CUCUMBER N NEED UNDER PROTECTED CULTIVATION USING ^{15}N-LABELLED UREA

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Abstract

To measure the N uptake and utilisation by plants, labelled ^{15}N has been used. In this paper ^{15}N-labelled urea was applied to cucumber under protected cultivation for two seasons, 1996/97 and 1997/98. Four levels of urea-N (0, 200, 400 and 600 kg N ha^{-1}) were used in a complete randomised block design with 8 replicates. The experiment was conducted in the UAE at the Humraniyah Agriculture Research Station (HARS) in collaboration with the International Atomic Energy Agency (IAEA). From the obtained results it was clear that the average optimal fertiliser rate was 200 kg N ha^{-1}. The N yield in the plant dry matter (fruits, shoots and roots) was 6.13 g N/plant under the specific experimental conditions (the area per plant was 1.23 m^2). Using ^{15}N, it was found that the fertiliser N yield obtained for the same plant parts was 1.82 g N/plant.

1. INTRODUCTION

Fertiliser use efficiency is a quantitative measure of the actual fertiliser uptake by the plant from a particular fertilised nutrient in relation to the amount of the same nutrient added to the soil [1]. However, it is the combination of different production strategies in a particular agricultural system that results in greater yields when the input for production is optimised. As such, input by fertilisers, if correctly used, have a marked contribution to an increased crop yield. Fertilisers, when used in combination with high yielding varieties and adequate irrigation water, can lead to a higher yield [2].

In Syria, a 2-year field experiment was carried out using ^{15}N-labelled urea to study the mechanism of N-losses and uptake by wheat [3]. Under sandy soil conditions, for example, it was estimated that losses of applied N was as high as 49% [4]. Under flooded conditions, Hamissa et al. [5] reported that the N recovery by rice ranged between 10% and 30% depending on the method of application. As a matter of fact introducing ^{15}N-labelled fertilisers permits direct measurement of fertiliser uptake by the different parts of the crop with no interaction of crop yield or responses to N fertilisation.

This paper discusses the results of trials on cucumber fertilisation under protected cultivation carried out in the United Arab Emirates (UAE) at the Humraniyah Agriculture Research Station (HARS) in collaboration with the International Atomic Energy Agency (IAEA). The experiment was conducted during the seasons 1996/97 and 1997/98, having as its main objective the use of ^{15}N (in our case ^{15}N-labelled urea) in a study related to soil fertility and plant growth to obtain maximum (optimum) N-level for maximising the cucumber yield.

2. MATERIALS AND METHODS

A two-year study was established at the Humraniyah Agricultural Research Station. The climate of the station is characterised by arid and semi-arid conditions. Maximum temperature ranges from 24° to 42°C. Maximum relative humidity ranges from 70% to 89% with an average annual rainfall varying between 100 mm to 120 mm.

The soil is medium textured varying from sandy loam to loamy sand with a marked deficiency in N content due to lack of organic matter being less than 0.1%. The P and K content is low. The $CaCO_3$ content is rather high ranging from 30% to 40%. The pH is about 8.2 and the EC may reach 4 dS/m.

Four levels of N (0, 200, 400 and 600 kg N ha^{-1}) with 8 replicates arranged in a completely randomised block were applied on 6.13 m^2 micro plots grown by cucumber. Fixed rates of P and K were applied (300 and 450 kg. ha^{-1}, respectively). Organic matter was applied on all four treatments at a rate of10 ton ha^{-1}. Each plant was irritated by a dripper having a discharge of 4 L/h. Nitrogen was added as urea, P as phosphoric acid (80%) and K as potassium sulphate, depending on the different treatments. ^{15}N-enriched urea (1.36% a.e.) was added to each cucumber plant through a plastic bottle hanging one each plant. The solution was prepared in different concentration depending on the treatment. It reached each plant via a plastic tube. Soil sampling was carried out at different depths (0-15, 15-30, 30-45 cm). The soil fertility level, salinity status and pH values were measured before and at the end of the experiment (Table I). At each picking, plant samples of the fruits related to the ^{15}N-labelled urea application were taken. At the end of the experiment, the whole plant including shoots and roots was harvested, oven-dried at 65°C and analysed for ^{15}N. The analysis was done by the IAEA laboratory in Vienna, Austria.

TABLE I. SOIL ^{15}N (BEFORE PLANTING AND AT HARVEST)

Sample No.	N rates (kg ha^{-1})	Depth (cm)	Description	pH	ECE (mmho/cm)	Mineral N	PO_4^{-3}-P	K Am-Ac
						ppm		
1		0-15	Mixed sample	7.9	3.47		50	100
2		15-30	before planting	8.0	3.07		40	110
3		30-45		8.1	2.26		30	115
1	0	0-15	Mixed sample	7.9	4.23	3.2	40	83
2	0	15-30	(under dripper)	8.1	2.97	2.1	30	110
3	0	30-45	Harvest	8.3	2.54	2.1	20	120
4	200	0-15		8.0	3.6	2.1	40	83
5	200	15-30		8.0	3.1	2.2	25	103
6	200	30-45		8.3	2.4	2.3	15	108
7	400	0-15		7.9	3.6	2.5	50	88
8	400	15-30		8.0	3.0	2.1	40	88
9	400	30-45		8.2	2.6	4.3	25	120
10	600	0-15		7.9	3.5	2.6	40	83
11	600	15-30		8.1	2.6	1.5	40	95
12	600	30-45		8.2	2.5	3.9	20	110

3. RESULTS AND DISCUSSION

Table II shows that the average cucumber yield (kg/plant) at different levels of N clearly responded to the N-fertilisation, with a significant difference between the different treatments. However, the levels of 200 kg N ha^{-1} and 400 kg N ha^{-1} showed no significant difference in cucumber yield. It shows, therefore, that the rate of 200 kg N ha^{-1} can be considered as the best N application level for cucumber under protected cultivation.

