Australian Journal of Basic and Applied Sciences, 10(15) October 2016, Pages: 209-214

AUSTRALIAN JOURNAL OF BASIC AND APPLIED SCIENCES

ISSN:1991-8178 EISSN: 2309-8414
Journal home page: www.ajbasweb.com

Conversion Efficiency Of Photosynthetically Active Radiation In Soybean Cultivars During Planting Seasons

[1]Julia Renata Schneider, [1]Braulio Otomar Caron, [2]Elvis Felipe Elli, [3]Felipe Schwerz, [4]Ana Paula Rockenbach, [1]Thaise Dieminger Engroff

[1]*Department of Agricultural and Environmental Sciences, Federal University of Santa Maria, Frederico Westphalen, RS, Brazil.*
[2]*Department of Biosystems Engineering, ESALQ, University of São Paulo, Piracicaba, SP, Brazil.*
[3]*Postgraduate Program in Agronomy, Federal University of Santa Maria, Frederico Westphalen, RS, Brazil.*
[4]*Postgraduate Program in Agronomy, Agronomy and Medicine Veterinary College, Passo Fundo, RS, Brazil.*

Address For Correspondence:
Julia Renata Schneider, Department of Agricultural and Environmental Sciences, Federal University of Santa Maria, Frederico Westphalen, RS, Brazil.

ARTICLE INFO

Article history:
Received 26 August 2016
Accepted 10 October 2016
Published 18 October 2016

Keywords:
Glycine max L. Merril. Growth habit. Dry matter.

ABSTRACT

Background: The soybean crop is of great importance, and there are several factors responsible for causing changes in their growth. Due to its extreme importance, the effect of weather elements in different genetic materials and at different times of sowing was verified. Objective: The study aimed to determine the conversion efficiency of photosynthetically active radiation intercepted in dry matter of two soybean cultivars, with determinate and indeterminate growth habits at different times of sowing. The studywas developed in the city of Frederico Westphalen – RS, Brazil. A randomized complete block design in a 2x5 factorial scheme was used, i.e.two CCGL Tec 5721 IPRO (super-early cycle) cultivars with determined growth and CCGL Tec 7849 IPRO (late cycle), with indeterminate growth, five sowing dates (15/10, 01/11, 15/11, 01/12 and 15/12 2014) with three replications. Samples were taken for determination of dry plant matter every two weeks, and from a relationship between this dry matter production by plants and photosynthetic active radiation intercepted, the conversion efficiency of solar radiation on dry matter was calculated. Results: The lower conversion efficiencies of solar radiation were found at the same times that presented the lowest values of dry matter. The total dry matter is proportional to the amount of radiation intercepted by the leaves of the crop. Conclusion: The cultivar with indeterminate growth habits had the highest conversion efficiency of solar radiation at the time of cultivation, with sowing on December 15. As to the other sowing dates, the cultivar with determinate growth habit achieved higher conversion efficiencies of solar radiation in relation to the indeterminate cultivar and its maximum solar radiation conversion efficiency corresponding to the sowing period on December 01.

INTRODUCTION

The soybean has a high yield potential, when associated with the appropriate chemical composition and high nutritional value, it has application in food and feed (Komatsu *et al.*, 2010). With an ample capacity to adapt to different environmental conditions and management, it is considered the main oilseed produced and consumed in the world.

Because of the importance of the culture, it is necessary to identify the factors that may influence their growth. Because there are differences in soil and climate environments and high genetic variability of cultivars, studies are needed to evaluate, at different seasons, the effect of weather elements in plant growth (Meotti *et al.*, 2012). The soybean-seeding season is a management practice that can cause changes in the production of this

To Cite This Article: Julia Renata Schneider, Braulio Otomar Caron, Elvis Felipe Elli, Felipe Schwerz, Ana Paula Rockenbach, Thaise Dieminger Engroff., Conversion Efficiency Of Photosynthetically Active Radiation In Soybean Cultivars During Planting Seasons. ***Aust. J. Basic & Appl. Sci.,*** *10(15): 209-214, 2016*

crop (Bornhofen *et al*., 2015). For Amorim *et al*. (2011) soybean cultivars sown at different times have the capacity to express their potential according to environmental conditions, which can change in space and time.

