DRY MATTER ACCUMULATION IN GENOTYPES OF BEAN SUBMITTED TO DIFFERENT LEVELS OF NITROGEN

Acúmulo de massa seca em genótipos de feijoeiro submetidos a diferentes níveis de nitrogênio

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ABSTRACT

The objective of this study was to verify the response of dry matter accumulation in bean lines (*Phaseolus vulgaris* L.) to different levels of nitrogen fertilizers. Six genotypes ('BRSMG Majestoso', 'Pérola', MA-I-18.13, 'Ouro Negro', 'BRSMG Talismã', and MA-I-2.5) were evaluated in Lavras, testing three N levels (0, 60, and 120 kg/ha) and using ammonium sulphate as N source. The experimental design adopted was the randomized block design in a 6 x 3 factorial structure with three replications and the plots were composed of five 5-m rows. The seeds were sown in November 2005 and July 2006. Total dry mass of five competitive plants was evaluated after 35 days from sowing, harvested from a pre-determined place in the useful area of the plots. This process was repeated every ten days until the harvest. The grain yield was also evaluated in one of the rows of the useful area of the plots. It was observed that regarding the dry mass accumulation, the genotypes did not present different responses at the N levels and the average increase per kg/ha applied N was 6.75 kg/ha grains. The genotype BRSMG Majestoso is the most responsive, with 14.4 kg/ha grains per kg applied N whereas the most tolerant is the MA-I-2.5 with1.8 kg/ha grains per kg N.

Index terms: Nitrogen fertilizer, phenology, differential response, *Phaseolus vulgaris*.

RESUMO

Neste trabalho, objetivou-se verificar como ocorre o acúmulo de massa seca em linhagens de feijoeiro (*Phaseolus vulgaris* L.) diferindo na resposta ao fertilizante nitrogenado. Para isso, seis genótipos ('BRSMG Majestoso', 'Pérola', MA-I-18.13, 'Ouro Negro', 'BRSMG Talismã', MA-I-2.5) foram avaliados em Lavras, na presença de três níveis de N (0, 60 e 120 kg/ha), tendo como fonte de N o Sulfato de Amônio. O delineamento experimental foi o de blocos casualizados no esquema fatorial 6 x 3 com três repetições e as parcelas constituídas de cinco linhas de cinco metros. A semeadura foi realizada em novembro de 2005 e julho de 2006. Obteve-se, a partir de 35 dias após a semeadura, a massa seca total de cinco plantas competitivas, colhidas em local pré-determinado na área útil das parcelas. O processo repetiu-se a intervalos de 10 dias até à colheita. Avaliou-se também a produtividade de grãos em uma das linhas da área útil das parcelas. Constatou-se que no acúmulo de massa seca os genótipos não diferem na resposta aos níveis de N e o incremento médio por kg/ha de N aplicado é de 6,75 kg/ha de grãos. O genótipo BRSMG Majestoso é o mais responsivo, com 14,4 kg/ha de grãos por kg de N aplicado, e o mais tolerante é o MA-I-2.5 com 1,8 kg/ha de grãos por kg de N.

Termos para indexação: Fertilizante nitrogenado, fenologia, resposta diferencial, *Phaseolus vulgaris*.

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INTRODUCTION

Nitrogen is one of the most important elements in plant growth and development, consequently presenting direct reflection on the grain yield. In the case of bean (*Phaseolus vulgaris* L.) culture, the use of nitrogen fertilizers largely varies amongst the producers. It is practically not used by small producers and, in the other hand, the large-scale producers that employ the irrigated cultivation use it in large doses.

Response of beans to nitrogen is frequently observed (ALVES, 2002; ROSOLEM, 1996; VIEIRA, 1998). However, there are reports of several attempts of supplying the necessities of this nutrient through biological fixation (ALVES, 2002; SILVA, 2002). In general, these studies evidence that the biological fixation of nitrogen via bacteria is not sufficient to attend the total demand with the crop management currently in use.

