DISTRIBUTION OF ASSIMILATES IN CULTIVARS BEAN POD IRRIGATION

J. B. de A. França[1], F. A. L. Soares[2], M. do C. Vieira[3], P. R. de Oliveira[4], N. Peixoto[5], M. B. Teixeira[6]

ABSTRACT: The objective of this study was to evaluate the effect of different water replenishments on the distribution of photoassimilates in plant parts and on the production of Contender and Napoli pod bean cultivars. The study was conducted at the State University of Goiás, Campus Ipameri. The beans were sown in may 2015, and the experimental design was randomized blocks analyzed in a sub - divided plots scheme 5 x 2 x 4. The plots were constituted of the irrigation levels determined by the water replenishment (RH) corresponding to 25; 50; 75; 100 and 125% of the evaporation of the Pichet evaporimeter, the subplots the cultivars Napoli and Contender and the subsubparcelas the vegetative parts of the plant (stem, leaf, root and pod). The fresh and dry masses of the individual parts of the plants (root, stem, leaf, pod and seed) were determined, the production of photoassimilates translocated to the vegetative parts and the water content in the seeds. The partition of photoassimilates of the cultivars behaved in different ways as the water replenishment. The water replacement of 50% presented greater gain in the increment in the production for the cultivar Napoli.

KEYWORDS: *Phaseolus vulgaris*, water content, mass accumulation.

DISTRIBUIÇÃO DE FOTOASSIMILADOS EM CULTIVARES DE FEIJÃO VAGEM IRRIGADO

RESUMO: O objetivo desse estudo foi avaliar o efeito de diferentes reposições hídricas na distribuição de fotoassimilados nas partes das plantas e na produção de cultivares de feijão-vagem Contender e Napoli. O estudo foi conduzido na Universidade Estadual de Goiás, Campus Ipameri. Os feijões foram semeados em maio de 2015, sendo adotado o delineamento experimental de blocos casualizados analisados em esquema de parcelas subsubdivididas 5 x 2

[1] Doctor student in Agronomy, Laboratory of Hydraulics and Irrigation, IF Goiano, Rio Verde Campus - Goiás and State University of Goiás, Câmps Ipameri- Goiás. Phone (064) 98133-3378. Email: janainaborgesdeazevedofranca@gmail.com.
[2] Doctor, Laboratory of Hydraulics and Irrigation, IF Goiano, Rio Verde Camps - Goiás.
[3] Doctor, IF Goiano Biotechnology Laboratory, Urutaí - Goiás Camps.
[4] PhD, Department of Soils and Fertilizers, UNESP - Jaboticabal.
[5] Doctor, State University of Goiás, Câmps Ipameri - Goiás.
[6] PhD, Laboratory of Hydraulics and Irrigation, IFGoiano, Rio Verde Camps - Goiás.

x 4. As parcelas foram constituídas dos níveis de irrigação determinadas pela reposição hídrica (RH) correspondente a 25; 50; 75; 100 e 125% da evaporação do evaporímetro de Pichet, as subparcelas as cultivares Napoli e Contender e as subsubparcelas as partes vegetativas da planta (caule, folha, raiz e vagem). Determinaram-se as massas frescas e secas das partes individuais das plantas (raiz, caule, folha, vagem e semente), a produção de fotoassimilados translocados para as partes vegetativas e o teor de água nas sementes. A partição de fotoassimilados das cultivares comportaram-se de maneiras diferentes quanto a reposição hídrica. A reposição hídrica de 50% apresentou maior ganho no incremento na produção para a cultivar Napoli.

PALAVRAS-CHAVE: *Phaseolus vulgaris*, teor de água, acúmulo de massa.

INTRODUCTION

Phaseolus vulgaris is an herbaceous plant belonging to the legume family, being essentially cultivated in family agriculture (FILGUEIRA, 2008). In terms of importance is the thirteenth vegetable and the sixth in volume produced in the country (PEIXOTO et al., 2001).

Native to Central America, this species is widely distributed in tropical, subtropical and temperate regions (FREYTAY & DEBOUCK, 2002).

