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ORIGINAL PAPER

Effect of the sowing norm and nitrogen fertilization on the yield from dry bean (*Phaseolus vulgaris* L.) cultivar Blyan

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Abstract

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During 2016 – 2018 a field trial was carried out with the new cultivar Blyan in the trial field of Dobrudzha Agricultural Institute on slightly leached chernozem soil. The aim of the investigation was to find out the optimal sowing and nitrogen norms for this cultivar under the conditions of the slightly leached chernozem soil in Dobrudzha region. Five sowing norms were tested: 20, 27, 34, 41 and 48 germinating seeds per m^2, as well as four variants of nitrogen fertilization: 0, 40, 80, and 120 kg/ha against phosphorus background of 60 kg/ha. The trial was designed according to the split plot method, with four replications of the variants, the size of the harvest plot being 12 m^2. The sowing norm of 41 g.s. / m^2 was found most efficient with regard to yield from cultivar Blyan. Nitrogen fertilization increased seed yield. The rate of increase being highest with the lowest nitrogen norm - $N_{40}P_{80}$. The subsequent increase of the sowing norm did not go together with the same rate of yield increase. Thousand seed weight reached a maximum as early as the first sowing norm (20 g.s. /m^2) and fertilization norm $N_{120}P_{80}$. The conditions of the respective year had strongest effect on two investigated indices. Highest yield was obtained during the first year of the investigation (2016), i.e. the year with optimal conditions for expression of the biological potential of cultivar Blyan. However, the weight of 1000 seeds is highest during the worst year (2018), i.e. dependence is inversely proportional to yield.

Key words: Bean cultivar Blyan, Sowing norms, Fertilization norms, Seed yield

Introduction

Growing of optimal number of plants per area unit and nitrogen fertilization of bean are of primary importance for the maximum expression of the biological potential of the cultivar. The nutrition area of each plant is optimized through the first agronomy element, while nitrogen fertilization contributes to adequate conditioning for nutrition of the plants with this element under the specific soil and climate. The significance of the second agronomy factor is very high, because bean, being a leguminous plant, takes up nitrogen from the soil, from fertilizers, and also assimilates nitrogen symbiotically fixated by the *Rhizobium* nodules.

The elements of the technology for growing dry bean such as sequence, way of performing, as well as their range of values specific for this crop have been, on the whole, well clarified (Dimitrov et al. 1993; Ivanovsky, 1992; Iliev and Ivanov, V, 1988). Regardless of this, at the level of the cultivar, the agro-technology of bean is specific because the elements of this technology are further determined within more narrow limits by the peculiarities of the cultivar (Milev, G., 2010; Mitranov, 1989; Stavreva and Dimitrov, 1981; Bozic, 1996; Eskert et al., 2010; Field and Nkumbula, 1986). The successful growing of a cultivar is determined by some of the cultivar's individual characteristics such as growing period, requirements to nutrients, optimal number of plants per unit area, etc. Finding the optimal parameters of the separate elements from the overall technology of the cultivar is especially important when introducing new cultivars in production.

The aim of this investigation was to find out the optimal norms of nitrogen fertilization and sowing for the best productivity of the recently released dry bean cultivar Blyan under the conditions of a specific agro-ecological region.

Material and methods

During 2016 – 2018 in the trial field of Dobrudzha Agricultural Institute (DAI) a field experiment was carried out with the new dry bean cultivar Blyan under the conditions of slightly leached chernozem soil. It belongs to the group of early cultivars: 90±3 day to full maturity. The seeds are white, medium-large, with 1000 seed weight 330 ± 20 g. The stem is erect and non-lodging (habit type II[a], Genchev et al., 1993).

The production potential of the new cultivar was tested against the background of five sowing norms: 20, 27, 34, 41 and 48 g.s. / m^2 and nitrogen fertilization with the following norms: N_0, $N_{40}P_{80}$, $N_{80}P_{80}$, $N_{120}P_{80}$ in kg/ha active substance.

The nitrogen fertilizer used was NH_4NO_3, with single application at the last pre-sowing cultivation of soil. The phosphorus fertilization was done with triple super phosphate with the main soil tillage. The trial was designed according to the split plot method, with four replications of each variant.

Sowing was done with a plot seeder at the end of April – beginning of May, within the optimal sowing dates for this crop in this agro-ecological region. Sowing was performed in narrow rows, with 35 cm inter-spacing. The previous crop was wheat treated with a low nitrogen norm. Harvesting was done during the last decade of July. It was direct (one-staged) harvesting with micro-combine.

