# ESTIMATED PRODUCTION AND EVAPOTRANSPIRATION OF IRRIGATED BEAN CULTIVARS

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**ABSTRACT:** The current study intended to determine the optimum water depth, yield and evapotranspiration (ETc) for bean cultivars. The experiment was conducted in the Campus of Unit I of the Triângulo Mineiro Federal Education and Technology Institute in Uberaba, MG, in a completely randomized design with three replications. The treatments consisted of four water-replacing levels in the soil (70, 100, 130 and 160% of the crop evapotranspiration) and four bean cultivars (Pérola, BRSMG Madrepérola, BRSMG Majestoso and IAC Alvorada). The average values of ETc obtained for soil water balance for the cultivars Pérola, BRSMG Madrepérola, BRSMG Majestoso and IAC Alvorada were, respectively, of 5.25 mm day$^{-1}$, 4.59 mm day$^{-1}$, 4.54 mm day$^{-1}$ and 4.77 mm day$^{-1}$. The water depths which provided the highest yields were for the cultivars Pérola, BRSMG Madrepérola, BRSMG Majestoso and IAC Alvorada of 451.61 mm, 454.41 mm, 504.71 mm and 344.30 mm, respectively. The maximum yields found were 4597.87 kg ha$^{-1}$ (Pérola), 4546.27 kg ha$^{-1}$ (BRSMG Madrepérola),  4253.39 kg ha$^{-1}$ (BRSMG Majestoso) and 3958.50kg ha$^{-1}$ (IAC Alvorada).

**KEYWORDS:** irrigation management, ETc, optimum water depth, *Phaseolus vulgaris* L.

# ESTIMATIVA DA PRODUTIVIDADE E DA EVAPOTRANSPIRAÇÃO DE CULTIVARES DE FEIJÃO IRRIGADO

**RESUMO:** Objetivou-se determinar a lâmina ótima, a produtividade e a evapotranspiração (ETc) de cultivares de feijoeiro. O experimento foi conduzido no Câmpus da unidade I do Instituto Federal de Educação, Ciência e Tecnologia do Triângulo Mineiro, em Uberaba - MG, em um delineamento em blocos casualizados com três repetições. Os tratamentos foram constituídos de quatro níveis de reposição de água no solo (70; 100; 130 e 160% da evapotranspiração da cultura) e quatro cultivares de feijão (Pérola, BRSMG Madrepérola, BRSMG Majestoso e IAC Alvorada). Os valores médios de ETc obtidos pelo balanço de água no solo para as cultivares Pérola, BRSMG Madrepérola, BRSMG Majestoso e IAC Alvorada, foram, respectivamente, de 5,25 mm dia$^{-1}$, 4,59 mm dia$^{-1}$; 4,54 mm dia$^{-1}$ m e 4,77 mm dia$^{-1}$. As lâminas que proporcionaram as maiores produtividades foram para as cultivares Pérola, BRSMG Madrepérola, BRSMG Majestoso e IAC Alvorada, de 451,61; 454,41; 504,71 e 344,30 mm, respectivamente. As produtividades máximas encontradas foram 4.597,87 kg ha$^{-1}$ (Pérola); 4.546,27 kg ha$^{-1}$(BRSMG Madrepérola); 4.253,39 kg ha$^{-1}$(BRSMG Majestoso) e 3.958,50 kg ha$^{-1}$(IAC Alvorada).

**PALAVRAS-CHAVE:** manejo da irrigação, ETc, lâmina ótima, *Phaseolus vulgaris* L.

## INTRODUCTION

Beans are one of the food produced in greater quantities in the whole national territory, being intense the search for productive and adapted cultivars to cultivation regions (FARINELLI & LEMOS, 2010).

From the 1980s the beans began to be cultivated in the winter. According to the same authors, at this time the beans have the greatest acceptance among medium and large producers, by obtaining higher yields compared to other times of the year (BINOTTI et al., 2007).

Faced the technological advances and socioeconomic characteristics, the bean cultivation has been practiced by farmers who have the most varied levels of technology, in which are highlighted irrigation and nitrogen fertilizer (LOPES et al., 2011). The participation of irrigation in the production costs of beans ranged from 26.6 to 37.6% in experiment conducted by OLIVEIRA & ZOCOLER (2010).

FREITAS et al. (2003) said that water is one of the production factors in agriculture, and every species needs an adequate level of water in the soil for their physiological needs to be satisfied.