Meteorological variables affect the growth and development of plants and solar radiation is one of the most important weather elements, considered essential. Just one fraction of the radiation is used by plants in the photosynthetic process, called PAR or photosynthetically active radiation (Ferreira Junior *et al*., 2012). This spectrum varies in wavelength from 0.4 to 0.7 micrometres (Fontana *et al*., 2012).

According to Caron *et al*. (2014), the solar radiation conversion efficiency in dry matter reflects the growth of plants, so this is a parameter that can be used for evaluation and estimation of crop growth. The plant production will depend on intercept, assimilation and conversion of solar radiation on dry matter (Uitzil *et al*., 2016). This production has been increasing by an increment in cultivation areas and the improvement of plants (Nardino *et al*., 2016).

Knowing the soybean importance, this work is justified by the relevance of the study of how radiation absorbed by the plant is converted into dry matter, which results in growth and because there are few studies in this direction by testing different seeding seasons. Given the above, this study aimed to determine the conversion efficiency of photosynthetic active radiation intercepted in dry matter content of two soybean cultivars, of determinate and indeterminate growth habits at different sowing times.

MATERIAL AND METHODS

Study area and experimental design:

The study was conducted in the municipality of Frederico Westphalen – RS, at theSete de Setembro line, under coordinates27º23’48’’ S, 53º25’45’’ Eand altitude of 490 m. The experiment was conducted during the 2013/2014 harvest, on the field in the experimental area of the Agroclimatology Laboratory, linked to the Federal University of Santa Maria, Frederico Westphalen Campus. According to the Köppen climate classification, the climate is Cfa, or humid temperate climate with hot summers (ALVARES *et al*., 2013).

The soil of the area belongs to the Passo Fundo mapping unit, classified as typical Oxisol, clayey, deep and well drained with the following physico-chemical composition: water pH: 6.0; P (Mehlich): 3.0 mg dm^{-3}; K: 160 mg dm^{-3}; Ca: 6.2 $cmol_c$ dm^{-3}; Mg: 3.3 $cmol_c$ dm^{-3}; Al: 0.0 $cmol_c$ dm^{-3}; CTC: 9.9 $cmol_c$ dm^{-3}; Base saturation: 76% and organic matter: 3.1%.

The experimental design was of randomized blocks, in a 2x5 factorial design, with two cultivars, CCGL Tec 5721 IPRO (super-early cycle) with determinate growth and CCGL Tec 7849 IPRO (late cycle), indeterminate growth and five sowing dates being 1st season = October 15, 2nd season = November 01, 3rd season = 15 November 4th season = December 01, 5th season = December 15) with three replications. The plots were arranged three meters long, with the rows spaced at 0.45 m. Each experimental unit had counted five lines, considering the useful portion to be the three central lines, retreating 0.45 m from the edges.

The seeding was carried out with the aid of a seeder, three centimeters in depth, and thinning at 7 days after emergence, keeping a final population of 250,000 plants ha^{-1}. The experimental procedures were the same for all sowing dates.

Reviews and statistical analysis:

Samples were taken for determination of dry matter of the plants every two weeks. This material was dried in an oven with air circulation at 60°C until constant weight for subsequent determination of dry matter on precision balance was achieved. These collections were followed up until the physiological maturation of the plants.

The conversion efficiency was estimated from a relationship between the dry matter production and PARi, according to Monteith and Moss' (1977) equation:

$$DMP = \varepsilon b * PARi \qquad (1)$$

In which: DMP = dry matter production, g m^{-2}; εb = conversion efficiency of PAR in dry matter produced, g MJ^{-1}; PARi = intercepted photosynthetically active radiation, MJ m^{-2}.

ThePARiwas determined according to Varlet-Grancher *et al*. (1989):

$$PARi = 0.95 * (PAR_{inc}) * (1 - e^{(-k*LAI)}) \qquad (2)$$

In which,PARi = intercepted photosynthetically active radiation, MJ m^{-2}; k = light extinction coefficient for the 0.5 culture according to Pengelly *et al*. (1999); LAI = leaf área index, dimensionless; PAR_{inc} = incidental photosynthetically active radiation, MJ m^{-2}.

