

**THE EFFECT OF DIFFERENT NITROGEN DOSAGES ON SOME YIELD AND
QUALITY PROPERTIES OF THE CUCUMBER GROWN WITH IN NUTRIENT
FILM TECHNIQUE**

ABSTRACT

The effect of 4 different nitrogen dosages (7, 10, 13 & 16 mM) on the Plant Height, Dry Matter Yield, Number of Fruit per Plant, Fruit Yield per Plant, and Total Nitrogen Concentration of the Spring S1, which is one of the parthenocarpic hybrid cucumber types grown in Nutrient Film Technique (NFT), has been examined in this study. Plant Height, Dry matter yield and total nitrogen content the plant samples were taken out (collected) with their roots on the 21st, 42nd, and 63rd days after planting. Number of fruit per plant and Fruit yield per plant the plant samples were taken out with their roots on the 42nd, 52nd, 63rd days after planting. According to the results obtained in the study, the values of the examined characteristics increased until the N₁₃ dosage of the nitrogen; and started to decrease in the N₁₆ dosage, which is the next dosage. While the effect of the nitrogen dosages on the nitrogen concentrations in the roots was not considered as being statistically significant, it was considered as being significant in the stem and leaves. Generally, it may be suggested that especially the N₁₆ dosage affects the plant negatively in the examined characteristics, and that it almost starts hazardous effect in this dosage.

Key Words: *Cucumis sativus*, soilless agriculture, NFT, cucumber

1. INTRODUCTION

Hydroponics is preferred in order to prevent the allelopathic relations among plants, diseases and pests stemming from the soil, to eliminate the saltiness problems which appears in the soil in the course of time, and also to eliminate the water stress and provide that the given nutrients reach the roots directly and thus obtain a quality crop with a better yield. Although the cost of this type of planting is high when compared with the other growth media (perlite, vermiculite, turf etc.), the eventual high yield compensates these costs more than expected.

The cucumber (*Cucumis sativus* L.) is a member of the *Cucurbitaceae* family in the summer vegetables group and has an economic importance. With the recent increase in diseases that are infected via soil, with better control of nutritious elements given to the plants, elimination of the side effects brought with the salinization in the soil, and the decrease in the low yield that stem from the lack of nutritious elements, the cucumber production has become widespread in soilless media (perlite, turf, vermiculite and hydroponics).

The nitrogen is a basic and unique macro element that increases the yield of the plant (Chuan et al. 2013). In the land types with continental climates, where plant development is limited, farmers use nitrogenous fertilizers and support the plant development (Robertson and Vitousek 2009). Many plants absorb the ammonium (NH₄⁺), nitrate (NO₃⁻), nitrite (NO₂⁻), amino acid and urea, which are soluble forms of nitrogen in the soil solution (Nasholm et al. 2009). However, the type of the plant, environmental conditions, light density, soil properties, and root zone temperature affect the nitrogen

absorption (Piwpuan et al. 2013). The nitrogen influences the plant yield and quality in a direct way (Lemaire et al. 2015). When given in proper ratios, it supports especially the root growth and ensures that the plant has a healthier structure (Liang et al. 2014). In case of nitrogen deficiency, leaves become yellow and are lost before the due time, the lifespan of flowers decrease, fruits become lighter in color, and do not grow in sufficient rate and are smaller than usual. In case of imbalanced or excessive use of fertilizers, the standard fruit size is ruined and the fruit becomes softer. In addition, the NO_3 and NO_2 forms of excessive nitrogen damages the environment (Gollany et al. 2004, Beman et al. 2005), accumulates on the fruit and damages human health (Ruiz and Romero 1999). For this reason, in determining the fruit yield level, it is very important to optimize the plant nitrogen management in the greenhouse in order to decrease the environmental dangers. To do this, it is necessary to measure the effects of the nitrogen on the plant growth process and plant yield (Dai et al. 2011). I would hope there would be a remedy in cases referred to the results of this research.