There are several systems of bean cultivation in Brazil (SENA et al., 2008). Small producers do not use N or

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use only in small doses. The choice cultivars for these producers should be the plants resistant to the low availability of this nutrient. On the extreme opposite end are the large-scale producers who use high N levels. In this case, the cultivars should be responsive to the nutrient in order to propitiate return to the investment employed. The question is if there are cultivars out there that fit this conditions.

The differential response of lines and/or hybrids to nitrogen is frequently reported in the literature for wheat (LE GOUIS et al., 2000), rice (BORRELL et al., 1998), and corn (BERTIN & GALLAIS, 2000). Hirel et al. (2007) present ample review on differential response to N and discuss the effort that had been made in the attempt to identify genes associated to a higher efficiency in the N use.

Some few works have been carried out in Brazil, showing that the bean lines present different response to the N applied (GUAZZELLI, 1988). In one of these works, Furtini et al. (2006) evaluated 100 lines in the presence and absence of N and observed that the lines differ in their response to N. However, there is no information regarding the strategy that the bean lines adopted in their divergent responses. It would be important to promote a growth analysis to verify how they respond or not the N applied. This procedure was used by Vieira et al. (2008) to assess cultivars of beans under no-tillage and conventional crop systems.

This work was conducted with the objective of verifying how the shoot dry matter is accumulated in lines that differ in the response to different N levels in the productivity of grains.

MATERIALAND METHODS

The experiments were carried out at the Biology Department, Universidade Federal de Lavras (UFLA) in two seasons: sowing in November 2005 and July 2006. Lavras is located in the south of Minas Gerais, at 21º 14'43''S, 44º 59'59''W and average altitude of 918 m. The main chemical characteristics of the soil where the experiments were conducted are presented on Table 1.

Six genotypes were evaluated, four of them being already recommended cultivars. Nevertheless, they are all going to be called genotype, indistinctively. These genotypes were chosen as a function of previous experiments, which evidenced the differential response to the N applied (FURTINI et al., 2006). Among them, 'BRSMG Majestoso', 'Pérola', and MA-I-18.13 were considered responsive, while 'Ouro Negro', 'BRSMG Talismã', and MA-I-2.5 were considered tolerant to the N applied.

These six genotypes were tested for three N levels: 0, 60, and 120 kg/ha N. The experimental design applied was the randomized blocks, in the 6 x 3 factorial structure with three replications. The plots were composed of five rows of 5 m. The spacing between the rows was 50 cm and the density was of 15 seeds/m.

Table 1 – Chemical analyses of the soils sampled at the depth of 0-20 cm in the experimental areas in Lavras, before the installation of the experiments[1].

Chemical analysis	rainy season 2005/2006	winter 2006
pH of H_2O	5.0	5.9
P (mg dm^{-3})	68.1	10.0
K (mg dm^{-3})	108	103
Ca^{2+}($cmol_c$ dm^{-3})	1.1	2.5
Mg^{2+}($cmol_c$ dm^{-3})	0.4	0.8
Al^{3+}($cmol_c$ dm^{-3})	0.5	0.0
H+Al ($cmol_c$ dm^{-3})	5.0	3.2
SB ($cmol_c$ dm^{-3})	1.8	3.6
t ($cmol_c$ dm^{-3})	2.3	3.6
T ($cmol_c$ dm^{-3})	6.8	6.8
V (%)	26.3	52.7
m (%)	22	0
OM (dag kg^{-1})	2.7	2.7
P-rem (mg L^{-1})	8.5	14.7

[1]Analyses performed at the Soil Analysis Laboratory, Soil Science Department, UFLA. SB: sum of bases; t: effective CTC; T: potential CTC; V: base saturation; m: aluminum saturation; OM: organic matter; P-rem: remaining P.

The equivalent of 300 kg/ha of the formula N, P_2O_5, and K_2O (00-20-20) was used on all of the plots at sowing. In the treatments with doses of 60 and 120 kg/ha N, 1/3 of these doses were applied at sowing and 2/3 in cover, 20 days after sowing (DAS). The N source was the ammonium sulphate.

Direct sowing system was applied for all of the crop production. The area was submitted to desiccation using glyphosate, around 15 days before the sowing. The culture in the winter crop was submitted to spray irrigation whenever necessary. The weeds were controlled through application of a mixture of fomesafen and fluazifop-p-butyl at post-emergence.

