried of last decade. The ten treatments tested consisted of: the splitting application at the establishment of the oats and maize crops of the organic residues sewage sludge (treatment SS), urban waste compost (UWC) and cattle slurry (CS); the yearly application of pulp mill sludge (PMS) to the oats crop, and SS and UWC to the maize crop only (SSm and UWCm); a mineral fertilizer treatment (MIN) and a Control were included, and the DCD effects were tested together with MIN (MIN+I) and CS (CS+I). PMS was applied in the first year only. Total N input was equal for all fertilization treatments (oats 80 kg N ha^{-1}; maize 170 kg N ha^{-1}), but amount of N applied by organic residues was variable (Table 1).

Table 1. Amounts (kg ha^{-1}) of N applied in each crop and treatment, through organic and mineral fertilizers.

Treatment	Oats			Maize		
	Organic fertilization	Mineral fertilization		Organic fertilization	Mineral fertilization	
		Sowing	Top-dressing		Sowing	Top-dressing
Control	0	0	0	0	0	0
MIN	0	30	50	0	90	80
MIN+I	0	80	0	0	170	0
PMS	10	20	50	0	90	80
SS	80	0	0	90	0	80
SSm	0	30	50	170	0	0
UWC	80	0	0	90	0	80
UWCm	0	30	50	170	0	0
CS	80	0	0	170	0	0
CS+I	80	0	0	170	0	0

The field was divided in plots of 45m^2 and the experimental design was randomized blocs, with 3 replications. In order to measure yield, plants (at milky/farinaceous grain stage) of middle plots were harvested in the surface of 2.25 m^2 and 0.5 m^2 for maize and oats, respectively. AE was defined as the ratio of forage yield with N application minus forage yield without N application to

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N application. ARE was defined as the ratio that total plant N uptake with N application minus total plant N uptake without N application, then divided by N application and multiply by 100.

Results and Discussion

The forage production were different ($P < 0.001$) in the two years (mean production of 19.4 and 27.9 t DM ha^{-1} in 1st and 2nd year, respectively). Different climatic conditions between years contributed to this result. In any fertilization system was observed higher forage production than that obtained in MIN, and lower results were particularly observed in Control (59% of the forage yield in MIN) and with soil incorporation of urban waste compost (75 and 72% of the forage yield in MIN, in UWC and UWCm, respectively).

Table 2. Forage production, agronomic N efficiency and apparent N recovery efficiency in different treatments and years.

Year	Control	MIN	MIN+I	PMS	SS	SSm	UWC	UWCm	CS	CS+I
	Forage production (t DM ha-1)									
I	16.0cd	23.2ab	23.4ab	18.4bcd	19.5bc	25.9a	13.13d	17.6bcd	21.0abc	16.1cd
II	16.7e	32.6ab	33.2a	32.6abc	28.4abcd	28.3ab	28.5cde	22.4de	26.2abcd	30.3bcd
		Agronomic N use efficiency (kg DM kg-1 N applied)								
I		29.1ab	29.6ab	9.8bcd	14.0bc	39.9a	-11.3d	6.6bcd	20.1abc	0.6cd
II		63.5	65.9	63.5	46.6	46.4	47.1	22.7	38.1	54.3
	Apparent N recovery efficiency (% of N applied)									
I		60.8a	48.7ab	39.2bc	37.4bc	45.9ab	19.9d	13.8d	28.4cd	15.6d
II		85.6abc	110.7a	97.3ab	65.6bcd	48.6def	72.2bcd	28.0f	37.2ef	64.4cde

In general, the N use efficiency was lower when organic residues were used in the crops fertilization. For instance, with slurry application, forage yield per unit of N corresponded to 69 and 60% of that measured in MIN in 1st and 2nd year, respectively. However at the end of the trial, very similar results were observed between MIN and SSm. DCD didn't promote important changes in AE, namely when used with mineral fertilizers and when applied in spring fertilization (data not show). ARE values were around 75-80% with the utilization of mineral fertilizers and between 20 and 50% with organic residues incorporation. The lower value was obtained in UWCm and DCD didn't produce an evident effect on N recovery efficiency when added to the slurry or to the mineral fertilizer, namely in spring fertilization (data not show). Better results of ARE were obtained with maize than with oats (data not show), when N was incorporated through slurry or sewage sludge (37 and 43% N applied in CS and SSm in spring; 31 and 16% of N applied in CS and SS in autumn).

Conclusion

The amount of N removed from the soil through the vegetal material collected was mainly related with dry matter production, and was greater with more intensive use of mineral fertilizers. It was in UWCm treatment that was measured the lowest value of N removed by plants (21% of N applied). In order to increment N use efficiency with soil application of this residue, it is recommended simultaneous incorporation of mineral N. The same strategy should be considered when a waste with higher C/N ratio is used in crops fertilization. In similar cultural systems, is recommendable the soil application of slurry and sewage sludge in spring.

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