Although there are many studies in the literature on cucumber planting in field conditions and the use of fertilizers, there are few studies on determining the proper dosage of nitrogen that determines the yield and quality of the cucumber grown in NFT Method (Ruiz and Romero 1999, De Groot et al. 2003, Han et al. 2008). In one of the rare studies in the literature it was reported that the 10 kg^{-1} and 20 kg^{-1} dosages in controlled greenhouse conditions give the best results in terms of economic benefit, human consumption and fruit quality; and the 40 kg^{-1} dosage cause low quality products and increase the NO_3^- accumulation in the fruit (Ruiz and Romero 1998). In another study, it was reported that the 200 mg kg^{-1} N dosage in planting cucumber in perlite affected plant development and fruit production in a positive way, and that the N dosages at and over 300 mg kg^{-1} decreased the plant development and yield (Altunlu et al. 1999, Güler et al. 2006). Jarosz et al. (2009) reported that the highest fruit yield was observed in the highest nitrogen dosage. Babik and Kowalczyk (2009) stated that the fruit yield decreased at 200 mg dm^{-3} application.

2. MATERIAL AND METHODS

In this study, the material Spring F_1 cucumber, which is one of the parthenocarpic hybrid type grown in the area, was used. Spring F_1 is an early-yielding type of cucumber and proper for spring and summer growth seasons with mid-green fruits and 12 cm in length. The fruits are very delicious and the shelf life is longer.

Four different nitrogen dosages (N_7 , N_{10} , N_{13} and N_{16} mM) were prepared according to the Randomized Block Design with 3 replications. A separate solution was used for the nitrogen dosages, and a specific solution which was prepared for cucumber by Sonneveld and Straver (1992) was used for the other elements (Table 1). The ammonium nitrate, potassium nitrate, calcium nitrate, magnesium nitrate and mono ammonium phosphate were used as the N sources in the prepared solutions.

Table 1. The contents of the nutrient solution used in the experiment (Sonneveld and Straver 1992).

Nutrient	mM
H ₂ PO ₄	1.0
K	6.5
Mg	1.0
Ca	2.75
SO ₄	1.0
Fe $\mu\text{mol.l}^{-1}$	15
Mn	10
B	25
Cu	0.75
Zn	5
Mo	0.5
Si	0.75

The plants were germinated in egg-trays, and after they had 3 leaves they were transferred to NFT Units with 12 compartments in which 16 plants were grown and which had the size of 105 cm x 91cm x 47cm with 4 pieces of 155 mm x 70 mm growth channel. The Plant Height, Dry Matter Yield (root, body and leaves), Fruit Yield, and Total Nitrogen Amount (root, body and leaves) were analyzed in the study. The plant samples were collected with their roots on the 21st, 42nd and 63rd days after planting.

2.1. Plant height: The height measured from the level of growth medium and expressed in cm.

2.2. Dry matter yield: The plant samples collected from each plot were immediately transported to laboratory in closed polyethylene bags and washed thoroughly with tap water, acidified (0.1 M HCl) water and then distilled water (Wallinga *et al.* 1989). Then the wet weights were measured. The samples were oven-dried at 70 °C for 72 hr and finely ground in stainless steel mill to pass through a 0.5 mm sieve. Care was taken to prevent contamination at all steps in progress. The plants that were taken out from the oven were weighed again and the total dry matter yield was reported in grams.

2.3. Number of fruit per plant: All the fruits on the plant were counted.

2.4. Fruit yield per plant: All fruits which were ripe enough on the plant were collected and weighed in a sensitive scale and recorded in grams.

2.5. Total nitrogen content %: Total N contents in the plant samples were estimated by Kjeldahl digestion procedure (Bremner 1965).

In evaluating the study results, the Minitab 14 statistical package program was used, and the variance analysis Fig was prepared thus making it possible to determine the significance level of the subjects. According to the $p < 0.05$ probability value, the Low Significant Difference Values (LSD) were determined, and the differences of the numbers were evaluated.