The availability of water in the soil is a limiting factor for the production of bean pods, because the plants have little tolerance to water stress during the critical stages of development: germination, flowering and grain filling (SORATTO ET AL., 2003).

The rational management of irrigation consists in the application of water to the plants at the right time and in the necessary quantities. Often the producer irrigates in excess, fearing that the crop undergoes water stress, which can favor the appearance of diseases, cause water and energy wastage and consequently compromise the production (LIMA et al., 2006). The adoption of rational techniques of soil and water conservation is of great importance for sustainability, so that these resources can be economically maintained over time, with sufficient quantity and quality to maintain satisfactory levels of productivity (WUTKE et al., 2000).

The participation of photoassimilates is defined by the distribution of the products of photosynthesis by the various organs of the plant, this process determines the growth model of the plant. The distribution of photoassimilates occurs as a function of vascular connections, types of translocation pathways, proximity between organs, stages of development of draining organs and sources (TAIZ & ZEIGER, 2004).

In a study carried out on 30 genotypes by Vaz (2014) the Contender cultivar presented characteristics to be used as pod beans in Brazil: long, thick pod, high number of pods per plant, high seed yield and commercial pods. On the other hand, the Napoli cultivar has a determined growth habit, cylindrical pod and excellent quality and productivity.

Other authors also address the need and importance of studies such as the evaluation of the influence of water replenishment application on common bean, as well as those of genetic and environmental factors, which may be acting in the architecture and morphogenesis of the plant and, consequently, in its flowering and production (LEITE et al., 2015, MORAES et al., 2015). The objective of this study was to evaluate the effect of different water replenishments on the distribution of photoassimilates in plant parts, as well as the influence of these replenishments on the production of Contender and Napoli bean cultivars.

MATERIAL AND METHODS

The experiment was carried out at the State University of Goiás, at Câmpus Ipameri (geographical coordinates of 17º71'82 " south latitude and 48º14'35 " west longitude). The altitude in the area is 800 m and the climate of the region according to the Köppen classification is defined as Tropical Humid (AW), with high temperatures with rainfall in summer and dryness in winter. The soil of the experimental area is classified as Dystrophic Red - Yellow Latosol (EMBRAPA, 2006).

A randomized complete block design was used, with treatments distributed in a sub-divided plots scheme 5 x 2 x 4, with 3 replicates. The plots were constituted of the irrigation levels determined by the water replenishment (RH) corresponding to 25; 50; 75; 100 and 125% of the reference evaporation of the pichet evaporimeter method, the Napoli and Contender cultivars were evaluated in the subplots and the vegetative parts of the plant (stem, leaf, root and pod) were sub-subtracted. The soil was conventionally prepared (a plowing and two harrowing), based on the soil analysis, the application of 779 kg ha^{-1} of dolomitic limestone with 92% PRNT was performed in order to raise the base saturation of the 0-20 cm layer to 60% and 20 kg ha^{-1} of N; 100 kg ha^{-1} of P_20_5; 60 kg ha^{-1} K_20 of the formulation 5.25.15. A further 69 kg ha^{-1} of N was applied as a source of urea.

Seeding was carried out in May, with row spacing of 0.40 m and each cultivar with 5 plant lines, the area planted to each cultivar corresponding to 10 m^2, the area of each block with 75 m^2 and the total area of the experiment with 300 m^2. In this way the experiment consisted of five rows of five meters with the plants, where the two extreme rows were border, as well as, half a meter from each end of the plot, the central row was used to evaluate the production variables and the other two intermediates Were used to evaluate biometric characteristics and destructive analyzes.

The need for irrigation application was recommended from the pichet evaporimeter (Mendonça & Rassini, 2006) and culture coefficient (KC) (Oliveira, 2013). At the time of pod production and seed production, samples were collected and 10 randomly selected plants were harvested in each season. The plants were cut and separated in their parts (stem, leaves, root and pod) and weighed in a precision digital scale, to obtain the mass of the total fresh matter; (1 bag per part of the plant) duly identified to be dried in a forced ventilation oven at 65°C until constant weight to obtain the mass of the dry matter.

