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EFFECT OF FERTILIZER SOURCE ON THE NUTRIENTS BIOLOGICAL UPTAKE WITH GARDEN BEANS PRODUCTION

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Abstract

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Garden bean pants (*Phaseolus vulgaris* (L.) Savi.) ssp. Nanus cv. Xera were grown under glasshouse conditions at optimal fertilizer rates using mineral, organic and foliar fertilizers previously established in a model pot experiments. The favorable effect of the foliar feeding on the yields of garden bean pods was shown. Total amounts of the biological uptake of nutrients with the vegetative biomass and pods production were observed to be maximal both in the organic and foliar fertilized plants. The percentage of nitrogen, phosphorus and potassium uptake in the plants with mineral and organic fertilization was equal. In foliar fed plants percentage of P and K increased in comparison in the other treatments on the account of nitrogen level. The amounts of nutrients required for the formation of obtained yield were determined on the base of its biological uptake.

Key words: Phaseolus vulgaris, mineral, organic and foliar fertilizers, nutrient plant requirements

Introduction

The biological uptake of nutrients – nitrogen, phosphorus and potassium is one of main parameters that indicate nutrient plant requirements. Accurately assays of nutrients, consumed by plants for yield formation determine reasonable fertilizer recommendations. Forms and amounts of applied fertilizers to ensure optimal nutritional regime for crops are very important for successful plant development and influence yield and quality of vegetables (Sidiras et al., 1999). Garden bean plants have big requirements to the cultivation conditions and especially to the nutrient regime (Mitova et al., 2008). In comparison with the other legumes with similar yield quantities, garden beans derived from the soil more nutrients (Pidov et al., 1995). Application of low to moderate nitrogen fertilizers on the background of optimal phosphorus and potassium nutrition stimulate nitrogen fixation and increased yields. Nutrient uptake with garden beans production strongly varied in dependence on soil-climatic conditions, crops locality and variety properties (Shaban and Rankov, 1991). Agrotechnical measures such as rates, terms and ways of fertilization, also influenced biological nutrient uptake (Shaban and Rankov, 1991; Shaban, 2002). The quality of fresh vegetable produce depends on several factors. Among these factors, fertilizer forms and rates play an important role in ensuring an optimal nutritional regime for successful plant development and in influencing the yield and quality of vegetables (Dimitrov et al., 2005; Atanasova et al., 2007; Mitova et al., 2008). In order to obtain fresh vegetable production with optimal yields and quality is necessary to apply fertilizer sources that appropriately meet crop nutrient requirements.

The study deals with the establishment of nitrogen, phosphorus and potassium content in different garden bean plant parts and biological nutrient uptake with biological plant production in dependence of the fertilizer source. Thus, the objective of our study is to estimate the most appropriate fertilizer source for maximal yields of garden beans crop and to recommend the amounts of nutrients for the optimal yield formation on the base of its biological uptake.

Materials and Methods

Garden bean plants (*Phaseolus vulgaris* (L.) Savi.) ssp. Nanus cv. Xera were grown under glasshouse conditions at optimal water regime without deficiency. Glasshouse soil substrate had the following agrochemical characteristics pH

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(H_2O) – 6.3, NH_4^+-N – 19.3 mg kg^{-1}, NO_3^--N – 49.72 mg kg^{-1}, P_2O_5 – 336.0 mg kg^{-1}, K_2O – 543.3 mg kg^{-1}. A randomized block design with 4 replicates was used at plant density 10 plants per 1 m^2. Each experimental plot was 6.72 m^2 in area and consisted of 4 rows. Plants were grown at optimal fertilizer rates previously determined in model pot experiments. The following treatments were tested: 1). Control – without fertilization; 2). Mineral nitrogen, applied as NH_4NO_3, 50 kg ha^{-1} active substance on a background of P and K, 100 kg ha^{-1} P_2O_5 and 120 kg ha^{-1} K_2O respectively; 3). Farmyard manure – 2080 kg ha^{-1}. (The composition of the farmyard manure is: total N – 0.64%, total P_2O_5 – 1.84%); 4). Foliar fertilizer Agroleaf (Agroleaf total) from Scotts company, Ohio, USA distinguishes with high purity, N: P: K – 20:20:20 + all important microelements. Agroleaf chemical characteristics were previously described (Stancheva et al., 2004)

The mineral nitrogen and farmyard manure were applied before the sowing. Agroleaf was applied with spraying under high pressure 5 times during the vegetation period at 10-day intervals at rates 3kg ha^{-1} or 0.3% solution (recommended by the Scotts Company) starting 3 weeks after planting. After young seedlings formation a pellucid plastic film to avoid penetration into the soil of the flier foliar fertilizer covered each plot.