SANTANA et al. (2008) stated that irrigation is a viable alternative for improving productivity and that its basic purpose is to provide water to the crop to attend its water requirement. The improper management of the soil and the water is a limiting factor to the productivity of irrigated beans (PAVANI et al.; 2008).

MENDONÇA et al. (2007) reported that the evapotranspiration of a crop is one of the major information required for irrigation management and for planning purposes of water use.

ARF et al. (2004) found that there was no significant effect of water depths (intervals from 215 to 287 mm in the first year of cultivation and 150 to 254 mm in the second year of cultivation) in beans yield of IAC Carioca Eté cultivar. Thus, as the authors commented, even with a difference of about 100 mm of water during the crop cycle, from rainfall and irrigation, among the treatments, there was no change in the yield.

MANTOVANI et al. (2012) in a study conducted in Cristalina, GO, concluded that the greatest productivity was 2,946.52 kg ha$^{-1}$ when it was irrigated in the system with higher coefficient of uniformity of water application (90%). In the 1990s it was launched the Pérola cultivar with resistance to some foliar diseases, presence of coarse grains and highly productive (YOKOYAMA et al., 2000).

Considering the above, the aim of this study is to determine the optimum water depth, the productivity and the evapotranspiration of beans cultivars grown in Uberaba, MG.

## MATERIALS AND METHODS

The study was conducted at the Annual Crops Sector, of the Federal Institute of Education, Science and Technology of Triângulo Mineiro (IFTM), Uberaba Câmpus, located in Uberaba, Minas Gerais, situated at 19° 39' 19'' S and 47° 57' 27'' W.

The obtained water curve in the soil was held in deformed samples collected at 0-20 and 20-40 cm deep, through adjustments of the characteristic curves of water retention in the soil (Table 1) in the Laboratory of Soil -Plant Relationship of IFTM Campus Uberaba, MG, by the Richards pressure chamber. The average density of the soil  at 0-20 and 20-40 cm layers, obtained by the Uhland cylinder method, gave values of 1.18 and 1.22 g cm-1, respectively. The corresponding moisture at field capacity is of 0.23 cm3 cm-3 (average water tension of the soil of 11 kPa in the 0-20 cm layer).

TABLE 1. Soil hydraulic characterization of the experimental area (IFTM, Uberaba, MG, 2011).

| Layer (cm) | Equation | $R^2$ |
|---|---|---|
| 0 - 20 | $\theta = \dfrac{0.42}{\left[1 + (1.32 * \psi_m)^{4.6}\right]^{0.11}} + 0.115$ | 0.911 |
| 20 - 40 | $\theta = \dfrac{0.38}{\left[1 + (0.899 * \psi_m)^{6.83}\right]^{0.13}} + 0.225$ | 0.936 |

$\theta$=volumetric moisture (cm$^3$ cm$^{-3}$); $\psi_m$=potencial matricial (kPa)

The cultivars planted were: Pérola, BRSMG Madrepérola, BRSMG Majestoso and IAC Alvorada. The sowing was carried on May 20th, 2011 and the harvest on August 19th, 2011. One sub soiling, one plowing and one tillage, in the soil of the area was realized. The sowing was carried out at a depth of approximately 3 cm above and beside the planted fertilizer with 15 seeds per meter, allowing 12-13 plants per meter of furrow after emergency (ARF et al., 2004; SANTANA, 2007).

The total doses of macronutrients (N, P and K) followed the recommendation of CHAGAS et al. (1999) for the technological level NT$_4$, and the coverage of nitrogen (30 kg ha$^{-1}$) and potassium (10 kg ha$^{-1}$) performed at 25 and 40 days after sowing (DAS). Zinc (2 kg ha$^{-1}$) and boron (1 kg ha$^{-1}$) were applied at sowing along with phosphorus and part of the nitrogen and potassium.

It was carried out before sowing, the seeds treatment with fungicides based on fludioxonil (2 ml kg$^{-1}$) and insecticide based on thiamethoxam (2.5 ml kg$^{-1}$). The phytosanitary control was done preventively at 25 and 45 days after emergence, seeking the control of the main diseases and pests in the region: anthracnose (*Colletotrichum lindemuthianum*), angular leaf spot (*Phaeoisariopsis griseola*), whitefly (*Bemisia tabaci*) and Cucurbit Beetle (*Diabrotica speciosa*). The products used were the fungicide azoxystrobin (80 g ha$^{-1}$) and the insecticide imidacloprid (150 g ha$^{-1}$).