To obtain the partition of photoassimilates, the percentage of dry matter of each part was determined in each evaluation period using the equation (1):

$$PFT = MSO / MST \times 100 \qquad (1)$$

In what,

PFT = percentage of photoassimilates translocated; MSO = dry matter of the organ and MST = total plant dry matter).

The water content in the vegetative parts was determined according to the equation (2):

$$TA = (MFO - MSO) / MFO \times 100 \qquad (2)$$

In where,

TA = water content in the organ, MFO = fresh organ matter, MSO = organ dry matter).

The data were submitted to analysis of variance and when the F test was significant the Tukey's test was applied to 5% probability for the cultivar and vegetative factors, in addition, a regression analysis was performed for the water replenishment factor.

RESULTS AND DISCUSSION

It was observed a significant difference for the water replacer interaction (RH) x cultivars (C) x vegetative part (PV), for fresh matter and dry matter in the pod and seed production phase. In this sense, the data of the present study, corroborate the affirmation of Santana et al. (2009) that irrigation is a procedure that improves crop productivity in order to meet the water demand during its cycle. In the Napoli x Saule combination, a decrease in fresh matter (MF) up to 85%

water replenishment was observed, while the stem of the cultivar plants had an MF of 24.49g, of which 25.73 % lower than the fresh matter of the plants irrigated with the highest water replenishment.

Analyzing the same unfolding with the Napoli x Leaf combination, it was verified, according to the regression equation ($Y = 64,8347 – 0,9047^{**}X + 0,0050^{**}X^2$), that the lowest fresh matter of the leaves was obtained with a water replacement of 90%, presenting a fresh matter of 23.9g, 19.95 % lower than the fresh matter of the plants that received 125% of water replenishment.

In this sense it would be interesting to maintain a higher water content, so that there is no loss of fresh matter and consequent less accumulation of photoassimilates, resulting in decreased production.

At the time of production, a significant effect was observed between the water replenishments for the fresh matter variables of the Contender pods and for the MF of the stem of the Napoli cultivar. According to the regression equation ($Y = - 14,250 + 1,1659^{**}X – 0,0068^{**}X^2$), there was an increase in fresh matter of the Contender pods until a water replacement estimated at 85.7%, giving a fresh matter of 35.73 g per pod.

The fresh matter of the stem of the Napoli cultivar decreased according to the regression equation ($Y = 58,0440 – 0,7785^{**}X + 0,0051^{**}X^2$) until a water replacement estimated at 76.3%, which caused a decrease in the production of fresh stem matter of 12.09g when compared to the highest replacement Water resources.

By examining the dry matter of the leaves of Contender cultivar, it was verified that according to the regression equation, there was an increase in the dry matter of the leaves of 60.3 and 15.7% when comparing the highest dry matter estimated with the water replenishments of 25 and 50%, respectively. The highest dry matter was estimated at 6.48g when a water replenishment of 76.1% was used.

The leaves are important organs for the capture of light, photosynthesis and the production of photosynthates that can be translocated by the plant to nourish it, while at the same time contributing to improve the productivity of the cultivar. Takakura et al. (2013) report that the dry matter fraction of cowpea did not influence the allocation of photoassimilates from the leaves to the other organs when evaluating beans with and without irrigation. In contrast, Aguiar et al. (2008) argue that bean cultivation requires good availability of water in the soil because of the low tolerance to water stress, with crop development limited by drought.

In the case of the fresh matter in the flowering using a water replenishment of 25%, there was a significant difference between the cultivars for the vegetative part of the stem, leaf and pod, with the cultivar Napoli beating Contender in the stem and leaves, already in the vegetative part pod, the fresh matter of the cultivar Contender was 21.36% greater than that of Napoli.

For a 50% water replacement, a significant difference was observed only for the leaf and pod, where the cultivar Contender obtained a fresh matter of the leaf 26.34% smaller than the Napoli cultivar, for the vegetative part pod, observed that the cultivar Napoli In 88.01% the fresh matter of the cultivar Contender.

