Proceedings of the 7th Hungarian Congress on Plant Physiology, 2002
S5-03

Volume 46(1-2):179-180, 2002
Acta Biologica Szegediensis
http://www.sci.u-szeged.hu/ABS

Effect of different N-fertiliser forms and water supply on dry matter production and N-response of maize studied in model pot experiments

Katalin Berecz, Katalin Debreczeni

University of Veszprém, Georgikon Faculty of Agriculture, Institute of Agronomy, Department of Soil Management and Land Use Keszthely, Hungary

Maize is one of our most important fodder-plants. In 1996-1998 the average maize production of 6320 thousand tons amounted to 49.3% of the total cereal production in Hungary (statistical data).

Of the three most important macro nutrients in maize production, N is of primary importance on soils well supplied with K. Without N fertilisation, P and K fertilisation raised maize yield only by 0.4 t ha^{-1} in a long-term experiment conducted on pseudogleyed brown forest soil with low nutrient content in Western Hungary (Németh 1983). Besides site characteristics, soil fertility, plant demand etc., the yield response to N-application largely depends on water supply as well (Debreczeni 1994; Nagy 1995). Among our main arable crops, the water use coefficient of maize is the second highest, it averages up to 9.6 kg dry matter per mm water (Buzás and Loch 2001).

Considerable proportions of the nitrogen incorporated into the different vegetative organs are reutilised in the grains through translocation besides continuing assimilation of mineral N by root uptake after anthesis (Debreczeni 1989; Ta and Weiland 1992). Both the fertiliser-N utilisation and N-reutilisation of the different organs are very different and largely depend on the applied N form as well as stated in ^{15}N-fertilisation studies (Debreczeni 1989, 2000; Szlovák and Debreczeni 1992).

In this paper we report our investigations on the effect of different N-fertiliser and water supply on the dry matter production, nitrogen uptake and ^{15}N-fertiliser utilisation of maize plant in model pot experiments.

Materials and Methods

Maize plants (hybrid Stira) were grown under green-house conditions using large pots filled with 40 kg dry clay lessivated brown forest soil (clay = 24%, humus = 1.7%). In the two-year (1997-1998) model experiment, 150 mg N kg^{-1} soil was applied in form of KNO_3 or NH_4Cl besides PK base fertilisation. The experiment was done at two soil moisture levels, 65 and 100% of the maximum water-holding capacity (WHC) of the soil, with or without incorporation of maize crop residues (R) into the soil (50 g dry powdered R per pot), with 4 replicates. Watering and weekly weighing were performed to keep the above WHC levels. In the second experimental year, ^{15}N-labelled N-sources (5 atom% ^{15}N) were also applied (without replication) to study the utilisation of the different N-forms. Each year ten maize plants per pot were grown until full ripening.

After harvest dry matter weight of the whole plants (including roots) and different plant parts was measured. Due to limited space, results are shown only for the grain and the whole plant. After grinding, the samples were analysed for total N content by the Kjeldahl method and for ^{15}N to ^{14}N ratios. Nitrogen isotope ratios were determined after a flash Dumas combustion applying an isotope ratio mass spectrometer. In the second year NO_3-N content of the plant parts was also measured by Thamm (1987-1988).

Results and Discussion

In both years, KNO_3 fertiliser increased the dry matter production to a much larger extent than NH_4Cl compared to the unfertilised control (Table 1). On the two-year average, grain dry weight amounted to 36% and 25% of the dry weight of the total plant averaged over the KNO_3 and NH_4Cl treatments, respectively. In most cases, higher dry matter weights could be achieved at the lower water supply. The saturation of soil pores with water at 100% WHC was somewhat unfavourable for the roots.

Similarly to the dry matter incorporation, the N-response of plants was more favourable to KNO_3 than to NH_4Cl and higher N-contents were measured at lower water supply in both years (Table 1). On the average of the WHC and R treatments, nitrate nitrogen form resulted in by 72% and 88% more grain-N than ammonium nitrogen form in the first and second experimental year, respectively. On the two-year average, grain-N content amounted to 54% and 44% of the total plant-N content averaged over the KNO_3 and NH_4Cl treatments, respectively.

The incorporation of crop residues into the soil slightly inhibited the dry matter accumulation in both years, and control plants responded more marked to this N-immobilisation effect. Nitrogen content of the whole plant was definitely higher without maize residue incorporation only in 1997.