The experiment was conducted in randomized block design (RBD) with three replications, and employed a 4 x 4 factorial arrangement, consisting of four levels of water replacement in the soil (70, 100, 130 and 160% of crop evapotranspiration, estimated by of Class A pan) and four cultivars. Each experimental plot consisted of five rows of planting five feet long. Plants located at the center of the area were considered useful plants for the collection of data (area of 2 m$^2$).

In each plot, four micro-sprinklers were used (simulating spraying) with 40% overlapping, auto compensating with a flow rate of 26 L h$^{-1}$. The pumping was performed with a 2.0 hp motor pump unit. Tensiometers batteries (at 10 and 30 cm deep) were installed in all treatments for controlling water storage in the soil. Irrigation interval of two days to replacement of water in the soil and tests for determining the uniformity coefficient of water distribution of the irrigation system were used. The average uniformity observed in the system was of 89%.

The irrigation water depth was determined by eqs. (1), (2) and (3), being considered as 100% of replacement. The other replacement water depth have been applied in relation to 100%.

$$LB = \frac{ETc}{Ea} \tag{1}$$

where,

Ea - application efficiency of the irrigation system (0.9); ETc - crop evapotranspiration (accumulated of two days, mm).

$$ETc = ETo.Kc.Ks \tag{2}$$

where,

ETo - reference evapotranspiration (accumulated of two days, mm); Kc - crop coefficients (according to SANTANA et al., 2008); Ks - coefficient of soil water deficit.

$$ETo=Kt.EV \tag{3}$$

where,

Kt - Class A pan coefficient; EV - Class A pan evaporation (mm).

It was installed near the experimental area (600 m) an automatic weather station with sensors for wind speed, precipitation, relative humidity, temperature and solar radiation. ETc was also determined by the soil water balance [eq. (4)] in a control volume corresponding to a depth of 0.4 m, in plots of the four cultivars (SANTANA, 2007).

$$\Delta h = P + I \pm Q - ETc - E \tag{4}$$

where,

$\Delta h$ - storage variation (mm); P - precipitated water depth (mm); I - irrigation (mm); Q - water depth entering or leaving the lower profile (mm) and E - surface runoff (mm).

To calculate the surface runoff (E), precipitated water depths were confronted with potential infiltrated water depths provided by accumulated soil infiltration equation, which was estimated using data obtained by the ring infiltrometer method, based on the potential type model [eq. (5)]:

$$I = aT^n \tag{5}$$

where,

I - cumulative infiltration (L); a -soil parameter, dependent on the initial moisture condition (L T$^{-n}$),

T - infiltration time (T); and  n - characteristic parameter of the soil, dimensionless and constant, whose value can be between 0 and 1.

The water movement in the lower profile (Q) was determined by the Darcy-Buckingham [eq. (6)]:

$$q = -K(\theta)\frac{d\psi t}{dx} \tag{6}$$

where,

q - water flow density in the soil (mm h$^{-1}$);  K($\theta$) - hydraulic conductivity in the soil (mm h$^{-1}$), and   $\frac{d\psi t}{dx}$ - total potential gradient (mm mm$^{-1}$).

The unsaturated hydraulic conductivity of the soil was determined according to [eq. (7)].

$$K(\theta) = K_0 w^L \left[ 1 - \left( 1 - w^{\frac{1}{m}} \right)^m \right]^2 \tag{7}$$

where,

$$w = \frac{\theta - \theta r}{\theta s - \theta r}$$

where,

w- relative saturation;

$K_o$- hydraulic conductivity of saturated soil;

L - empirical parameter, regarded as approximately 0.5 for most soils;

$\theta$ - soil humidity ($cm^3 cm^{-3}$);

$\theta r$ - residual soil moisture ($cm^3 cm^{-3}$), and

$\theta s$ - soil saturation moisture ($cm^3 cm^{-3}$).

In order to obtain the hydraulic conductivity of saturated soil (K0) the Guelph permeameter was used. The change in storage has been calculated based on [eq. (8)], considering the depth of 0.4 m.

$$\Delta h = (\theta_2 - \theta_1).z \tag{8}$$

where,

$\Delta h$ - storage variation at the time interval considered (mm);

$\theta_2$ - average moisture at the final time ($cm^3 cm^{-3}$);

$\theta_1$ - average moisture at the initial time ($cm^3 cm^{-3}$), and

z - depth considered for the balance (400 mm).