Characters that were evaluated:

- Dry matter at different ages: the first sample was taken at 35 days after the sowing (DAS). This process was repeated every ten days up to the harvest. A sample was taken from a pre-determined spot in the useful area of the plot (five competitive plants per sample). The sample was dried in a forced air circulation oven at the temperature of 65 to 70 ºC for 72 hours.
- Weight of 100 grains: 100 grains were weighed (in g) after the harvest.
- Number of pods: the number of pods was counted on five plants from the last sampling period for the dry matter.
- Grain yield: The grain yield was obtained from the harvest of one of the rows in the useful area of the plots (g/plots) and expressed in kg/ha.
- Harvest index: the harvest index was also estimated from the relation between the pod dry matter and total dry matter.

Analysis of variance of the total dry matter was performed considering the different periods of sampling as well as the analysis of variance of the grain yield, square root of the number of pods from five plants, harvest index, and weight of 100 grains using the methodology presented by Ramalho et al. (2005).

RESULTS AND DISCUSSION

In the joint analyses of variance, the sources of variation (N levels, genotypes, and harvests) were significant for all of the characters, except the genotypes for the number of pods and N levels for the weight of 100 grains. However, the majority of the interactions of these sources of variation were not significant, especially the interaction between levels and genotypes, for all characters. It was observed that the behavior of the genotypes was similar in the different harvests and levels, especially for the grain yield (Table 2). With this information in hand, the majority of the discussions will emphasize the average performance of the genotypes, levels or harvests.

It was observed that the grain yield, pod number and weight of 100 grains from the harvest sowed in July were higher (Table 3). As for the harvest index in this season, the estimate obtained was the lowest. Although the experiments were implemented in areas very close to each other, the soils used have different fertility levels (Table 1). It is important to mention, nevertheless, that probably the highest averages obtained in this period were also attributed to climate conditions, especially temperature and relative humidity. There was no water deficiency because the culture was irrigated and the lower temperature

Table 2 – Summary of the joint analysis of variance involving two seasons for the grain yield (GY) (Kg/ha), harvest index (HI), square root of the pod number (PN), and weight of 100 grains (W100).

SV	DF	MS							
		GY	P<F	HI($x10^3$)	P<F	PN	P<F	W100	P<F
Blocks/season	4	420723.63	0.3001	6.11574	0.0058	2.32535689	0.2691	1.2672824	0.4503
Genotypes (G)	5	845535.18	0.0386	32.90093	<0.0001	2.18455132	0.2976	11.008835	<0.0001
Levels (L)	2	5906120.08	<0.0001	11.6287	0.0011	6.99531297	0.023	0.869475	0.5304
Seasons (S)	1	17029712.93	<0.0001	221.40833	<0.0001	29.21519974	0.0001	716.3650231	<0.0001
G x L	10	53266.29	0.1624	2.,78093	0.0746	2.80793011	0.125	1.1404317	0.5928
G x S	5	659534.33	0.097	3.71278	0.0443	0.88785436	0.7705	10.4942898	<0.0001
L x S	2	601100.18	0.1765	7.13611	0.0128	1.8689162	0.3501	3.6290565	0.0764
G x L x S	10	358538.61	0.4039	2.23056	0.176	0.73585676	0.9324	2.1011865	0.1422
Error	68	337841.18		1.53339		1.7534534		1.3585657	
Mean		3020		0.641		7.517		23.21	
CV%		19.24		6.11		17.62		5.02	
R^2 %		0.68		0.83		0.47		0.90	

at the blooming time, especially at night, promoted better conditions for a higher flower production. The low humidity decreases the probability of pathogen occurrence, such as *Colletotrichum lindemuthianum* and *Pseudocercospora griseola (Sacc.)*, which reduce the productivity when present. These factors, associated, promote conditions for a higher grain yield in the culture of beans when they are sown in July. This fact is frequently observed in experiments with the bean culture in the region (GONÇALVES et al., 2001).