The photosynthetically active radiation was estimated according to the methodology of Assisi and Mendez (1989), which considers this as 45% of global solar radiation, not distinguishing clear and cloudy days.

The leaf area (LA) was calculated according to the equation:

$$AF = (\text{№ of disks} * \text{leaker area}) * \frac{(\text{MS leaves + disks})}{\text{MS disks}} \qquad (3)$$

Where, № of disks = number of disks made per sample; leaker area = leaker area in mm^2; MS leafs + disks = sum of the leaves dry matter + disks, i.e. the total dry leaves, in grams; and MS disks = dry matter of the disks.After obtaining the leaf area, the leaf area index (LAI) was determined from the total leaf area of each plant and the soil area traveled by the latter, according to the equation:

$$LAI = LA / SA \quad (4)$$

In which, LA is the leaf area, and SA is the soil area occupied by the plant, both in m^2, and AS amounts to 0.04 m^2, calculated from the spacing and plant population used.

The values of global solar radiation and precipitation were obtained from the INMET Climatological Station (National Meteorological Institute), linked to the Agroclimatology Laboratory for characterization of growth environment. The station is about 150 m from the place of study, under the coordinates 27.3956°S and 53.4294°W and is linked to the Agroclimatology Laboratory.

RESULTSAND DISCUSSION

In Figure 1 the mean values of solar radiation, precipitation and air temperature encountered during the implementation of the experiment are shown, and the thermal time calculated for culture throughout the experiment.

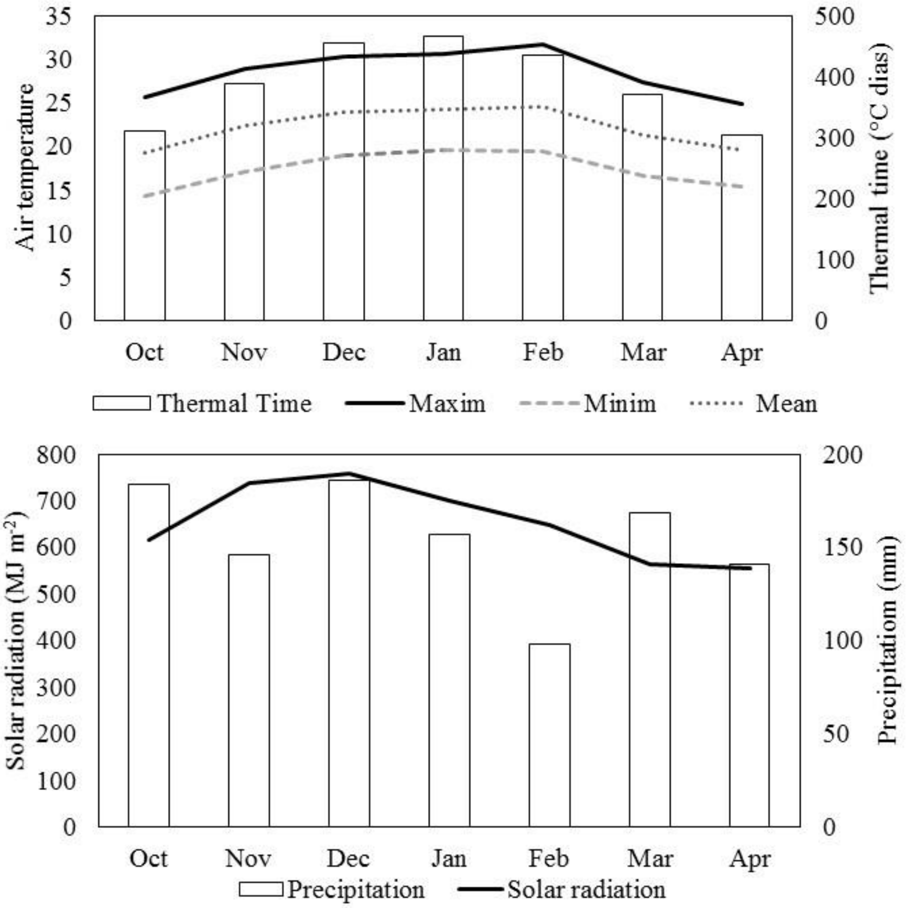

Fig. 1: Average monthly values of global solar radiation, rainfall, temperature (minim, maximand mean) and the thermal time calculated for the soybean crop. Frederico Westphalen, RS, 2013.