The soil in the trial field was slightly leached chernozem with low content of humus in the plow layer (3.33 % according to Tyurin), low acid reaction (pH_{KCl} - 5.48), low reserves of mineral nitrogen (15.8 mg/1000 g) and mobile phosphorus forms (5.40 mg/100 g), and good reserves of potassium (24 mg/100 g, according to Ivanov, 1984). The natural population of *Rhizobium* bacteria in the soil of the trial field was good (Milev, 1996).

Agro meteorological conditions during the growing season

Depending on the requirement of the bean to the main meteorological elements - rainfall and air temperature, the first year of the experiment can be considered the most favorable for its development (Table 1). The amount of 196.4 mm of vegetation rainfall fully covered the physiological needs for growth and culture development. Autumn-winter rainfall of 315.3 mm was also above the average.

Table 1. Vegetation rainfalls, mm

Month	Years			Averaged for 3 years	Averaged for 50 years
	2016	2017	2018		
IV	20.8	38.4	4.9	21.3	48.3
V	117.1	16.7	30.9	54.9	49.6
VI	55.7	87.7	90.8	78.0	64.0
VII	2.8	66.3	59.6	42.9	51.8
Amount IV-VII	196.4	209.1	186.2	197.2	213.7
Autumn-and-winter rainfalls, X-III	315.3	252.8	340.0	302.7	231.2

The total amount of vegetation rainfall in the second year was 209.1 mm, and it was enough, but their distribution by phases of development was not appropriate. Under these conditions, the mass of the vegetative part retreated to that of 2016, respectively, and a lower yield was formed.

The vegetation of bean in 2018 took place under conditions insufficient in the early stages of development rainfalls (April and May) and sufficient precipitation, during the flowering-pouring phase of the grain. Insufficient rainfall during the above-mentioned first subperiod led to a fall in height in the height of the bush. The lowest grain yield is formed over the previous two years.

In temperature terms, bean vegetation was carried out in temperatures typical of individual months without the presence of extremely high values (over 32^{o}C) for an extended period of time (over 3-4 days).

Results and discussion

The mean grain yield during the first year of the experiment, the year with the best conditions for bean growth and development, was high (2796 kg/ha) regardless of the tested variants. During the second year the yield remained medium (2677 kg/ha). The yield during the third year was lowest (2290 kg/ha). The main reason for the low yield in this year were the high air temperatures and soil drought. They occurred together with low air humidity for long periods of time thus causing significant yield decrease due to abortion of flowers and young pods. The significance of the effect of the meteorological factor on yield is demonstrated in Table 3. The dispersion analysis of yield showed variations of high significance of its value over years.

The expression of the factors investigated in this trial averaged for three yiears are shown in Figure 1 and 2. On the whole, the higher sowing norm increased yield; in two of the years yield maximum was realized at norm 41 g.s./m^2, and in the third year of the experiment (2018) the maximum was realized at the highest sowing norm, 48 g.s./m^2.

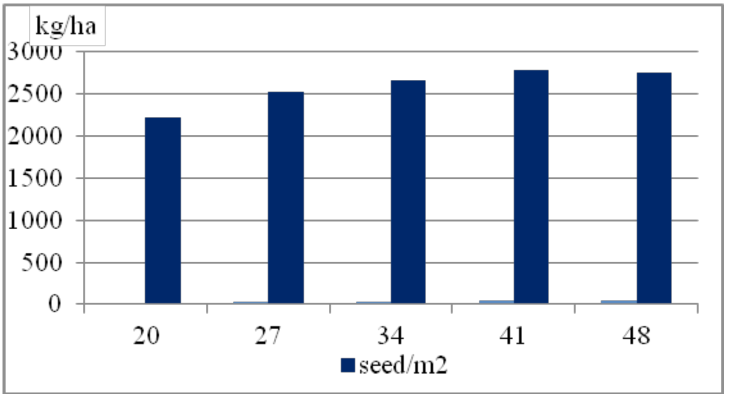

Figure 1. Dry bean grain yield depending on sowing norm, averaged for 3 years, kg/ha

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The same tendency of yield variation was registered for the effect of nitrogen fertilization as well. The size of yield increased proportionally to the increase of the applied nitrogen to norm $N_{80}P_{80}$. This result confirmed the fact that soil humidity plays a decisive role for the uptake of fertilizer nitrogen.