Mineral nitrogen in soil and plant samples was determined spectrophotometrically after Kjeldal digestion, assimilated by plants P after acetate – lactate method with modification (Ivanov, 1984) and plant potassium by flame spectrometry. Soil phosphorus and potassium accessible for plants (movable P and K forms) in the soil were determined according to the method of Ivanov (1984). Uptake of nutrients (N, P, K) was estimated as: % of nutrients x plant productivity (vegetative biomass and/or yield of pods).

Data are expressed as means ± standard error where n=4. Comparison of means was made by the Fisher LSD test ($P \leq 0.05$) after performing multifactor ANOVA analysis. The Statgraphics software (statistical package version 5.0) was used for statistical analysis.

Results and Discussion

The effect of different fertilizer sources of application on the yield of garden beans, first, second and third gathering is given in Figure 1. High yield levels from garden beans – third gathering are obtained in the variants with farmyard manure and foliar fertilizer, i.e. pod formation in these variants is prolonged. Maximal yields from first, second and third bean pods gathering are obtained under conditions of foliar fertilization 17412 kg ha^{-1} and exceeded control with 49% (Figure 1). High yields were obtained from the variants with organic fertilization – 36% higher in comparison with the control. Among the treatments with different fertilizer sources, the lowest yield was obtained from the variants with mineral fertilization - only about 6% higher than the control. Combined soil and foliar fertilization was large used in agricultural practice especially during the stages of fast growth, enhanced biomass accumulation and formation of reproductive organs. Feeding plants though the foliage at these critical stages resulted in high yields with good quality (Dixon, 2003).

Vegetative aboveground biomass also differed significantly among the treatments (Figure 2). Maximal fresh biomass values were observed because of organic fertilization, while dry above ground biomass was approximately equal in the treatments with organic and foliar fertilization. Maximal garden bean yields in the treatments with foliar fertilization coincided with maximal leaf dry biomass accumulation while dry biomass in the organic fertilized plants accumulated mainly in the stems (data are not shown). Some studies (Peev, 1985; Tonev et al., 1999) on beans and other legume crops showed that quality parameters and especially dry matter content were genetically determined and that several environmental factors had a weak impact on these parameters.

Nitrogen content in the aboveground vegetative mass was in the range 3.32 –3.70% that is an optimal content for garden bean plants (Table 1). Shaban and Rankov (1991) reported that normally nitrogen content for this legume species varied between 1.83 and 3.80. The lowest N level was observed in the biomass of the control plants. High N levels were assayed in the biomass both of mineral fertilized and organic fertilized plants. Total phosphorus content in the vegetative aboveground biomass was lower than the values reported for

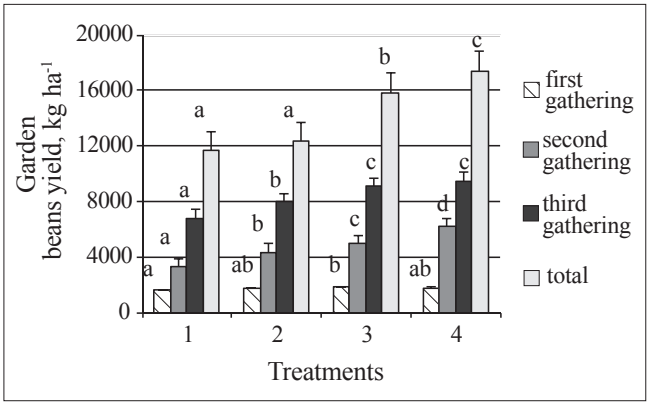

Fig. 1. Yield of garden bean pods in dependence on different fertilizer sources

Treatments: 1-control; 2 - mineral fertilization, 3 - organic fertilization; 4 - foliar fertilization