The lowest values of solar radiation coincided with high rainfall, which may have affected the PAR values due to the presence of cloudiness. This information was reported by Andrade *et al*. (2014), who found a decrease in PAR in the presence of cloudiness and precipitation. However, for Brazilian conditions and the radiation values obtained, this meteorological element does not restrict the growth and development of the crop. The maximum solar radiation in December, led to the summer solstice, which takes place between 21 and 22 December for the Southern Hemisphere.

The average air temperature during the crop cycle remained within the ideal range and precipitation in the same way for all times reached levels that corresponded to the needs of the culture.

Figure 2 describes the conversion efficiency of radiation for cultivars CCGL TEC 5721 IPRO and CCGL TEC 7849 IPRO on the five sowing dates.

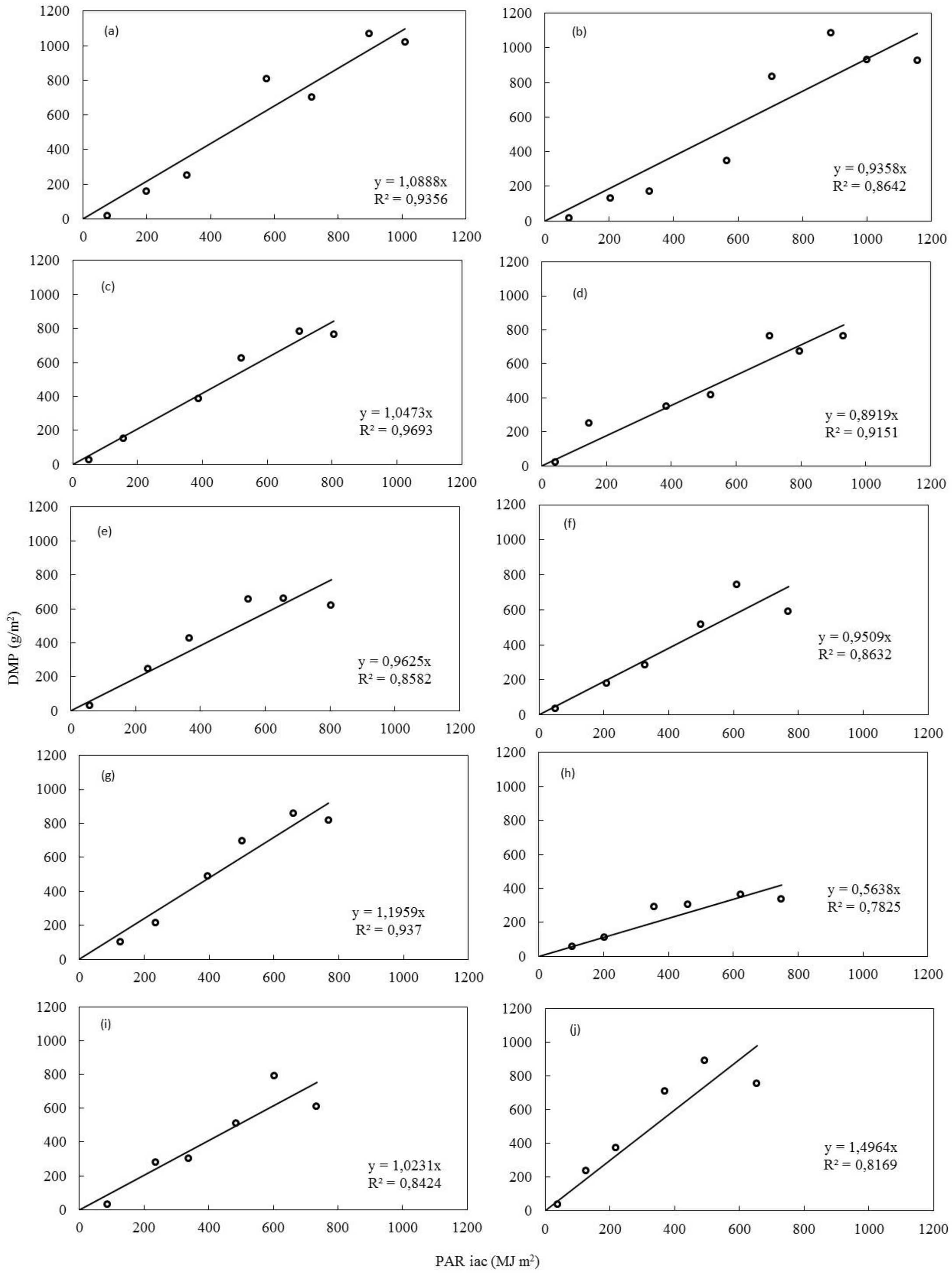

Fig. 2: Conversion efficiency of solar radiation (g MJ^{-1}) of CCGL TEC 5721 IPRO cultivars, the sowing dates on October 15 (a), November 01 (c), November 15 (e), December 01 (g) and December 15 (i) and CCGL TEC 7849 IPRO and sowing on October 15 (b), November 01 (d), November 15 (f), December 01 (h) and December 15 (j). Frederico Westphalen, RS, 2013.

The dry matter accumulated by soybean plants related linearly and positively with the accumulated photosynthetically active radiation intercepted. However, variations were found in the conversion efficiency values obtained among cultivars and sowing dates.

Considering the sowing dates, the higher conversion efficiency was found for the December 15 sowing, reaching an average of cultivars of 1.2598 g MJ^{-1}, with higher values for the 7849 IPRO cultivar with indeterminate growth habit, which reached 1.4964 g MJ^{-1}.

These values are consistent with those found by Petter *et al*. (2016), working with three soybean varieties on five different seeding densities. According to Souza *et al*. (2009), the soybean crop showed values of 1.46 g MJ^{-1} for the year 2007 and 1.99 g MJ^{-1} for 2008.

By analyzing the cultivars, the most efficient at converting solar radiation into dry matter was 5721 IPRO with a determinate growth habit, which obtained the highest values in five sowing dates, with the largest at the time of sowing on December 01. If we consider the sowing season, the season with sowing on December 15 had the highest conversion efficiency of solar radiation on dry matter, for the 7849 IPRO cultivar.