TABLE II. AVERAGE CUCUMBER YIELD (KG/PLANT) UNDER NORMAL UREA APPLICATION

Treatment (kg ha-1)	1st season (Nov. 96-Mar. 98) (kg/plant)	2nd season (Nov. 97-Mar. 98) (kg/plant)	Mean yield (kg/plant)
0	3.2	3.4	3.3
200	4.9	5.9	5.4
400	4.5	5.6	5.1
600	4.3	4.8	4.6

However, significant differences in cucumber yield were observed in the ^{15}N labelled urea treatments (Table III).

From the plant dry matter analysis of the fruits, shoots and roots it was seen that the total N required by the crop was within an optimal range. It was distributed among the plant parts as follows: fruits > shoots > roots (Table IV).

Table V shows the results of the $\%^{15}N$ derived from the labelled urea in the different plant parts (roots, shoots, fruits).

The following data were used to calculate the uptake of labelled urea N:

1. natural abundance: 0.37 % ^{15}N
2. abundance of the applied fertiliser: 1.36%
3. N derived from the fertiliser (%Nddf) = ($\%^{15}N$ a.e. in the plant / $\%^{15}N$ a.e. in the fertiliser) × 100

The basic yield and N uptake parameters for the 200 kg N ha^{-1} are given in Table VI.

TABLE III. AVERAGE CUCUMBER YIELD (KG/PLANT) USING ^{15}N LABELLED UREA

Treatment (kg ha^{-1})	1st season (kg/plant)	2nd season (kg/plant)	Mean yield (kg/plant)
0	2.8	3.6	3.2
200	3.5	4.7	4.1
400	4.1	5.3	4.7
600	3.4	4.5	4.0

TABLE IV. AVERAGE TOTAL N (%) UNDER NORMAL UREA APPLICATION

Treatments (kg N/ha^{-1})	% N 1st season			% N 2nd season		
	Roots	Shoots	Fruits	Roots	Shoots	Fruits
0	1.68	1.97	2.35	1.48	1.92	2.54
200	2.21	2.20	2.64	1.58	2.09	2.76
400	1.96	2.21	2.71	1.78	2.36	3.10
600	1.99	2.35	2.70	1.93	2.35	3.10

TABLE V. AVERAGE NITROGEN PERCENTAGE (% ^{15}N) FROM THE LABELLED UREA

Treatments (kg N/ha-1)	% ^{15}N 1st season			% ^{15}N 2nd season		
	Roots	Shoots	Fruits	Roots	Shoots	Fruits
0	0.015	0.028	0.086	0.010	0.010	0.010
200	0.910	0.790	0.780	0.680	0.680	0.660
400	1.145	1.010	0.980	1.060	1.040	1.110
600	1.130	1.060	0.820	0.960	1.010	1.040

TABLE VI. EXPERIMENTAL DATA

Plant part	Dry matter yield (g/plant)	Total N (%)	N yield (g/plant)	Nddf (%)	Fertiliser N yield (g/plant)
Fruits	162	2.76	4.50	29	1.31
Shoots	75	2.09	1.60	31	0.50
Roots	1.5	1.58	0.03	31	0.01
Total			6.13		1.82

Plant area (1.75 m × 0.70 m) = 1.23 m2

% Ndff (weighted average) = (1.82 / 6.13) × 100 = 30.

Table VI shows that the N yield of the cucumber plant (fruits, shoots and roots) was 6.23 g N/plant, the area occupied per plant being 1.23 m^2. The fertiliser N yield for the same plant parts was 1.82 g N / plant per 1.23 m^2. The % Ndff (weighted average) was 30. The results of this experiment are based on the data obtained per plant in order to avoid the interaction between the different sources of N (normal urea and ^{15}N-labelled urea). This is the reason why the plants were not spaced according to the standard cucumber spacing ($\leq$ 0.50 m^2). The same ^{15}N isotope technique will be repeated for studies dealing with N losses including volatilisation, N movement in the soil and biological N fixation.

4. CONCLUSION

From the results of this study it is clear that, using ^{15}N-labelled urea, that the average optimum fertiliser rate for cucumber under protected cultivation is about 200 kg N ha^{-1}. The data presented in this paper show that the N yield in the different cucumber plant parts (fruits, shoots and roots) was 6.13 g N/plant under the specific experimental conditions (notably the plant area). The fertiliser N yield for the same plant parts was 1.82 g N/plant.

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