3. RESULTS AND DISCUSSION

3.1. Plant Height

The effects of different nitrogen dosages on plant height on Planting the Following Day (PFD) are given in Fig 1.

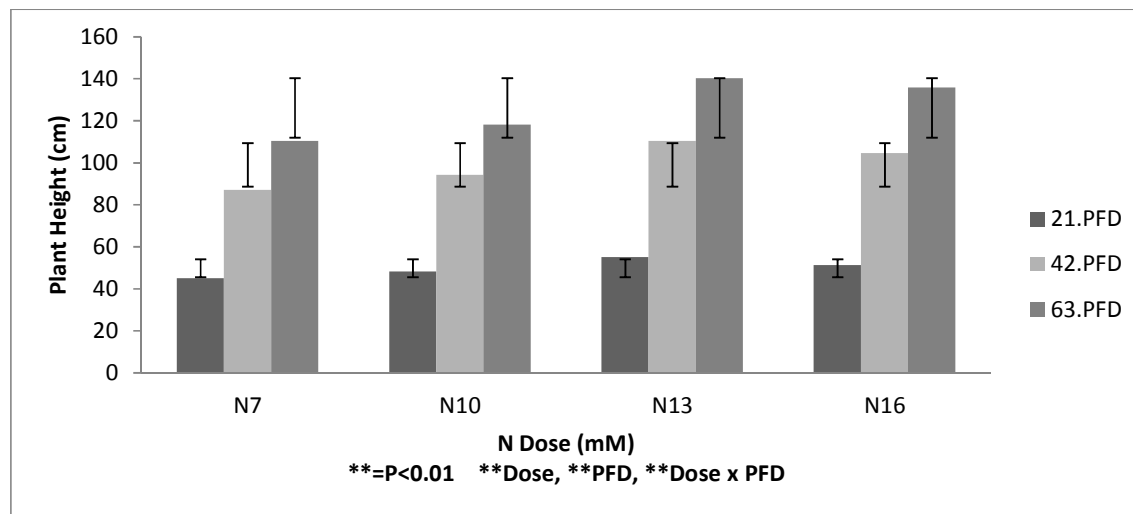


Figure 1. The effect of different Nitrogen dosages (7, 10, 13 & 16 mM) on cucumber plant height (cm) on planting the following day (21st, 42nd, 63rd days).

As can be seen in Fig 1, it is observed that the average Plant Height increased until the N₁₃ dosage; however, it is also observed that the Plant Height decreased at the N₁₆ dosage, which is the highest dosage. The biggest Plant Height value was measured in N₁₃ x 63rd PFD interaction (140.28 cm), and the smallest Plant Height value was measured in N₇ x 21st PFD interaction (45.15 cm).

The order of the effects of nitrogen on Plant Height is as N₁₃ > N₁₆ > N₁₀ > N₇. These findings are in accordance with the findings stating that the nitrogen dosage increases the plant height (Arslan 1989).

3.2. Dry Matter Yield of the Plant

The effect of different nitrogen dosages on the root, stem and leaves dry matter yield of the plant on Planting the Following Day (PFD) is shown in Fig 2.