Using a 75% water replenishment, the fresh matter of the Contender pod was 28.29% higher than the Napoli cultivar, in the other vegetative parts there were no significant differences. The highest leaf fresh matter yield was obtained by the cultivar Contender when irrigated with a 100% water replenishment. On the other hand, in the 125% water replenishment the Napoli cultivar showed significantly a fresh pod content of 48.52% more than The cultivar Contender.

By verifying the differences between the cultivars in the various water replenishments it was verified that the fresh matter produced in the roots were statistically similar among the cultivars in all the water replenishments at any time of evaluation.

At the time of production it was observed that a significant difference occurred, the fresh matter of the cultivar Napoli exceeded the cultivar Contender in all the vegetative parts in the various water replenishments, except for the stem and leaves at 75% replenishment and in the stem in the water replenishment of 100%.

Vieira (2013) verified that the bean, when in consortium with the taro crop, can produce fresh and dry matter of the aerial parts in the amount of 23.29 kg ha^{-1} to 5.12 kg ha^{-1} in contrast to Single bean and consortium. This demonstrates the multiplicity of cultivation conditions of this species and its variation as a function of environmental conditions, genetic and cultivation and management.

In the dry matter variable, it is observed that using the 25% water replacer the Napoli cultivar produced significantly more dry matter in the stem and leaves, in the two evaluation periods. On the other hand, the dry matter of the stem of the cultivar Contender was higher than that of the Napoli cultivar. However, when evaluating the dry matter of the pods in the same water replenishment, the cultivar Napoli significantly exceeded the Contender cultivar in both seasons, Similar to that verified in the water recovery of 125%.

According to Portes (2008), in a plant, photoassimilates are almost always partitioned for the benefit of one organ, while another is likely to be impaired, because the plant does not always produce sufficient photoassimilates to supply all its organs simultaneously. In bean trees, for example, at the beginning of flowering, the photoassimilates are no longer translocated to the roots and take the direction of the flowers and fruits, where the metabolic activity becomes intense with high demand for photoassimilates, resulting in less root growth.

When a water replenishment of 50, 100 and 125% was applied, the cultivar Contender presented a photoassimilate production in the larger stem than the cultivar Napoli, in 43.98; 40.65 and 22.67%, respectively.

The production of photoassimilates translocated to the leaf in the highest water replenishment evaluated, no significant difference was observed between the cultivars in the pod production phase, but in the other replacements, a statistical difference between the cultivars was verified, when using a 50% of the cultivar Contender produced 23.46% more in photoassimilates translocated to the leaf than the cultivar Napoli, already for the water replenishment of 25; 75 and 100% the Napoli cultivar yielded 1.18; 1.36 and 1.60 times more photoassimilates translocated to the leaf, than the cultivar Contender, respectively. The preferential pathway of accumulation in the leaves is understandable at first because the plant needs to form the whole assimilatory apparatus, the basis for greater photoassimilate production and development of new organs (TAIZ & ZEIGER, 2004).

In the water replenishment of 25% the Contender cultivar presented a photoassimilate production translocated to the pod in the pod production phase 50.74% higher than the Napoli cultivar, but in the 50% hydric replenishment was the Napoli cultivar that produced 82.89% More than the cultivar Contender. There was also a significant difference in water replenishment of 75% and 125%, in which the cultivar Contender exceeded the Napoli cultivar in 28.64% in the 75% water replenishment and 38.91% in the 100% water replenishment. By means of the changes of priority in the supply of photoassimilates it is noticed that until the formation of the pods the production of assimilates in the stems surpassed the other organs, in the two cultivars, showing that it is possible to maintain supplied a growing area and at the same time. To avoid that a fabric or organ with little activity is overcrowded by assimilated ones.

Analyzing the translocated photoassimilates production in the pod production phase, it was verified that the production of photoassimilates translocated to the stem in the water replenishment of 25% of the Napoli cultivar exceeded the Contender cultivar by 17.83%.