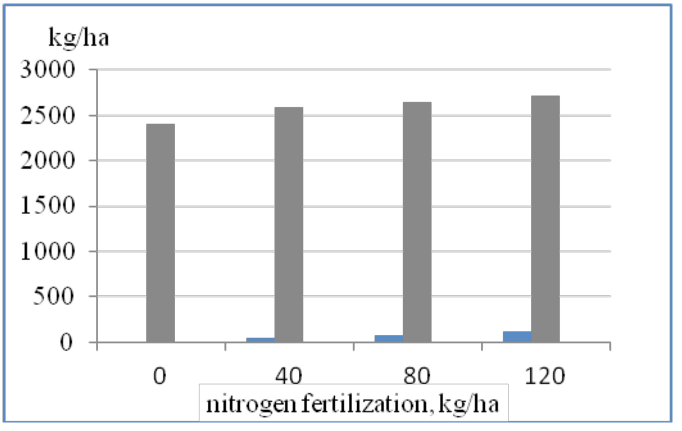

Figure 2. Dry bean grain yield depending on nitrogen fertilization, averaged for 3 years, kg/ha

Table 3. Dispersion analysis of grain yield and weight of 1000 seeds

Factors	Yield, kg/ha	±D, kg/ha	Weight of 1000 seeds	±D, g
A. Sowing norm, seeds/m^2				
20 – check	2224	-	351.8	-
27	2523	+299*	345.5	-6.3*
34	2655	+431*	339.0	-12.8**
41	2783	+559**	338.9	-12,9**
48	2756	+532**	334.3	-17.5**
B. Fertilization norm, kg/ha				
N_0P_0 – check	2406	-	339.3	-
$N_{40}P_{80}$	2582	+176*	338.9	-0.4^{NS}
$N_{80}P_{80}$	2638	+232**	342.9	+3.6^{NS}
$N_{120}P_{60}$	2711	+305***	346.6	+7.6*
C. Years				
2016-check	2796	-	324.6	-
2017	2677	- 119^{NS}	314.2	-10.4*
2018	2290	- 506**	386.9	+62.3 ***

*,**,*** *Significance at p= 5%, 1% and 0.1%; NS – not significant*

Table 2. Weight of 1000 seeds averaged for 3 years, g

Efect of sowing norm, grains/m²	g	Efect of nitrogen norm, kg/ha	g
20	351.8	N_0P_0	339.3
27	345.5*	$N_{40}P_{80}$	338.9^{NS}
34	339.0**	$N_{80}P_{80}$	342.9^{NS}
41	338.9**	$N_{120}P_{80}$	346.6*
48	334.3***	-	-

*,**,*** *Significance at p= 5%, 1% and 0.1%; NS – not significant*

The grain yield, averaged for the three-year period of the investigation, is shown on table 3. Highest yield was obtained at sowing density 41 g.s. / m^2 and fertilization with $N_{120}P_{80}$ per ha. The graphic representation reveals the insignificantly higher effect of the sowing norm in comparison to the effect of nitrogen fertilization.

In two of the investigated years, 1000 seed weight was practically the same: 324.7 g and 314.2 g in 2016 and 2017, respectively. During the third year least favorable for bean, this index was highest: 386.9 g. The factor "year conditions" (i.e. the abiotic factor) had highest relative significance (Table 3). The other two factors, fertilization and sowing norm, had lower influence on this index.

It is clear from table 3, which shows the averaged data for the 3-year period of investigation, that nitrogen fertilization had positive effect on 1000 seed weight, while the increase in the sowing rate has a negative effect on that index.

Conclusions

The results from this investigation allow formulation the following important conclusions:

With regard to yield, the sowing norm of 41 g.s./m^2 was most efficient for growing of cultivar Blyan. The further increase of the sowing norm had negative effect. Nitrogen fertilization increased seed yield. The rate of increase being highest with the lowest nitrogen norm, $N_{40}P_{80}$. The subsequent increase of the nitrogen norm was not accompanied with the same rate of yield increase.

Thousand seed weight reached a maximum as early as the first sowing norm (20 g.s. / m^2) and fertilization with N_{120} $P_{80.}$

The conditions of the respective year had strongest effect on two investigated indices. Highest yield was obtained during the first year of the investigation (2018), i.e. the year with optimal conditions for expression of the biological potential of cultivar Blyan. However, the weight of 1000 seeds is highest during the worst year (2018), i.e. dependence is inversely proportional to yield.

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