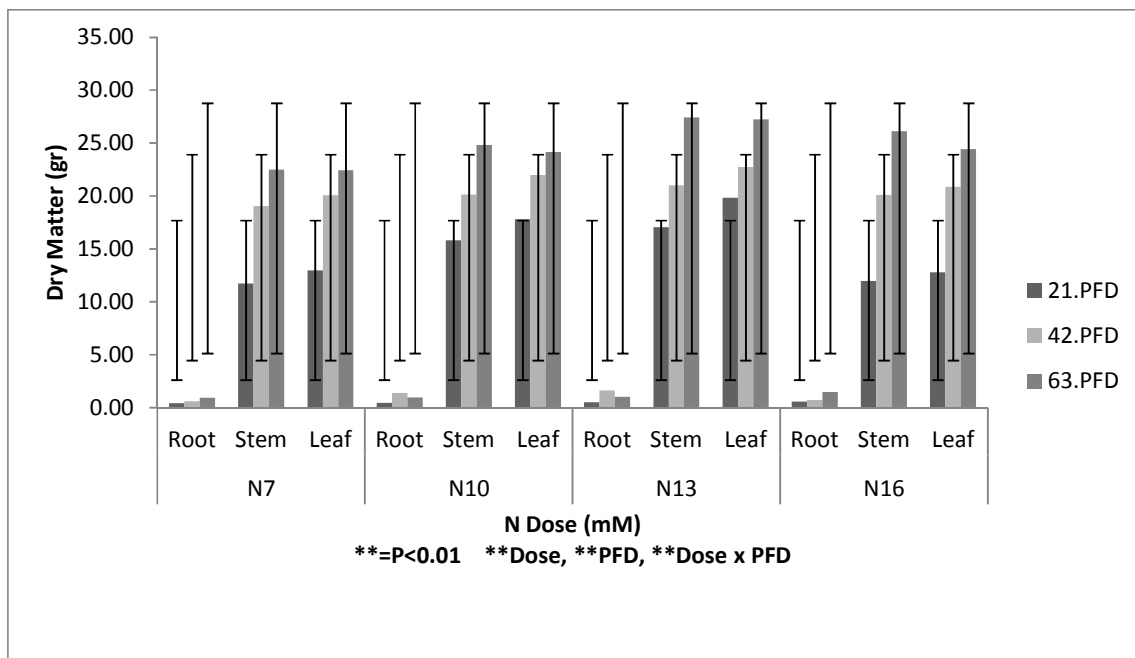


Figure 2. The effect of different Nitrogen dosages (7, 10, 13 & 16 mM) on dry matter yield of cucumber root, body and leaves on planting the following day (21st, 42nd, 63rd days).

The root, body and leaves dry matter yield of the plant increased until the N₁₃ dosage (Fig.2). The biggest root dry matter yield was obtained in N₁₃ x 42nd PFD (1.65 g.); stem dry matter yield in N₁₃ x 63rd PFD (27.41 g.); and leaf dry matter yield in N₁₃ x 63rd PFD (27.26 g.) interactions. Just as it is the case in Plant Height characteristics, the effect of nitrogen dosages was observed as N₁₃>N₁₆>N₁₀>N₇. These findings are in accordance with the findings reporting that the nitrogen dosage increases the dry matter yield of the plant (Bergman 1992).

3.3. Number of Fruit per Plant:

When evaluated in general, an increase in the number of the fruits was observed in nitrogen dosage treatments and this increase was found to be statistically significant in terms of nitrogen dosage average values and in terms of days (Fig 3). In these characteristics, the number of fruit increased from the lowest dosage till the N₁₃ dosage; however, decreased in N₁₆ which is the highest dosage. Since the doesn't appear on the 21st day, it was measurement on the 42nd, 52nd and 63rd.

