Effect of fertilisation on the N utilisation of sunflowers.

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Summary

The economic justification of fertilisation is determined by economic factors, by crop response as well as the utilisation of the applied fertiliser. If the utilisation could be improved the negative influence of increasing cost could at least partly be counter-acted. A 4^2 factorial trial with four N levels (0, 60, 120 and 180 kg ha^{-1}) and four P levels (0, 15, 30 and 45 kg ha^{-1}) was done over three years to asses the effect of N and P on the N utilisation. N utilisation varies from 45 - 170%. N utilisation decreases with increasing N levels. Under favourable conditions a figure of 60 - 80% can be expected.

Introduction

The economic justification of fertilisation is determined, apart from economic factors, by crop response as well as the utilisation of the applied fertiliser. If the utilisation could be improved the negative influence of increasing cost could at least partly be counter-acted.

The recovery of applied N by crops vary greatly due to various factors. Dijkhuis, Jurgens & Botha (1982) reported figures of 31 to 122% for maize and wheat and Loubser, Grimbeek & Beulah Bronkhorst (1990) reported figures of 10 to 32% for sunflowers. These workers did not take into account the contribution of soil N. If a significant amount of N is available in the soil, it should be possible to enhance the utilisation of these elements by taking into account the possible contribution of the soil. The aim of this study was to obtain more information on the utilisation of soil as well as applied N.

Materials and methods

A field trial was conducted over three seasons at the Sandvet research station (28° 08'S, 26° 41'E; 1 295 m altitude) on a Plinthic ferralsol soil type (pH (KCl) 4.6, P (Bray 2) 6.5 mg kg^{-1}, Ca 2.27, Mg 1.52, K 0.54 and Na 0.08 me $100g^{-1}$). The trial was irrigated regularly to prevent any water stress. The trial consisted of four N (0, 60, 120 and 180 kg N ha^{-1}) and four P (0, 15, 30 and 45 kg P ha^{-1}) levels in a factorial combination with two replicates. N was applied as limestone ammonium nitrate (28% N) and P as double superphosphate (19.6% P). At the beginning of the third season the P rates were increased to 0, 70, 125 and 180 kg P ha^{-1} in the form of superphosphate (10.5% P). The fertiliser was broadcast by hand before ploughing the soil. Nett plots consisted of two rows 900 mm apart and 14 m long. The trial was carried out in rotation with maize, and the maize plots received the same treatments.

Three plants per plot were used for observations at growth stages 4.1, 5.1 and 6.5 (head visible, 50% flowering and physiological maturity as described by Birch (1983). Leaves, stems and flower heads were sampled separately. Samples were dried at 60°C, followed by mass determination. The samples were milled and ashed at 475°C. N was extracted by micro Kjeldahl and determinations done with an auto analiser. Appropriate statistical analysis were done and LSD values calculated using values of the T - table. The utilisation of N was calculated by dividing the N content of the above ground plant parts at harvest by the sum of the inorganic soil N at planting and the applied N.

Results

The effect of N and P on the N content of the plants at harvest is presented in Table 1. It is clear that the effect of N increased significantly as the P level increased and the effect of P increased significantly as the N level increased.

Table 1 Effect of fertilisation on the N content (kg ha^{-1}) of the crop at harvest maturity.

N level	P level				
	0	1	2	3	Mean
0	74	102	121	119	104
1	98	127	151	131	127
2	77	147	153	155	133
3	91	142	190	194	154
Mean	85	130	154	150	130

LSD_t (0.05) N = 13 ; P = 13 ; N x P = 27

The effect of N and P on the percentage utilisation of N by sunflowers is presented in Tables 2 and 3 respectively. Both N and P responded differently over years. The utilisation of N decreased sharply with increasing N levels. This decrease intensified over years. In contrast the N utilisation increased with increasing P levels. This effect also intensified over years.

Table 2 Effect of N over years on the N utilisation (%) by sunflowers.