As expected, higher grain yield, pod number, and total dry matter were obtained with the increase in the N level (Table 4). For grain yield, the increase was 16% when 60 kg/ha N was used and 31% with 120 kg/ha N, in relation to the absence of this nutrient in the sowing fertilization and top dressing. An average increase of 6.75 kg/ha grains was observed per kg/ha N used. Consequently, the use of this fertilizer would not be economically viable, independent of the season, if the price of one kg N would exceed 6.75 times the grain price, disregarding the cost of the fertilizer application in top dressing. For the remaining characters, the effect of N levels was not expressive (Table 4).

The genotypes Ouro Negro and MA-I-18.13 presented higher average grain yield (Table 5). 'Ouro Negro' confirmed the good performance already observed in previous experiments conducted in the region (BORGES et al., 2000; NUNES et al., 2005). MA-I-18.13 is a new genotype, resulted from a recurrent selection program, aiming at the resistance to *Pseudocercospora griseola (Sacc.)*. It is possible that its higher resistance to this pathogen had contributed to a higher grain yield. The remaining genotypes evaluated occupied the same group in the Scott & Knott (1974) test.

The highest harvest index, i.e, the dry matter of the pods divided by the total dry matter, was observed in the genotypes MA-I-18.13 and 'BRSMG Talismã', indicating that they were more efficient than the others in transforming the photo assimilates into pods.

Table 3 – Means of the harvests from the sowing in November 2005 and July 2006 for grain yield (GY), harvest index (HI), square root of pod number (PN), weight of 100 grains (W100), and dry matter (DM).

Sowing Seasons	PN	W100 (g)	DM (g/5plants)	GY (kg/ha)	HI
November 2005	6.99 (100)	20.63 (100)	76.18 (100)	2623 (100)	0.686 (100)
July 2006	8.04 (115)	25.78 (125)	80.39 (106)	3417 (130)	0.595 (87)

Table 4 – Means of the three N levels (kg/ha) obtained for the harvests from the sowing in November 2005 and July 2006 for the grain yield (GY), harvest index (HI), square root of the pod number (PN), weight of 100 grains (W100), and dry matter.

N levels	PN	W 100	Dry matter (g/5plants)	GY (kg/ha)	HI
0	7.17 (100)	23.31 (100)	65.61 (100)	2612 (100)	0.653 (100)
60	7.37 (103)	23.03 (99)	76.75 (117)	3027 (116)	0.649 (99)
120	8.01 (112)	23.29 (100)	92.5 (141)	3421 (131)	0.62 (95)

Table 5 – Means of the genotypes obtained from the joint analyses of the harvests from sowing in November 2005 and July 2006 for grain yield (GY) (kg/ha), harvest index (HI), square root of the pod number (PN), and weight of 100 grains.

Lines	PN	Weight 100 grains (g)	GY (kg/ha)	HI
Majestoso	7.52 a	22.62 c	2947 b	0.64 b
Pérola	7.06 a	23.09 c	2790 b	0.61 c
MA-I-18.13	7.95 a	23.63 b	3190 a	0.69 a
Ouro Negro	7.28 a	23.39 b	3366 a	0.65 b
Talismã	7.40 a	22.14 c	2969 b	0.68 a
MA-I-2.5	7.89 a	24.37 a	2861 b	0.58 d

[1/] Means followed by the same letter belong to the same group by Scott & Knott (1974) test at 5% probability.

Even though the interaction between the genotypes and the N levels was not significant, a response regression equation fitted to the N levels per genotype was estimated (Table 6). The adjustment of the regression equation (R^2) was high for all of the genotypes, except MA-I-2.5. It was verified in other instances, that this genotype does not respond to the N levels (FURTINI et al., 2006). The response to the N levels in the grain yield varied from b_1 = 1.8 kg/ha in the genotype MA-I-2.5 to b_1 = 14.4 kg/ha in the genotype 'BRSMG Majestoso'.

The average behavior of the three genotypes, previously identified by Furtini et al. (2006) as tolerant or responsive, deserves mentioning. Note that the genotypes considered responsive presented herein an increase of 9.6 kg/ha grains per kg/ha N, whereas for the tolerant, this value was 3.9 kg/ha, or a decrease of 59% in the response to the fertilizer.