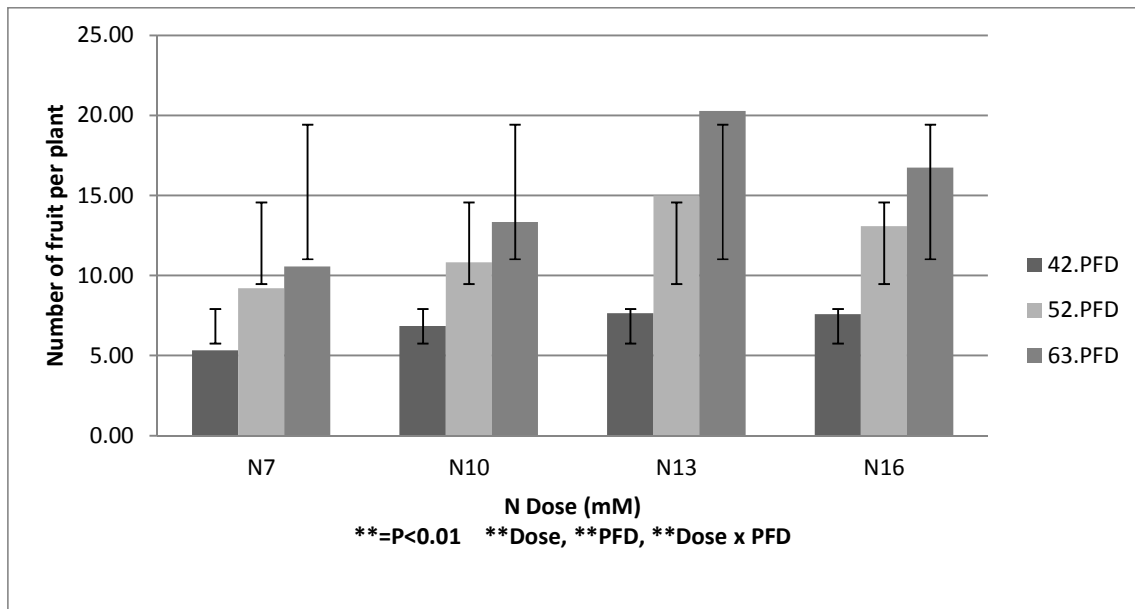


Figure 3. The effect of different Nitrogen dosages (7, 10, 13 & 16 mM) on fruit number of cucumber on planting the following day (42nd, 52nd 63rd days).

The highest number of fruit was obtained from the N₁₃ x 63rd PFD (20.28 pieces) interaction; and the lowest number of fruit was obtained from the N₇ x 21st PFD interaction (5.32 pieces). The order of the effect of the nitrogen on the number of fruit has been determined as N₁₃>N₁₆>N₁₀>N₇.

3.4.Fruit Yield

The effect of different nitrogen dosages on the fruit on Planting the Following Day (PFD) is shown in Figure 4.

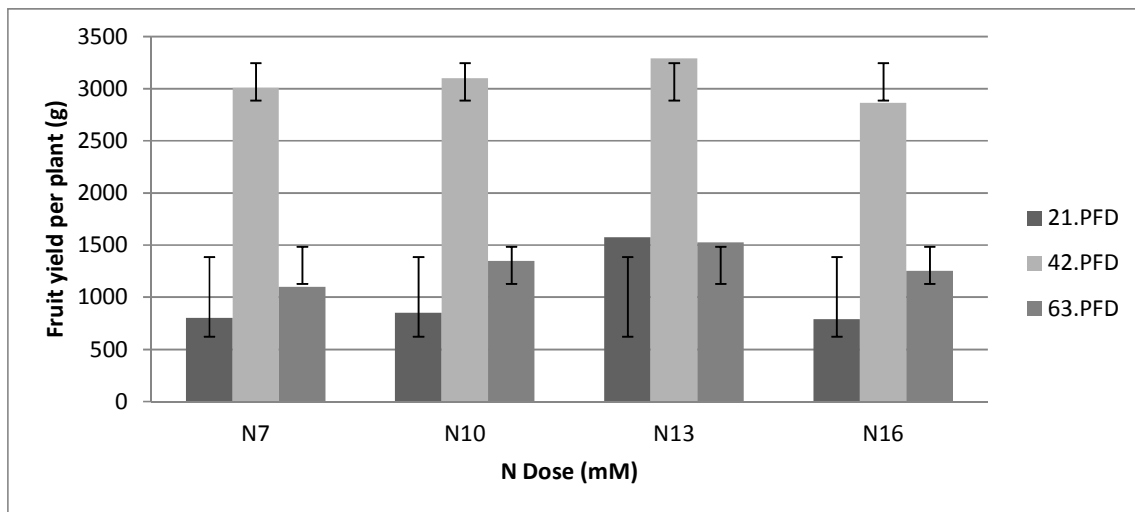


Figure 4. The effect of different Nitrogen dosages (7, 10, 13 & 16 mM) on the number of fruit per plant on planting the following day (42nd, 52nd 63rd days).