Values are means ± S.E., n=4. Different letters indicate significant differences assessed by the Fisher LSD test ($P \leq 0.05$) after performing ANOVA multifactor analysis.

this crop at the same vegetative stage (Shaban and Rankov, 1991). P content values varied between 0.67 and 0.78% and maximal levels were observed in the plants with organic fertilization. It is known that phosphorus mobility and uptake strongly depends on the soil temperatures – at the temperatures lower than 10°C inhibition of P uptake is obviously expressed (Mengel and Kirkby, 1982). It could be suggested that prolonged low temperatures in the beginning of vegetation in April resulted in reduction of phosphorus uptake and assimilation. Potassium content in aboveground vegetative biomass in the end of the vegetation is in the range of reported data (1.66 – 1.68) for the garden beans crop according to the Rankov and Poryazov (1981). The lowest values were observed in the control plants and maximal in the foliar fertilized plants.

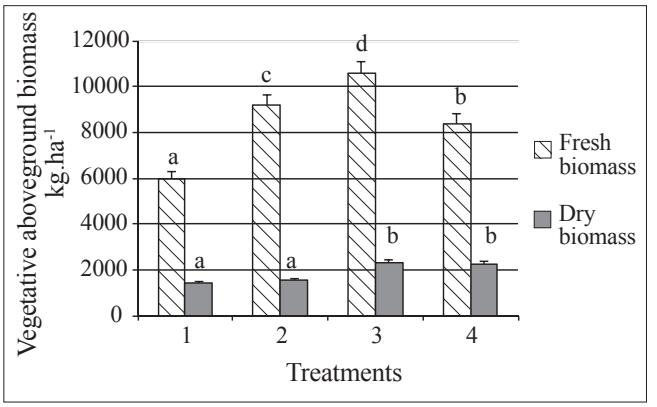

Fig. 2. Fresh and dry aboveground biomass of garden beans, grown at different fertilizer sources

Treatments: 1-control; 2 - mineral fertilization, 3 - organic fertilization; 4 - foliar fertilization

Values are means ± S.E., n=4. Different letters indicate significant differences assessed by the Fisher LSD test (P≤0.05) after performing ANOVA multifactor analysis

The content of nitrogen in the pods aroused from the first to the third gathering and the highest N content was observed as a result of organic fertilization (Table 1). Among the treatments where fertilization was applied the lowest N levels were found in foliar fed plants. Total N content in the pods from the final gathering varied from 2.0% for the plants without fertilization to 3.40% for organic fertilized plants. With the exception of the control plants N content in the pods is in its optimal range (2.67 – 3.92%) (Rankov and Poryazov, 1981). P content in the pods is lower while K content is higher than the reported optimal values for this crop, 0.88 and 2.03% respectively (Rankov and Poryazov, 1981). Low P content in the pods corresponded to the low P levels in the vegetative biomass. Differences regarding NPK values obtained in our study and reported by the other authors could due to the specific soil, varieties and cultivation properties.

The amounts of nitrogen and potassium removed with the production of pods were maximal and almost equal in the treatments with organic and foliar fertilization (Table 2). Only the phosphorus uptake with the pods was the highest in foliar fed plants. Uptakes of N and P with the vegetative biomass were maximal as a result of organic fertilization. Removed K with the vegetative mass did not significantly differ between organic and foliar fertilized plants. Total amounts of the nutrients uptake with the vegetative biomass and pods production were observed to be maximal in the organic and foliar fertilized plants without statistically proved differences. Among the fertilized treatments plants with mineral nutrition showed low values of the removed nutrients.

Because of the relatively low garden bean yield levels, the main nutrients removed with biological production varied close to the low limit reported values according to Shaban and Rankov (1991) especially for the N (101.6 – 270.9 kg ha^{-1}) and P (85.1 – 170.3).