Compared to the unfertilised control plants, N-fertilisation significantly increased the NO_3 content not only in vegetative plant parts, but also in the grains (Table 2), similarly to the results of Debreczeni (2000). On the average of the WHC and R treatments, nitrogen fertilisation in form

*Corresponding author. E-mail: dbk@georgikon.hu

Table 1. Dry matter weight and total N content of maize hybrid Stira in the different treatments

Fertiliser treatments	WHC	Dry matter weight (g/10 plants) 1997		Total N (mg/10 plants) 1997		Dry matter weight (g/10 plants) 1998		Total N (mg/10 plants) 1998	
		Total plant	Grains	Total plant	Grains	Total plant	Grains	Total plant	Grains
control	100%	102.0	-	364	-	185.3	22.5	1772	451
KNO_3		459.3	79.7	4380	1174	643.0	314.5	8177	5613
NH_4Cl		372.8	55.8	2621	851	376.8	124.0	5163	2754
control	65%	97.0	-	351	-	254.6	43.5	3040	856
KNO_3		634.8	170.3	4805	2541	524.5	265.8	9422	5763
NH_4Cl		509.5	69.2	3125	1080	456.6	203.5	6946	4023
control+R	100%	62.0	-	260	-	150.0	-	2077	-
KNO_3+R		523.0	82.6	3638	1234	536.8	292.3	8356	4882
NH_4Cl+R		362.3	70.2	2161	974	314.8	86.0	4573	1535
control+R	65%	46.0	-	232	-	182.3	-	2967	-
KNO_3+R		613.5	91.6	4393	1257	511.1	295.3	10531	6716
NH_4Cl+R		485.0	58.8	2405	694	490.0	185.5	8907	3922
$LSD_{(5\%)}$		79.5	47.5	367	645	63.1	47.8	1712	1518

Table 2. Nitrate-N content of maize hybrid Stira (1998)

Fertiliser treatments	WHC	Grains (mg NO_3-N/10 plants)	Total plant (mg NO_3-N/10 plants)
control	100%	3.7	48.1
KNO_3		50.0	126.8
NH_4Cl		19.9	77.5
control	65%	7.5	90.0
KNO_3		42.5	152.3
NH_4Cl		32.5	94.6
control+R	100%	-	36.6
KNO_3+R		47.0	114.6
NH_4Cl+R		13.6	69.8
control+R	65%	-	47.8
KNO_3+R		46.0	102.0
NH_4Cl+R		28.3	95.9
$LSD_{(5\%)}$		7.6	20.4

Table 3. Utilisation of fertiliser-N by maize hybrid Stira (1998)

Fertiliser treatments	WHC	Grains (%)	Total plant (%)
KNO_3	100%	38.75	49.69
KNO_3	65%	49.75	65.24
NH_4Cl	100%	23.21	34.60
NH_4Cl	65%	22.71	31.83
KNO_3+R	100%	33.69	43.44
KNO_3+R	65%	52.73	69.52
NH_4Cl+R	100%	7.52	14.47
NH_4Cl+R	65%	20.46	30.68

of KNO_3 resulted in twice and one and a half times as high NO_3-N content in the grains and whole plant, respectively, than in form of NH_4Cl. These differences in the accumulation of toxic NO_3 are not indifferent from the point of view of the human nutrition or animal feeding.

Hybrid Stira utilised NO_3-N in higher proportion than NH_4-N. On the average of the WHC and R treatments, KNO_3 resulted in twice and 2.4 times higher utilisation in the total plant and grains, respectively (Table 3). The highest utilisation was measured with treatment KNO_3+R at 65% WHC while the lowest one with NH_4Cl+R at 100% WHC both in the grains and in the whole plants. In most cases, fertiliser-N utilisation was higher at lower soil moisture level.

Acknowledgment

This research was supported by the Hungarian Foundation for Scientific Research (OTKA, project No. T 035189).

References

Buzás I, Loch J (2001) Country Report 2. Development of potash fertiliser input and the consequences for soil fertility and crop production in Hungary. (In Hungarian) International Potash Institute. Basel/ Switzerland, Debreceni Agrártudományi Centrum, Debrecen.

Debreczeni B *(*1994) Ökológiai hatások és a műtrágyázás kapcsolata. In Debreczeni B, Debreczeni K, eds., Trágyázási kutatások 1960-1990. (Fertilisation Researches 1960-1990.) Akadémiai Kiadó, Budapest, 371-398.

Debreczeni K (1989) Az őszi búza és kukorica fejlődéskori N-felvételének tanulmányozása. Doktori értekezés. Keszthely. (N-uptake by winter wheat and maize during development. Doctoral dissertation).

Debreczeni K (2000) Response of two maize hybrids to different fertilizer-N forms (NH_4-N and NO_3-N). Commun Soi Sci Plant Anal 31:2251-2264.

Nagy J (1995) Evaluation of fertilization effect on the yield of maize (*Zea mays* L.) in different years. (In Hungarian) Növénytermelés 44:493-506.

Németh I (1983) Investigations into the efficiency of nitrogen fertilization on pseudogleyed brown forest soil in maize. (In Hungarian) Növénytermelés 32:559-564.

Statistical Yearbook of Agriculture, 1998. Hungarian Central Statistical Office, Budapest, 1999.

Szlovák S, Debreczeni K (1992) Dry matter accumulation and distribution, soil and ^{15}N labelled fertilizer nitrogen uptake and redistribution in maize. Acta Botanica Hungarica 37:387-400.

Ta CT, Weiland RT (1992) Nitrogen partitioning in maize during ear development. Crop Sci 32:443-451.

Thamm B (1987-1988) Determination of nitrate concentration of plants. Agrokémia és Talajtan 36-37:323-337.