The fruit yield has increased generally as parallel to the increase in the dosage of the nitrogen (Fig 4). The highest yield was obtained in $N_{13} \times 52^{nd}$ PFD ($3291 \text{ g. plant}^{-1}$) interaction; and the lowest yield was obtained in $N_7 \times$ PFD (803g. plant^{-1}) interaction. As it is the case in all nutrient elements, the reflection of the increase in the nitrogen dosage to the fruit yield has been negative after a certain level (N_{13}). These findings are parallel to the findings of some other researchers (Lopez et al. 1997, Ruiz and Romero 1998). The order of the effects of nitrogen on Plant Fruit Yield has been as $N_{13} > N_{10} > N_7 > N_{16}$.

3.5. Total Nitrogen Concentration in the Plant

The effect of different nitrogen dosages on total nitrogen concentration in different parts of the plant is given in Fig 5.

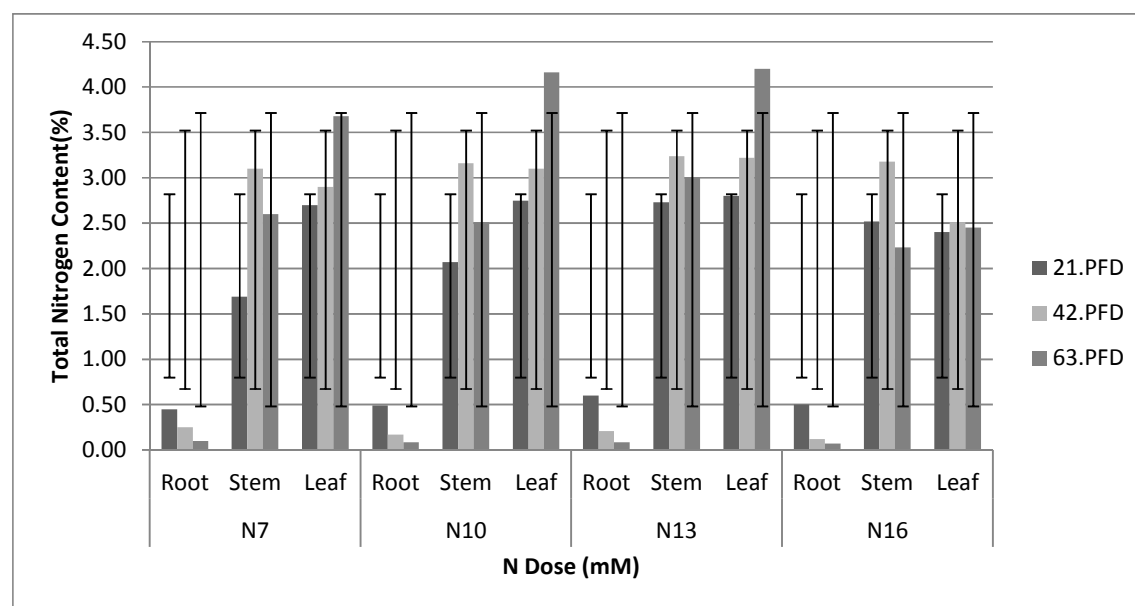


Figure 5. The effect of different Nitrogen dosages (7, 10, 13 & 16 mM) on total nitrogen concentration in different parts of the plant on planting the following day (42nd, 52nd 63rd days).

As can be seen in Fig 5, when each dosage is evaluated individually, the nitrogen concentration in the root decreased on the following PFDs; the nitrogen concentration in the stem increased first and then decreased; and the nitrogen concentration in the leaves increased regularly. The highest nitrogen concentration in the root was obtained in $N_{13} \times$ PFD interaction (0.60); the highest nitrogen concentration in the stem was obtained in $N_{13} \times 42^{nd}$ PFD interaction (3.24); and the highest nitrogen concentration in the leaves was obtained in $N_{13} \times 63^{rd}$ PFD interaction (4.20).

