ORIGINAL ARTICLE

BIOMETRIC AND PHYSIOLOGICAL CHARACTERISTICS OF CHRYSANTHEMUM (*CHRYSANTHEMUM INDICUM* L.) PLANTS GROWN AT DIFFERENT RATES OF NITROGEN FERTILIZATION

БИОМЕТРИЧНИ И ФИЗИОЛОГИЧНИ ХАРАКТЕРИСТИКИ НА ХРИЗАНТЕМА ПРИ РАЗЛИЧНИ НИВА НА АЗОТНО ТОРЕНЕ

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РЕЗЮМЕ

Проведен беше опит в неотопляема пластмасова оранжерия с едроцветния сорт хризантема "Dark Westland". Проучени бяха три нива на азотно торене: 0, 100 и 140 kgN/ha и два начина на формиране на растенията — едно- и двустъблено. Бяха определени параметрите на биометрични показатели, листен газообмен и съдържание на листни пигменти. Беше отчетено, че най-добри резултати по отношение на растежните и декоративни прояви са получени при нива на азотно торене 100 kgN/ha. Установено беше също, че азотното торене със 100 и 140 kgN/ha повишава скоростта на фотосинтезата и при двата начина на формиране на растенията.

КЛЮЧОВИ ДУМИ: ***Crysanthemum indicum*** **L., азотно торене, многостъблено формирани растения, листен газообмен, фотосинтетични пигменти**

ABSTRACT

A trial with large the flowered chrysanthemum cultivar Dark Westland was carried out in an unheated greenhouse. Three rates of nitrogen fertilization were studied: 0, 100 and 140 kgN/ha, as well as two modes of plant formation – single- and two-stemmed plants. Parameters of the biometric characteristics, leaf gas-exchange and leaf pigment content were determined. The best results about growth and decorative behaviour were achieved at nitrogen fertilization level of 100 kgN/ha.

It was established that nitrogen fertilization in rates of 100 and 140 kgN/ha enhances photosynthetic rate in both modes of plant formation.

KEY WORDS: ***Chrysanthemum indicum*** **L., nitrogen fertilization, poly-stem formatted plants, leaf gas-exchange, photosynthetic pigments**

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DETAILED ABSTRACT

The effect of nitrogen upon plant growth and development is often connected with the process of photosynthesis because the supply of nitrogen in the highest degree determines the formation and the functional state of the photosynthetic apparatus of plants. The nitrogen nutrition influences the content of photosynthetic pigments, synthesis of some enzymes involved in carbon reduction, formation of the membrane system of chloroplasts, etc. There are only few studies on the effect of different rates of nitrogen fertilization upon the morphological characteristics of poly-stem formatted chrysanthemum plants. The information about the physiological response of those plants to different nitrogen nutrition is scant.

The present investigation was conducted during a three-year period under unheated greenhouse conditions. The large-flowered cultivar Dark Westland was used. The plants were planted in the end of June at spacing 15 x 15 cm. Plants were pinched two weeks later as they were formed as single- or two-stemmed plants. Three rates of nitrogen fertilization were studied: 0, 100 and 140 kgN/ha. Biometric parameter, leaf gas-exchange and leaf pigment content were determined.

It was established that the length of stem, the number of leaves and the flower diameter had highest values at nitrogen fertilization rate of 100 kgN/ha. The highest rate – 140 kgN/ha had a negative effect upon the parameters of these characteristics. No effect upon the volume of root system was registered. No significant differences were observed between the different plant formations.

Improvement of photosynthetic performance in actively functioning leaves was observed under the influence of the nitrogen fertilization in rates of 100 and 140 kgN/ha, as in the highest stem density this improvement was determined by the more intensive gas-exchange, while in the lower density – by the higher content of photosynthetic pigments.

INTRODUCTION

Chrysanthemum is the most important traditional flower crop in Bulgaria. Regulation of nitrogen nutrition is one of the basic elements of chrysanthemum growing. Maintaining high nitrogen level during the period of early growth is essential [1, 3]. The optimal term of application and the optimal nitrogen rates for a good growth and cut flower production with good quality have been determined [5, 6].

The influence of nitrogen on plant growth and development is often connected with the process of photosynthesis because the supply of nitrogen in the highest degree determines the formation and the functional state of the assimilation apparatus of plants. It is well known that nitrogen nutrition influences the content of photosynthetic pigments, the synthesis of the enzymes taking part in the carbon reduction, the formation of the membrane system of chloroplasts, etc. [4, 7, 8].

Despite the significant number of investigations on chrysanthemum requirements of nitrogen, little is known about the influence of different rates of nitrogen fertilization on the morphological characteristics of poly-stem formatted plants. On the other hand, information about the physiological response of ornamental plants to different nitrogen nutrition is scant [2].

The aim of the present investigation is to study the effect of different rates of nitrogen fertilization upon dry mass accumulation and some decorative characteristics of chrysanthemum plants, as well as upon leaf gas-exchange and the content of photosynthetic pigments.