In this work, the objective was to verify the occurrence of differences among the genotypes regarding the responses to N levels in the accumulation of total dry matter. The sources of variation in the analyses of variance of the dry matter (N levels and seasons) were significant (P<0.01) in both sowing periods (Table 7).

The sources of variation genotypes and the interaction genotypes x levels were not significant, evidencing that the accumulation of shoot dry matter was similar and that the responses to N levels were coincident.

Table 6 – Mean of grains yield (kg/ha) in the three N levels and estimates of regression coefficients obtained by joint analysis of the harvests from sowing in November 2005 and July 2006.

	N levels (kg/ha)					
Lines	0	60	120	b_0	b_1	R^2
Majestoso	2148 (100)	2822 (131)	3870 (180)	2085	14.4	0.98
Pérola	2299 (100)	2900 (126)	3172 (138)	2354	7.3	0.95
MA-I-18.13	2828 (100)	3058 (108)	3686 (130)	2761	7.2	0.93
Ouro Negro	3089 (100)	3496 (113)	3513 (114)	3154	3.5	0.78
Talismã	2645 (100)	2845 (108)	3416 (129)	2583	6.4	0.93
MA-I-2.5	2664 (100)	3043 (114)	2875 (108)	2755	1.8	0.31
Responsive	2425 (100)	2927 (121)	3576 (147)	2400	9.6	0.99
Tolerant	2799 (100)	3128 (112)	3268 (117)	2831	3.9	0.95

Table 7 – Summary of the analyses of variance of total dry matter obtained from the evaluation of bean lines under different N levels and period of evaluation in the harvests from sowing in November 2005 and July 2006.

	Sowing season November 2005			Sowing season July 2006		
SV	GL	QM	P<F	GL	QM	P<F
Blocks	2	74.7226	0.8522	2	836.7409	0.5503
Genotypes (G)	5	1413.0418	0.3637	5	2530.30377	0.3172
Levels (L)	2	6766.9784	0.0091	2	42861.0651	<0.0001
G x L	10	2423.5383	0.0739	10	816.51681	0.9391
Error a	34	1251.0086		34	2059.4517	
Periods (P)	4	62059.279	<0.0001	6	142890.237	<0.0001
Error b	8	457.8789		12	1332.5039	
G x P	20	599.9372	0.5386	30	1992.3164	0.0007
L x P	8	312.0589	0.8625	12	2240.336	0.0047
G x L x P	40	657.6167	0.4353	60	855.8543	0.583
Error c	136	638.3961		204	901.302	

In order to facilitate the visualization, the data were plotted on a graphic considering only the genotypes of higher (‘BRSMG Majestoso’) and lower (MA-I-2.5) response for the N levels, in terms of grain yield (Figure 1). As expected, there was accumulation of dry matter in both genotypes, with an increase of N levels. No trend of behavior change was observed in both genotypes in the accumulation of dry matter throughout the experiment. The same observation is valid for the effect of the harvests, except in the sowing performed in July, especially for the genotype MA-I-2.5, which means that the accumulation of dry matter was of higher magnitude and crescent until the last harvest period. It is necessary to emphasize that in this harvest, because of the lower temperatures, especially after the sowing, the vegetative cycle tends to be prolonged (ABREU et al., 2005; GONÇALVES et al., 2001). It might be that this is the main reason for this behavior. It is also probable that this was the reason why the harvest index was low in this harvest (Table 3). Everything points out to the conclusion that the responsive or tolerant genotypes use the same strategy in terms of accumulation of dry matter, regarding the response to fertilization with increasing N levels.