There was a significant difference in the water content when analyzing the root when using 75% of water replenishment, in the stem, leaf and root when using the 100% replenishment and in the leaves and root when applying 125% of water replenishment. Among these differences, the cultivar Contender presented higher water content than the Napoli cultivar only in the leaf and root when using a 100% water replacement, in the other treatments the

Napoli cultivar was superior. The supply of water to a crop results from interactions that are established throughout the soil-plant-atmosphere system. The reciprocal influences between these basic components make the system dynamic and strongly interconnected, so that the water condition of the crop will always depend on the combination of these three segments (SANTOS & CARLESSO, 1998).

Analyzing the unfolding of the cultivars within each vegetative part using different water replenishments for the water content in the pod production phase, a significant difference was verified for the stem and the leaves when using a 50% water replenishment. In this sense Raven (1996) points out that the leaf is an organ, usually laminar, whose main function is the photosynthesis, for the maintenance of the plant, although it may present other functions, such as transpiration, water storage, protection and attraction of pollinators.

Leite et al. (2015) in studies with RH of 25%, 50%, 75%, 100% and 125% of the evapotranspiration of the crop and with the cultivars BRS Radiante and BRSMG Talismã for the dry matter variable of the flowering plants found that there was no difference Between cultivars, water replenishment and interaction of factors.

CONCLUSION

Independently of the cultivar, there was alteration in the partition of photoassimilates produced between the organs of the plant as a function of water replenishment. The source, represented mainly by the stems, was not limiting to the growth of the pods and seeds and vegetative organs, throughout the experiment in the different water replenishments.

Napoli cultivars have superior adaptability characteristics and greater pod production by the translocation of photoassimilates verified in the vegetative parts, when compared to the cultivar Contender, under Ipameri-GO conditions. The water replacement of 50% presented greater gain in the increment for the production of the Napoli cultivar.

ACKNOWLEDGMENT

CNPQ, FAPEG, CAPES.
Federal Institute of Education, Science and Technology Goiano - Rio Verde Campus.
UEG – State University of Goiás - Câmps Ipameri.

REFERENCES BIBLIOGRAPHIC

AGUIAR, S.R.; MODA-CIRINO, V.; FARIA, R.T.; VIDAL, L.H.I. Avaliação de linhagens promissoras de feijoeiro (*Phaseolus vulgaris* L.) tolerantes ao déficit hídrico. Semina: Ciências Agrárias, V.29, n.1, p.1-14, 2008.

EMBRAPA. Empresa Brasileira de Pesquisa Agropecuária. Centro Nacional de Pesquisa de Solos. Sistema Brasileiro de Classificação do Solo. Rio de Janeiro: Embrapa, 2006, 306 p.

FILGUEIRA, F.A.R. Novo manual de olericultura: agrotecnologia moderna na produção e comercialização de vegetais. 3ªed. Viçosa: UFV, 2008. p. 322-334.

FREYTAG, G. F.; DEBOUCK, D. G. Taxonomy, distribution, and ecology of the genus phaseolus (Leguminosae-papilionoideae) in North America, Mexico and Central America. Botanical Research Institute of Texas (BRIT). USA. 298 p. 2002. (Sida, botanical miscellany no. 23).

LEITE, L.S.; SANTANA, M.J.; SOUZA, L.; SILVA F.M.; Produtividade de cultivares de feijoeiro submetidos a reabastecimento de água no solo. Anais ... XLIV Congresso de Engenharia Agrícola. CONBEA, 2015. São Pedro, SP. 1 CD-ROOM.

LIMA, J.E.F.W .; FERREIRA, R.S.A .; CHRISTOFIDIS, D. Estudo do uso de água e energia elétrica para irrigação no Brasil. 2006. Disponível em <http://www.iica.org.uy/p2-5htm>. Acessado em 8 de junho de 2016.