MATERIAL AND METHODS

The investigation was conducted in the period 1998–1999 in an unheated plastic greenhouse with the large flowered cultivar Dark Westland on the experimental field of the Agricultural University of Plovdiv, Bulgaria. The soil is assigned as Fluvisols (Gjurov, 1959) with the following soil characteristics: loam texture, average organic matter content of 4.0–4.5%, $pH_{(H2O)}$ – 7.9 and content of mobile forms of nitrogen, potassium and phosphorus – 13.05, 302.0 and 194.5 mg/kg, respectively.

Plants were planted at the end of July in density of 50 plants per m^2. Pinching was done two weeks later and plants were single-or two-stem formatted. Three nitrogen rates were tested – the control (without fertilization), 100 and 140 kg/ha. The treatment was done as soil fertilization with NH_4NO_3 every week during the period of the active vegetative growth – four times total. The experiments were conducted in four replications of the variants.

During the period of the active vegetative growth the leaf gas-exchange (photosynthetic rate – A; transpiration rate – E and stomata conductance – g_s) was measured by LCA-4 (ADC, England) under the following conditions: leaf temperature – 28–30^0 C; CO_2 concentration – 400 µmol mol^1, and photon flux density – 550–600 µmol m^{-2} s^{-1}. Chlorophyll and total carotenoid contents of leaves were estimated in 80% acetone extracts according to Lichtenthaler and Wellburn (1983). All physiological analyses were made in triplet in 1997. For those analyses the 7th fully developed leaf (from the stem bottom) was used.

At the end of vegetation the dry mass of plants and the biometrics parameters – stem length, number of leaves and flower diameter were determined in 10 plants from each variant. Dry mass was established after drying the plant material at 80^0 C for 48 hours.

Significant differences, between treatments were determined by the Student's *t*-test.

RESULTS AND DISCUSSION

The observations indicated that the different rates of nitrogen fertilization, as well as the mode of plant formation had an influence upon the growth and the decorative behaviours of chrysanthemum (Tabl. 1). A slight tendency towards increasing the stem length of single- and two-stem formatted plants was observed with increasing the nitrogen rates until the determined level of 100 kg/ha – var. 2 in single-stemmed plants and var. 5 in two-stemmed plants: 67.1 and 69.2 cm, respectively. Analogical tendency was observed in the number of leaves, too.

Table 1: Dry mass and biometric characteristics of chrysanthemum plants grown at different nitrogen rates

Treatments		Stem length (cm)	Number of leaves	Flower diameter (cm)	Dry mass of plants (g)
1. Control – 50		66.6	11.7	11.2	13.7
2. 100 kg N/ha		67.1	16.5	14.3	14.7
3. 140 kg N/ha		63.6	14.1	13.6	15.6
4. Control – 100		59.2	13.3	10.6	14.1
5. 100 kg N/ha		69.2	14.8	12.5	14.5
6. 140 kg N/ha		64.5	13.0	11.9	15.4
	5%	17.3	2.9	1.7	3.5
GD	1%	19.4	4.1	1.9	4.7
	0,1%	23.5	3.5	2.1	5.8

The flower diameter is one of the important characteristics determining the production quality. The value of this characteristics showed that increasing the number of branches per plant had a negative effect upon flower size – the differences between average values of separate variants of single- and two-stemmed plants were 1.4, 1.8 and 1.7 cm. The differences from the control were statistically significant.

The most obvious effect of nitrogen fertilization was observed in dry mass accumulation of plants. The higher rates of nitrogen fertilization increased the dry mass of the single-stem formatted plants by 13% and of the two-stem formatted ones – by 10%. The higher dry mass of nitrogen treated plants could be connected with the positive effect of nitrogen in some important physiological processes. These differences were statistically significant.

The results given in table 2 show that nitrogen fertilization increased the photosynthetic rate in the actively functioning leaves of chrysanthemum formatted as single- or two-stemmed plants. The tendency towards increasing was expressed stronger in single-stem formatted plants, where fertilization with 140 kgN/ha enhanced photosynthetic rate by 13%. In those plants nitrogen fertilization significantly increased the transpiration rate by 26% and the stomata conductance by 31%.

Table 2: Influence of nitrogen fertilization upon leaf gas-exchange and content of photosynthetic pigments in chrysanthemum plants

Treatments		1. Control - 50	2. 100 kg N/ha	3. 140 kg N/ha	4. Control - 100	5. 100 kg N/ha	6. 140 kg N/ha
Leaf gas-exchange	A	10.69 (100)	11.06 (103)	12.08 (113)*	10.15 (100)	10.76 (106)	11.06 (109)
	E	2.43 (100)	2.89 (119)*	3.05 (126)*	3.03 (100)	2.99 (99)	3.06 (101)
	g_s	0.16 (100)	0.19 (119)*	0.21 (131)*	0.23 (100)	0.22 (96)	0.24 (104)
Content of photosynthetic pigments (mg dm^{-2})	Chl. a	2.96 (100)	2.88 (97)	3.06 (103)	3.10 (100)	3.47 (112)*	3.45 (111)*
	Chl. b	1.29 (100)	1.32 (102)	1.35 (105)	1.59 (100)	1.80 (113)*	1.75 (110)
	carotenoids	1.16 (100)	1.17 (101)	1.21 (104)	1.16 (100)	1.30 (112)*	1.26 (109)
Chl. a /Chl. b		2.29 (100)	2.18 (95)	2.27 (97)	1.95 (100)	1.93 (99)	1.97 (101)
Chl. a + b, carotenoids		3.66 (100)	3.59 (98)	3.64 (99)	4.04 (100)	4.05 (100)	4.13 (102)