The times studied presented differences, since the first three times, despite the IPRO 5721 cultivar showing itself superior, the differences were smaller, with both cultivars displaying similar behavior.

As discussed in Figure 1, the weather conditions were generally favorable for the culture. However, the fact of having grown at different seasons caused the plants to be in different stages of development to cope with these conditions. This probably resulted in differences for the conversion efficiency for the same cultivar at different times.

At sowing on December 01, the 7849 IPRO cultivar presented a reduced efficiency of about 50%, compared to others. This may have been due to the increase in temperature at the beginning of February, which exceeded 30°C, getting close to the optimum temperature for flowering of 32.4°C (Setyono*et al*., 2007), which anticipated its flowering. This accelerated their maturation (Guimarães *et al*., 2008), its vegetative stage decreased, shortening the cycle. Thus, the plant produced fewer leaves, reached lower LAI, intercepted less radiation and was less efficient in conversion efficiency of solar radiation in dry matter.

At sowing on December 15, temperatures remained around 24°C, which helped extend the growing season. This temperature is within the optimum range for the development of soybeans, 20 to 33°C (Setyono *et al*., 2007), however according to Rodrigues *et al* (2001), warmer temperatures helped to increase the interval until flowering. By having a habit of indeterminate growth, it showed a higher emission of nuts and leaves, reaching higher LAI and higher conversion efficiency of solar radiation (Cunhaand Volpe, 2010).

This increase in the vegetative stage may have contributed to these plants reaching a greater height and more efficient use of the resulting diffused radiation of the canopy, corroborating with Caron *et al*. (2014). These features may have favored the shading of lower leaves, avoiding the luminous saturation of the same, as this may be responsible for decreasing the utilization efficiency of radiation (Taiz and Zeiger, 2013; Jiang *et al*., 2006).

The lower conversion efficiencies of solar radiation were found at the same seasons that presented the lowest values of dry matter. The total dry matter is proportional to the amount of radiation intercepted by the leaves of the crop. Thus, when the amount of intercepted radiation is decreased, it is reflected in lower RFAi conversion of dry matter of the aerial part, as described by Kunz *et al*. (2007).