Table 1
Percent content of nitrogen, phosphorus and potassium in vegetative parts and bean pods in dependence on fertilizer sources

Treatments	Nitrogen, %	Phosphorus, %	Potassium, %
Vegetative biomass at pod formation stage			
1. Control	3.32	0.67	1.48
2. Mineral fertilization	3.70	0.74	1.58
3. Organic fertilization	3.67	0.78	1.78
4. Foliar fertilization	3.37	0.75	1.90
Pods I+II+III gathering			
1. Control	2.0 +2.93+3.0	0.71+0.70+0.74	3.03+3.03+3.15
2. Mineral fertilization	3.0+3.32+3.00	0.73+0.75+0.77	3.10+3.28+3.22
3. Organic fertilization	3.10+3.33+3.40	0.76+0.75+0.74	3.03+3.35+3.40
4. Foliar fertilization	2.92+2.96+3.05	0.76+0.74+0.80	3.10+2.98+3.00

In total nutrient NPK uptake with the yield of pods and vegetative biomass the share of the nitrogen is the highest (Figure 3), followed by the potassium and phosphorus. The percentage of NPK uptake in the plants with mineral and organic fertilization is equal. In foliar fed plants percentage of P and K increased in comparison in the other treatments on the account of nitrogen level.

Percentage of nitrogen and phosphorus uptake was higher with above ground vegetative biomass than with the pods, while the potassium nutrient uptake was higher with the

Table 2
Biological uptake of nutrients (kg ha^{-1}) with garden beans production in dependence on fertilizer sources

Treatments	Yield of pods (I+II+III gathering)			Vegetative biomass			Vegetative biomass + pods		
	N	P	K	N	P	K	N	P	K
1. Control	31.6^{a*}	8.0^{a}	34.5^{a}	46.4^{a}	9.4^{a}	20.8^{a}	78.0^{a}	17.4^{a}	55.3^{a}
2. Mineral fertilization	46.8^{b}	10.7^{b}	45.4^{b}	56.4^{b}	11.3^{b}	24.1^{b}	103.2^{b}	22.0^{b}	69.5^{b}
3. Organic fertilization	54.7^{c}	12.2^{c}	54.7^{c}	85.0^{d}	18.1^{d}	41.2^{c}	139.7^{c}	30.3^{c}	95.9^{c}
4. Foliar fertilization	56.5^{c}	14.6^{d}	56.4^{c}	75.1^{c}	16.7^{c}	42.3^{c}	131.6^{c}	31.3^{c}	98.7^{c}
LSD (P≤ 0.05)	4.5	1.1	4.5	6.4	1.4	3.2	10.9	2.5	7.7

*Values are means ± S.E., n=4. Different letters indicate significant differences assessed by the Fisher LSD test (P≤0.05) after performing ANOVA multifactor analysis