A - photosynthetic rate (μmol CO_2 m^{-2} s^{-1}); E - transpiration rate (mmol H_2O m^{-2} s^{-1});
g_s - stomatal conductance (mol m^{-2} s^{-1}); in brackets – percentage of the control; * $P< 0.05$

It is accepted that factors changing the photosynthetic rate have stomatal and non-stomatal nature. To what extent the increased transpiration enhances photosynthetic rate could be explained after the analysis of the dependence of CO_2 assimilation on the intercellular CO_2 concentration. In this case we can only admit that the increased leaf gas-exchange, which also includes photosynthesis, is a result of the complex positive effect of nitrogen fertilization upon the single-stemmed plants. The results also indicate that nitrogen fertilization did not influenced neither the content, nor the ratios between the photosynthetic pigments, most probably because at this stem density nitrogen was not a limiting factor for their biosynthesis.

With increasing the density of stems to 100 per m^2 competitiveness between plants in nutritional, water and light regime becomes stronger. Under these conditions a positive effect of nitrogen fertilization upon the content of photosynthetic pigments was observed. The results in table 2 show that the contents of chl. *a*, chl. *b* and carotenoids were increased by 10% and in most cases it is statistically significant. The ratios between pigments were not changed and were within the limits of the norm. However, it can be pointed out that the ratio chl. *a* / chl. *b* was decreased to some extent compared to that in the single-stem formatted plants. This is a result from the higher values of chl. *b* in the two-stem formatted plants and could be explained as an adaptation of photosynthetic apparatus to the limitations in the light regime. Regarding that the nitrogen fertilization in density of 100 stems per m^2 did not exert a significant effect on the process of transpiration, the slight tendency towards increasing the photosynthetic rate was probably due to non-stomatal factors, one of which was the higher content of photosynthetic pigments.

The obtained by us results about the positive effect of nitrogen fertilization upon the photosynthetic rate are in line with those about its effect on the dry mass accumulation of chrysanthemum plants. In both cases the values were increased by 10% averagely. This gives us a reason to admit that one of the factors providing higher dry mass accumulation in nitrogen treated plants was the increased capacity for CO_2 assimilation.

CONCLUSIONS

The length of stem, the number of leaves and the flower diameter in the large-flowered cultivar Dark Westland were with the highest values in the both modes of formatting at nitrogen rate of 100 kgN/ha. Significant differences between the single- and the two-stem formatted plants were not observed.

The nitrogen fertilization at rates of 100 and 140 kgN/ha increased the photosynthetic rate in the actively functioning leaves of single- and two-stem formatted chrysanthemum plants. In the density of 50 stems per m^2 the increased photosynthetic rate corresponded to the enhanced leaf gas-exchange, while in the density of 100 stems per m^2 – with the higher content of the photosynthetic pigments.

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REFERENSES

[1] Angel - Aristizabal M., 1994. Mineral nutrient deficiencies in chrysanthemum. Universidad Nacional de Colombia, Santafe de Bogota (Colombia), Facultad de Agronomia, p. 154.

[2] Atanassov Chr., N. Stoeva, O. Tafradjiiski, 1998. Influence of mineral nutrition of leaf gas-exchange of tagetes plants. In: Proceedings of Jubilee Scientific session "50 years union of scientists in Bulgaria", t. 1, 175-177 (In Bulgarian).

[3] Chezhiyan N., K.Nanjan, A. Khader, 1986. Studies on nutrient requirement of Chrysanthemum indicum cv. Co. 1. South Indian Horticulture, 34 (3), 173-178.

[4] Gjurov, G., 1959. The complex of saline soils to the east of Plovdiv. Scientific reports of Agricultural University, 6, 431-461.

[5] Ivanova V., 1997. Effect of nitrogen rates and mode of plant formatting on the growth, flowering responses and vase - life of Chrysanthemum indicum L. - Dahlia Gredinger

International Symposium on Fertilization and the environment, Technion - II - T, Haifa, Israel, 24 - 27.03.1997., p. 457-466.

[6] Ivanova V., N. Panayotov, N. Shaaban, 1996. Effect of increasing rates of nitrogen nutrition on vegetative and decorative behaviour of Chrysanthemum indicum L. - Prague, 8-15 Sept., p. 310-314.

[7] Lishtenthaler, H. K., Wellburn, A., 1983. Determination of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. Biochem. Soc. Trans. 603: 591-592.

[8] Stanev, V., 1984. Influence of deficit of nitrogen, phosphorus and potassium on the photosynthetic apparatus. In: Formation and functional activity of the photosynthetic apparatus (Eds. Yordanov, I), Publ. House of BAS, Sofia, 159-171.