MORAES, J. E. F. de; SILVA, T. G. F. da; BARBOSA, M. L.; DINIZ, W. J. da S. ; SOUZA, C. A. A. de ; ALEXANDRE JARDIM, M. da R. F.; FERREIRA, J. M. da S. Impactos das mudanças climáticas na demanda hídrica e duração do ciclo do sorgo forrageiro e feijão-caupi no estado de Pernambuco. Revista Brasileira de Geografia Física vol. 08, número especial 470 (IV SMUD), (2015) 542-559. Disponível em: <http://www.revista.ufpe.br/rbgfe/index.php/revista/article/view/1466/752. Acesso em 16 de jun.2016.

MENDONÇA, F.C.; RASSINI, J.B. Temperatura-base inferior e estacionalidade de produção de gramíneas forrageiras tropicais. São Carlos: Embrapa Pecuária Sudeste, 2006. 14p. (Circular Técnica da Embrapa, 45).

OLIVEIRA S.R.M. Densidade populacional de caupi em níveis de irrigação. Ceará, 2013. 104 p. Tese (Doutorado em Engenharia Agrícola) - Universidade Federal do Ceará, UFC.

PEIXOTO, N.; MORAES, E.A.; MONTEIRO, J.D.; THUNG, M.D.T. Seleção de linhas de feijão-vagem de crescimento indeterminado para cultivo no Estado de Goiás. Horticultura Brasileira. V. 19, n.1, p. 85-88, 2001.

PORTES, T.A. Translocação de solutos orgânicos. 2008. Disponível em: https://www.icb.ufg.br/up/99/o/transoluto.PDF. Acessado em: 20 mar. 2016.

RAVEN, P.H .; EVERT, R.F., EICHHORN, E.S. Biologia vegetal. 5. ed. Rio de Janeiro: Guanabara Koogan. 1996. 738p.

SANTANA, M.J.; CARVALHO, J.A.; ANDRADE, M.J.B.; GERVÁSIO, G.G.; BRAGA, J.C.; LEPRI, E.B. Viabilidade técnica e econômica da aplicação de água no feijoeiro comum (*Phaseolus vulgaris* L.). Ciência e Agrotecnologia, V. 33, n. 02, p. 532-538, 2009.

SANTOS, R. F.; CARLESSO, R. Déficit de água e os processos morfológicos e fisiológicos das plantas. Revista Brasileira de Engenharia Agrícola e Ambiental, Campina Grande, V. 2, n. 3, p. 287-294, 1998.

SORATTO, R.P.; ARF, O.; RODRIGUES, R.A.F.; BUZETTI, S.; SILVA, T.R.B. Resposta do feijoeiro à preparação do solo, manejo da água e particionamento de nitrogênio. Acta Scientiarum: Agronomia Maringá, V. 25, n. 1, p. 89-96, 2003.

TAIZ, L.; ZEIGER, E. Fisiologia das plantas. 3. ed. Porto Alegre: Artemed, 2004. 719p.

VAZ, D. da C. Avaliação agronômica e divergência genética em feijão - arbustivo. Ipameri, 2014.46p. Dissertação (Mestrado em Produção Vegetal) - Câmpus Ipameri, Universidade Estadual de Goiás, UEG.

TAKAKURA, G.M.; FARIAS, V.D.DAS S.; RIBEIRO, O.A.V.; ENCARNAÇÃO, V.M.B.DA; SOUZA, P.J.O.P. Distribuição de matéria seca em feijão de caupi irrigado e em condições naturais. XVIII Congresso Brasileiro de Agrometeorologia. Anais ... Universidade Federal do Pará, Belém - PA. 2013.

VIEIRA, J.C.B. Consórcio taro e feijão-vagem em função da época de plantio. Viçosa: 2013. 44p. (Dissertação de Mestrado) Universidade Federal de Viçosa, UFV.

WUTKE, E.B.; ARRUDA, F.B.; FANCELLI, A.L.; PEREIRA, J.C.N.A.; SAKAI, E.; FUJIWARA, M.; AMBROSANO, G.M.B. Propriedades do solo e sistema radicular do feijoeiro irrigado em rotação de culturas. Revista Brasileira de Ciência do Solo, V.24, n.3, p.621-633, 2000.