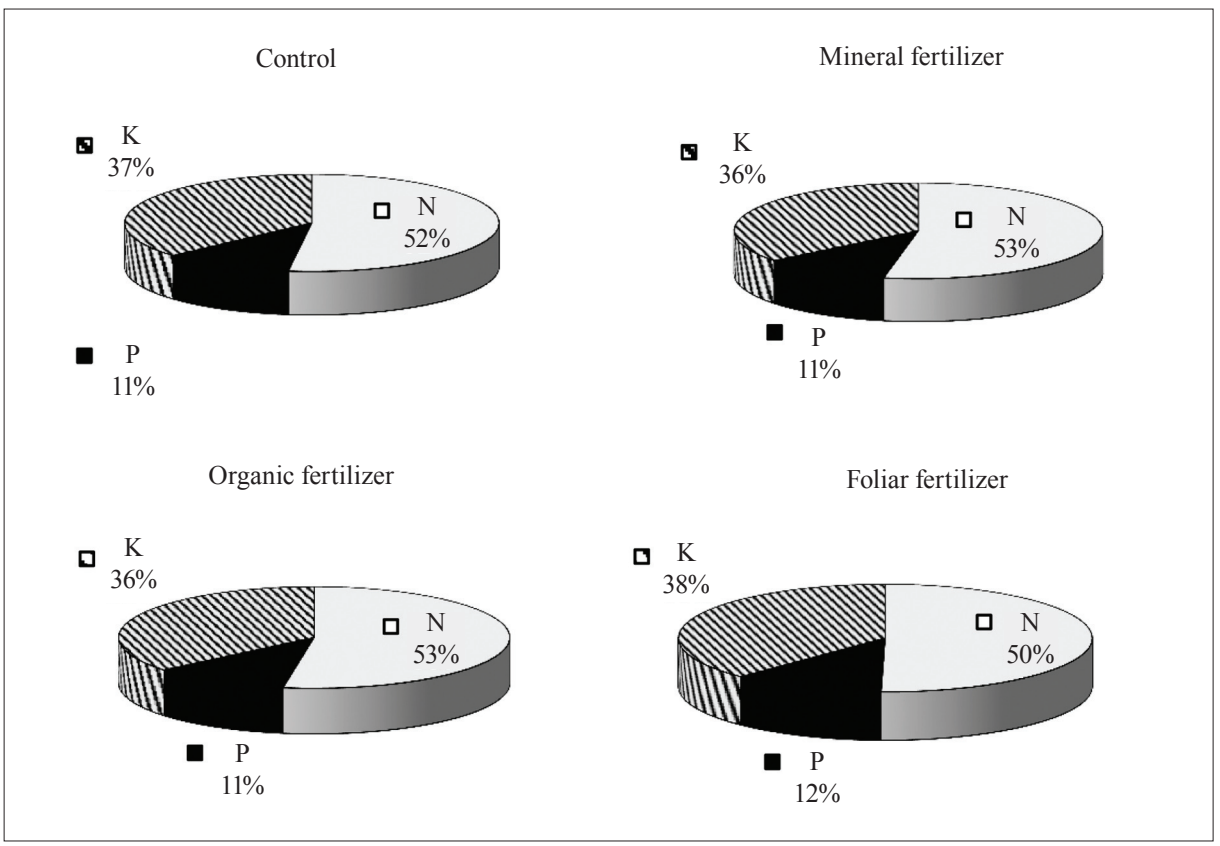

Fig. 3. Share of nutrient elements (%) in total uptake of N, P and K with garden beans biological production (aboveground biomass and pods)

Table 3
Percentage of nutrients uptake with pods and vegetative biomass in dependence on fertilizer sources

Treatments	N, %		P, %		K, %	
	Pods	Vegetative biomass	Pods	Vegetative biomass	Pods	Vegetative biomass
1. Control	40.40^{a*}	59.6^{ab}	46.0^{ab}	54.0^{a}	62.37^{ab}	37.63^{a}
2. Mineral fertilization	45.33^{b}	54.67^{a}	48.60^{b}	51.4^{a}	65.30^{b}	34.70^{a}
3. Organic fertilization	39.16^{a}	60.84^{b}	40.31^{a}	59.69^{b}	57.02^{a}	42.98^{b}
4. Foliar fertilization	42.99^{ab}	57.01^{ab}	46.67^{ab}	53.33^{a}	57.14^{a}	42.86^{b}
LSD (P≤ 0.05)	3.96	5.46	7.85	5.15	5.41	3.74

*Values are means ± S.E., n=4. Different letters indicate significant differences assessed by the Fisher LSD test (P≤0.05) after performing ANOVA multifactor analysis

beans pods (Table 3). In the treatments with organic fertilization, N and P were removed previously with the vegetative biomass. Potassium was removed mainly with the pods in the treatments with mineral fertilization.

Conclusions

The present study showed that the maximal garden bean yields in the treatments with foliar fertilization are in correspondence with maximal leaf dry biomass accumulation. Total amounts of the nutrients uptake with the vegetative biomass and pods production were observed to be maximal in the organic and foliar fertilized plants without statistically proved differences. Among the fertilized treatments, plants with mineral nutrition showed low values of the nutrient uptake with total garden beans production, which means that nutrients were used more effectively for formation of pods. The percentage of NPK uptake in the plants with mineral and organic fertilization is equal. In foliar fed plants, percentage of P and K increased in comparison in the other treatments on the account of nitrogen level. For the yield levels obtained in our study in the range 11680 - 17410 kg ha^{-1} the amounts of 27.1- 37.9 kg N ha^{-1}, 6.9-8.7 kg P ha^{-1} and 29.5 –36.7 kg K ha^{-1} were required. In the treatments with organic fertilization, N and P were removed previously with the vegetative biomass while the potassium was removed mainly with the pods in the treatments with mineral fertilization.

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