According to Sanquetta *et al*. (2014), the balance of dry matter that is accumulated by the plant from photosynthesis reflects on plant growth, and this dry matter produced is dependent on the amount of photosynthetically active radiation absorbed by the leaves and the plant efficiency in converting this radiant energy assimilates itself in the process of photosynthesis. Differences in morphology of the plant, such as in te foliar architecture of cultivars with contrasting growth habits can generate influence on the amount of PAR intercepted, absorbed and later utilized by the plant (Fagundes *et al*., 2001).

Conclusions:

The cultivar with indeterminate growth habit had the highest conversion efficiency of solar radiation at the time of cultivation, with sowing on December q5 (season). As to the other sowing dates, the cultivar with determinate growth habit achieved higher conversion efficiencies of solar radiation in relation to the indeterminate cultivar, its maximum solar radiation conversion efficiency corresponding to the sowing period on December 01.

REFERENCES

Alvares, C.A., J.L. Stape, P.C. Sentelhas, J.L.de M. Gonçalves, 2013. Köppen'sclimateclassificationmap for Brazil. MeteorologischeZeitschrift, 22(6): 711-728.

Amorim, F.A., O.T. Hamawaki, L.B. Sousa, de., R.M.Q. Lana, C.D.L. Hamawaki, 2011. Época de semeadura no Potencial produtivo de Soja em Uberlândia-MG. Semina: Ciências Agrárias, 32(1): 1793-1802.

Andrade, A.M.D.de., M.A.L. Moura, A.B.dos. Santos, R.G. Carneiro, R.S. da. Silva Junior, 2014. Radiação fotossinteticamente ativa incidente e refletida acima e abaixo do dossel de floresta de mata atlântica em Coruripe, Alagoas**.** Revista Brasileira de Meteorologia, 29(1): 68-79.

Assis, F.N. and M.E.G. Mendez, 1989. Relação entre radiação fotossinteticamente ativa e radiação global. Pesquisa Agropecuária Brasileira, 2(7): 797-800.

Bornhofen, E., G. Benin, D. Galvan, M.F. Flores, 2015. Épocas de semeadura e desempenho qualitativo de sementes de soja. Pesquisa Agropecuária Tropical, 45(1): 46-55.

Caron, B.O., D. Schmidt, P.A. Manfron, A. Behling, E. Eloy, C. Busanello, 2014. Eficiência do uso da radiação solar por plantas Ilex paraguariensis A. St. Hil. cultivadas sob sombreamento e a pleno sol. Ciência Florestal, 24(2): 257-265.

Cunha, A.R. da. and C.A. Volpe, 2010. Relações radiométricas no terço superior da copa de cafeeiro.Bragantia, 69(2): 263-271.

Fagundes, J.L., S.C. da. Silva, C.G.S. Pedreira, R.A. Carnevalli, C.A.B. de. Carvalho, A.F. Sbrissia, L.F. de. M. Pinto, 2001. Índice de área foliar, coeficiente de extinção luminosa e acúmulo de forragem em pastagens de*Cynodon* spp. sob lotação contínua. Pesquisa Agropecuária Brasileira, 36(1): 187-195.

Farias, J.R.B., A.E. Nepomuceno, N. Neumaier, 2007. Ecofisiologia da soja**.** Londrina: Embrapa Soja. 10p (Embrapa Soja. Circular Técnica, 48).

Ferreira Junior, R.A., J.L. de. Souza, G.B. Lyra, I. Teodoro, M.A. dos. Santos, A.C.S. Porfirio, 2012. Crescimento e fotossíntese de cana-de-açúcar em função de variáveis biométricas e meteorológicas. Revista Brasileira de Engenharia Agrícola e Ambiental, 16(11): 1229-1236.

Fontana, D.C., G.M. Alves, D. Roberti, O.L.L de. Moraes, A. Gerhardt, 2012. Estimativa da radiação fotossinteticamente ativa absorvida pela cultura da soja através de dados do sensor Modis.Bragantia, 71(4): 563-571.