Season	N level				
	0	1	2	3	Mean
1986/87	99	77	60	56	73
1987/88	169	101	75	67	103
1988/89	138	98	53	56	90
Mean	135	92	67	60	89

LSD_t (0.05) N = 11 ; years= 8 ; N x years= 16 ;
N x years within N = 15

Table 3 Effect of P over years on the N utilisation (%) by sunflowers.

Season	P level 0	1	2	3	Mean
1986/87	60	73	81	78	73
1987/88	72	100	119	121	103
1988/89	46	93	115	105	90
Mean	59	89	105	101	89

LSD_t (0.05) P = 11 ; years= 8 ; P x years= 16

The effect of fertilisation on the inorganic N content of the soil at the end of the growing season is presented in Table 4. In 1988/89 the soil N content was significantly higher than in the preceding years. The main effects of N and P did not have a significant effect on this parameter.

Table 4 Effect of N over years on the N content (kg ha^{-1}) of the soil at the end of the growing season. (Transformed figures in brackets).

Season	N level 0	1	2	3	Mean
1986/87	20 (3.02)	16 (2.76)	18 (2.91)	21 (3.04)	19 (2.93)
1987/88	21 (3.04)	28 (3.33)	25 (3.21	30 (3.41	26 (3.25)
1988/89	40 (3.69)	42 (3.74)	45 (3.81)	51 (3.93)	44 (3.79)
Mean	26 (3.25)	26 (3.28)	27 (3.31)	32 (3.46)	28 (3.32)

LSD_t (0.05) N = ns; years = (0.18) ; N x years = ns

Discussion

It is clear that a large quantity of N can be taken up by the crop, sometimes almost 200 kg ha^{-1}. It is also clear that N utilisation can be increased sharply by providing sufficient P. N utilisation decreases with increasing N supply. This correspond with the findings of Loubser *et. al.* (1990) who also indicated a decrease in N utilisation at higher N levels.

Another prominent feature of the results is the large variation in N utilisation that was also found by Dijkhuis *et. al.* (1982). As a result of the dynamics of N in the soil there must have been additions and losses that were not measured in this study. Utilisation figures of >100 imply additions of utilisable N after planting that could be ascribed to mineralisation and N in rain water. The possibility of losses through leaching and denitrification should also be borne in mind. The variation in N utilisation could therefore at least partly be ascribed to variation in the rate of mineralisation, denitrification and leaching. It is calculated from the data that in case of the N0 level the crop had taken up 45 kg N ha^{-1} more than was available as inorganic N at planting, which means that at least 45 kg N ha^{-1} became available through mineralisation and/or rain water during the growing season.

At the higher N levels the N utilisation was lower, ranging from 60 - 80% for N levels of 120 and 180 kg ha^{-1} at higher P levels. Good P supply therefore seems to be a prerequisite for good N utilisation. If the utilisation of applied N only is considered, the following facts came to the fore. From Table 1 can be calculated that the N utilisation for the N1 level was 20%, for the N2 level 30% and for the N3 level 42%, this is at the P3 level. The utilisation of applied N is however lower than the utilisation of total inorganic N throughout.

At the end the 1986/87 season there was 19 kg N ha^{-1}, and at the end of 1987/88 26 kg N ha^{-1}, while in the beginning of 1987/88 there was 70 kg N ha^{-1} and at the beginning of 1988/89 69 kg N ha^{-1}. This means that the inorganic N in the soil increased with 45 kg N ha^{-1} during the fallow period. From 60 to 70% of the N taken up by the crop is in the seed. This means that 30 to 40% of the N remains in the stover and is therefore available for the next crop. In the present study the stover was removed from the plots. It is therefore expected that in a situation where the stover is not removed, more N would be carried over from one season to the next.

Conclusions

N utilisation varies from 45 to 170%. N utilisation decreases sharply with increasing N levels. Under favourable conditions utilisation figures of 60 to 80% can be expected even at high N levels.

Utilisation figures above 100% imply an increase in plant available N during the growing season, apparently as a result of mineralisation and N in rain water.

Inorganic soil N increases sharply from the end of one season to the beginning of the next season with the result that a significant quantity of N is available for the following crop. It is therefore important to make use of soil N analysis.

References

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