The order of the effects of nitrogen dosages on Plant Nitrogen Concentration has been observed as $N_{13} > N_{10} > N_7 > N_{16}$.

According to the findings of the study, the values of the examined characteristics increased till the N_{13} level of the nitrogen; and then turned to decrease in the N_{16} dosage, which is the next dosage.

These results are consistent with the findings of many other researchers (Arslan 1989, Bergman 1992, Lopez-Cantarero et al. 1997, Ruiz and Romero 1998, Altunlu et al. 1999, Güler et al. 2006, Babik and Kowalczyk 2009).

On the other hand, the N concentrations determined in the root, body and leaves of the plant showed differences when compared with the nitrogen dosage amount and sampling periods. The highest values in the same dosage were obtained on the PFD in the roots; on the 42nd PFD in the stem; and on the 63rd PFD in the leaves. This situation is considered to be related with the mobility of the nitrogen in the stem of the plant because the nitrogen is a mobile element in the plant (Rahn et al. 2001).

4. CONCLUSION

Generally, it may be suggested that especially the N₁₆ dosage affects the plant negatively in the examined characteristics, and that it almost starts hazardous effect in this dosage.

REFERENCES

1. Altunlu H, Gül A, Tunç A, Tüzel Y. 1999. Effects of Nitrogen and Potassium Nutrition on Plant Growth, Yield and Fruit Quality of Cucumber Grown in Perlite. *Acta Horticultura* 491: 377-382.
2. Arslan R., 1989. Sunflower in Thrace Conditions, N and P fertilizer demand and Calibration of Olsen phosphorus analysis methods. Kırklareli Atatürk Research Institute. Gen.Pub.15, Report Number: 11, Kırklareli(In Turkish)
3. Babik J, Kowalczyk W. 2009. Determination of the optimal nitrogen content in a fertigation medium for the greenhouse cucumber grown on slabs of compressed straw. *Vegetable Crops Research Bulletin* 71, 79-87.
4. Beman JM, Arrigo K, Matson PM. 2005. Agricultural runoff fuels large phytoplankton blooms in vulnerable areas of the ocean. *Nature* 434, 211-214.
5. Bergmann W. 1992. Nutritional Disorders of Plants. Development, Visual and Analytical Diagnosis. Florida: VCH Publishers.
6. Bremner JM. 1965. Total nitrogen. In: C.A. Black *et al.* (ed). *Methods of Soil Analysis*, Part 2. *Agronomy* 9:1179-1237. Am.Soc.of Agron., Inc., Madison, Wisconsin, USA.
7. Chuan LM, He P, Pampolino MF, Johnston AM, Jin J, Xu X, Zhao S, Qiu S, Zhou W. 2013. Establishing a Scientific Basis for Fertilizer Recommendations for Wheat in China: Yield Response and Agronomic Efficiency. *Field Crops Res.* 140, 1-8.
8. Dai JF, Liu SS, Zhang WR, Xu R, Luo WH, Zhang SF, Yin XY, Han L., Chen WP. 2011. Quantifying The Effects of Nitrogen on Fruit Growth and Yield of Cucumber Crop in Greenhouses. *Scientia Horticulturae* 130: 3, 551-561.