Guimarães, F.deS., P.M. de. Rezende, E.M. de. Castro, E. de. A. Carvalho, M.J.B. de. Andrade, E.R. Carvalho, 2008. Cultivares de soja [*Glycine max* (L.) Merrill] para cultivo de verão na região de Lavras-MG. Ciência e Agrotecnologia, 32(4): 1099-1106.

Jiang, C.D., H.Y. Gao, Q. Zou, G.M. Jiang, L.H. Li, 2006. Leaf orientation, photorespiration and xanthophyll cycle protect young soybean leaves against high irradiance in field. Environmental and Experimental Botany, 55(1): 87-96.

Komatsu, R.A., D.D. Guadagnin, M.A. Borgo, 2010. Efeito do espaçamento de plantas sobre o comportamento de cultivares de soja de crescimento determinado. Campo Digit@l, 5(1): 50-55.

Kunz, J.H., J.I. Bergonci, H. Bergamaschi, G.A.D almago, B.M.M. Heckler, F. Comiran, 2007. Uso da radiação solar pelo milho sob diferentes preparos do solo, espaçamento e disponibilidade hídrica. Pesquisa agropecuária brasileira, 42(11): 1511-1520.

Meotti, G.V., G. Benin, R.R. Silva, E. Beche, L.B. Muraro, 2012. Épocas de semeadura e desempenho agronômico de cultivares de soja. Pesquisa Agropecuária Brasileira, 47(1): 14-21.

Monteith, J.L. and C.J. Moss, 1977. Climate and the efficiency of crop production en Britain. PhilosophicalTransactions B. The Royal Society, 28(1): 277-294.

Nardino, M., I.R. Carvalho, G. Demari, G. Pelissari, A.J. de. Pelegrin, M.F errari, V.J. Szareski, D. Meira, V.Q. de. Souza, 2016. Components Of Variance, Linear And Canonical CorrelationSoybeanCultivars.

Pengelly, B.C., F.P.C. Blamey, R.C. Muchow, 1999. Radiation interception and the accumulation of biomass and nitrogen by soybean and three tropical annual forage legumes. Field Crops Research, 63: 99-112. Australian Journal of Basic and Applied Sciences, 10(10): 202-208.

Petter, F.A., J.A. da. Silva, A.M. Zuffo, F.R. Andrade, L.P. Pacheco, F.A. de. Almeida, 2016. Elevada densidade de semeadura aumenta a produtividade da soja? Respostas da radiação fotossinteticamente ativa.Bragantia, 75(2): 173-183.

Sanquetta, C.R., A. Behling, A.P.D. Corte, G.C. Cadori, S. Costa Junior, J.H.P. Macedo, 2014. Eficiência de conversão da radiação fotossintética interceptada em Fitomassa de mudas de *Eucalyptus dunii* Maiden em função da densidade de plantas e do ambiente de cultivo. Scientia Forestalis, 42(104): 573-580.

Setiyono, T.D., A. Weiss, J. Specht, A.M. Bastidas, K.G. Cassman, A. Dobermann, 2007. Understanding and modeling the effect of temperature and daylength on soybean phenology under high-yield conditions. Field Crops Research, 100: 257-271.

Souza, P.J. de O.P. de., A. Ribeiro, E.J.P. da. Rocha, J.R.B. Farias, R.S. Loureiro, C.C. Bispo, L. Sampaio, 2009. Solar radiation use efficiency by soybean under field conditions in the Amazon region. Pesquisa Agropecuária Brasileira, 44(10): 1211-1218.

Taiz, L. and E. Zeiger, 2013. Fisiologia Vegetal**.**5. Ed. Porto Alegre: Artmed, p: 918.

Uitzil, A.M.P., V.Q. de S. Souza, T. Olivoto, M. Nardino, I.R. Carvalho, M. Ferrari, A.J.de P. Pelegrin, V.J. Szareski, G.H. Demari, 2016. Yield Components Of Hybrid Based On The Plant Population And Artificial Defoliation. Australian Journal of Basic and Applied Sciences, 10(10): 136-142.

Varlet-Grancher, C., G. Gosse, M. Chartier, H. Sinoquet, R. Bonhomme, J.M. Allirand, 1989. Mise au point: rayonnementsolaireabsorbé ou intercepté par uncouvertvégétal. Agronomie, 9: 419-439.