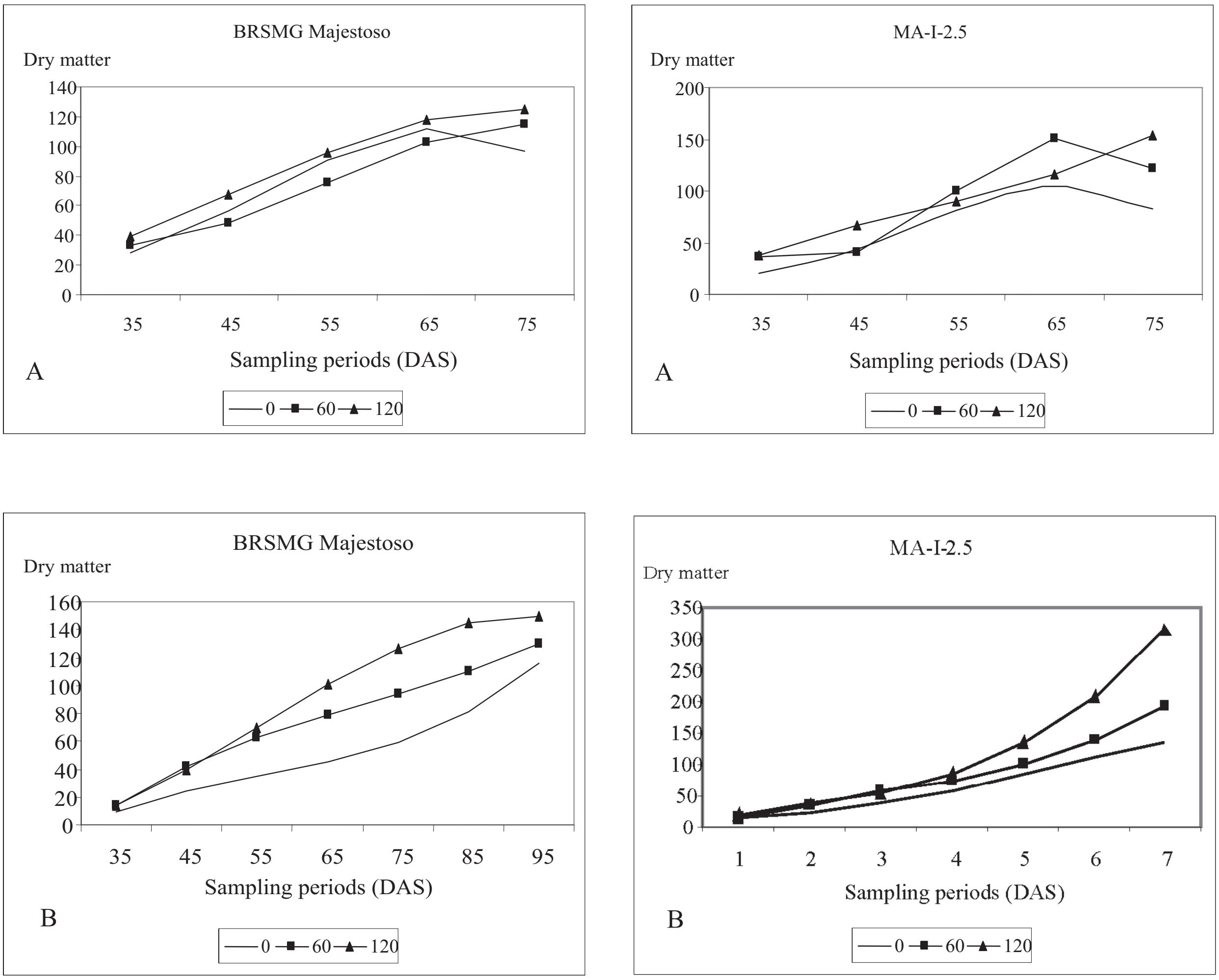

Figure 1 – Regression equations of total dry matter (g/5 plants) of the genotypes BRSMG Majestoso and MA-I-2.5 as a function of the sampling periods in the three N levels (0, 60, and 120 kg/ha) in the harvests from sowing in November 2005 (A) and July 2006 (B).

CONCLUSIONS

The genotypes did not differ in the response to N levels regarding the accumulation of dry matter.

The average increase per kg/ha N is 6.75 kg/ha grains. The genotype BRSMG Majestoso is the most responsive, with 14.4 kg/ha grains per kg N and the most tolerant is the MA-I-2.5 with 1.8 kg/ha grains per kg N.

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