9. De Groot CC, Marcelis LFM, van den Boogaard R, Kaiser WM, Lamber H. 2003. Interaction of Nitrogen and Phosphorus Nutrition in Determining Growth. *Plant and Soil* 248, 257-268.
10. Gollany HT, Molina JE, Clapp CE, Allmaras RR, Layese MF, Baker JM, Cheng HH. 2004. Nitrogen Leaching and Denitrification in Continuous Corn as Related to Residue Management and Nitrogen Fertilization. *Environmental Management* 33: 1, 289-298.
11. Güler S, İbrikçi H., Büyük G. 2006. Effect of different nitrogen rates on yield and leaf nutrient contents of drip-fertigated and greenhouse-grown cucumber. *Asian J.Plant Sci.* 5 (4), 657-662.
12. Han L, Dai JF, Luo WH, Tai XA, Chen YS, Zhang SF, Li YX, Lin L, Chen CH, Bu CX. 2008. Simulation of the effects of nitrogen on after anthesis dry matter partitioning and yield of greenhouse cucumber. *Trans. Chinese Soc. Agri. Engineering* 24, 206-213.
13. Jarosz Z, Dzida K, Nurzyn´ska-Wierdak R. 2009. The effect of foliar feeding with Plonochron fertilizers (K, Mg, Ca) and differentiated rhizosphere fertilization with nitrogen upon yield and contents of selected components in cucumber leaves and fruit. *Acta Scientiarum Polonorum - Hortorum Cultus* 8 (4), 59-67.
14. Lemaire G, Gastal FF, Durand JL, Louarn G. 2015. Quantifying crop responses to nitrogen and avenues to improve nitrogen use efficiency. V. Sadras, D. Calderini (Eds.). *Crop Physiology Applications for Genetic Improvement and Agronomy*. Second Edition Academic Press in an imprint of Elsevier, Chapter II, 161-206.
15. Liang XS., Gao YA., Zhang XY., Tian YQ., Zhang ZX., Gao LH. 2014. Effect of Optimal Daily Fertigation on Migration of Water and Salt in Soil, Root Growth and Fruit Yield of Cucumber (*Cucumis sativus* L.) in Solar-Greenhouse. *PloS one* 9:1.
16. Lopez-Cantarero I, Ruiz JM., Romero L. 1997. Nitrogen Metabolism and Yield Response to Increases in Nitrogen-Phosphorus Fertilization: Improvement in Greenhouse Cultivation of Eggplant (*Solanum melongena* Cv Bonica). *J. Agric. Food Chem.* 45, 4227-4231.
17. Nasholm T., Kielland K., Ganeteg U. 2009. Uptake of organic nitrogen by plants, *New Phytol.*, 182, 31-48.
18. Piwpuan N, Zhai X., Brix H. 2013. Nitrogen nutrition of *Cyperus laevigatus* and *Phormium tenax*: effects of ammonium versus nitrate on growth, nitrate reductase activity and N uptake kinetics. *Aquat. Bot.* 106, 42-51.
19. Rahn CR, Lillywhite RD, DeNeve S. 2001. Associated with Nitrogen Fertilisation of Field Grown Vegetable Crops Location: I. Conference: International Conference on Environmental Problems Book *Acta Horticulturae* 563, 81-86.
20. Robertson GP, Vitousek PM. 2009. Nitrogen in agriculture: balancing the cost of an essential resource. *Annu. Rev. Environ. Resour.* 34, 97–125.
21. Ruiz JM, Romero L. 1998. Commercial Yield and Quality of Fruits of *Cucumber* Plants Cultivated Under Greenhouse Conditions: Response to Increases in Nitrogen Fertilization. *J. Agric. Food Chem.* 46 (10), 4171-4173.

- 258 22. Ruiz JM, Romero L. 1999. Cucumber yield and nitrogen metabolism in response to nitrogen
259 supply. *Scientia Horticulturae* 82, 309-316.
- 260 23. Sonneveld C, Straver N. 1992. Nutrient solutions for vegetables and flowers grown in water or
261 substrates. Proefstation voor tuinbouw onder gla2 te Naaldwijk. 9th edition. No:8., 15. The
262 Netherlands.
- 263 24. Wallinga I., van Vark W., Houba V.J.G., van der Lee JJ. 1989. Plant Analysis Procedures
264 (Soil and Plant Analysis, Part 7). Wageningen Agricultural University, Dept. of Soil Science & Plant
265 Nutrition. p 10. The Netherlands. ISBN: 978-1-4020-2769-7