After harvest, the grains were weighed and had their moisture degree measured for weight correction to 13% of moisture on a wet basis (ARF et al., 2004; SANTANA, 2007). The grain weight was expressed in kg ha$^{-1}$. The harvest was done manually and the determination of moisture in standard meter at the Laboratory of Soil-Plant Relationship of IFTM, Campus Uberaba, MG. Productivity data, number of grains per pod and per plant were subjected to analysis of variance, the effects of the treatments studied by means of regression analysis or to a Scott-Knott test, as appropriate. The tool used for the analyzes was the Sisvar software for Windows, version 4.3.

**RESULTS AND DISCUSSION**

The replacement water depth applied varied between 316.95 and 666.60 mm (Table 2). During the experimental period there was precipitation of 36.80 mm (not counted in the final value). ARF et al. (2004) realized maximum irrigation of 219 mm and do not reach statistical difference in productivity when irrigated with different water depths. . LOPES et al. (2011) applied in their different treatments (methods of obtaining evapotranspiration) water depths between 410.5 and 471.1 mm, leading to the cultivar Pérola. For the cultivar BRSMG Talisman, SANTANA et al. (2009) used in their treatment of different replacement water depths values between 598.58 and 623.97 mm. It is noted that the water depth applied has a variation in the studies found between 250 and 600 mm, and that depending on the implanted local and cultivars.

TABLE 2. Water depths applied during the experimental conduction. (IFTM, Uberaba, MG, 2011).

| Water Replacement (%) | Water depths applied (mm) |
|---|---|
| 70 | 316.95 |
| 100 | 433.50 |
| 130 | 550.05 |
| 160 | 666.60 |

The analysis of variance revealed statistically effect of the interaction cultivar and replacement of water in the soil for bean yield (with the coefficients of the regression equations significant). There was an increase in productivity with subsequent decrease after the water depths

applications were considered excessive (Figures 1, 2, 3 and 4). The reduction in crop yield with excessive replacements was also verified by SANTANA (2007). When it was applied water depth corresponding to 70% of evapotranspiration, it was also observed lower yields. For PÀEZ et al. (1995) the reduction of water absorption and the subsequent dehydration of the cells compromise physiological processes, thus affecting all components of growth.
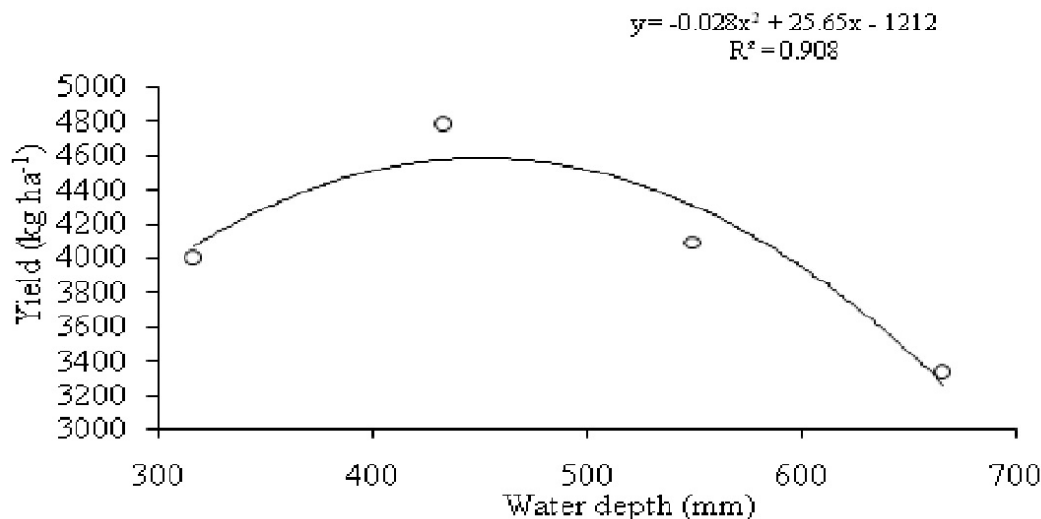


$$y = -0.028x^2 + 25.65x - 1212$$
$$R^2 = 0.908$$

FIGURE 1. Bean yield of cultivar Pérola due to irrigation water depths applied. (IFTM, Uberaba, MG, 2011).



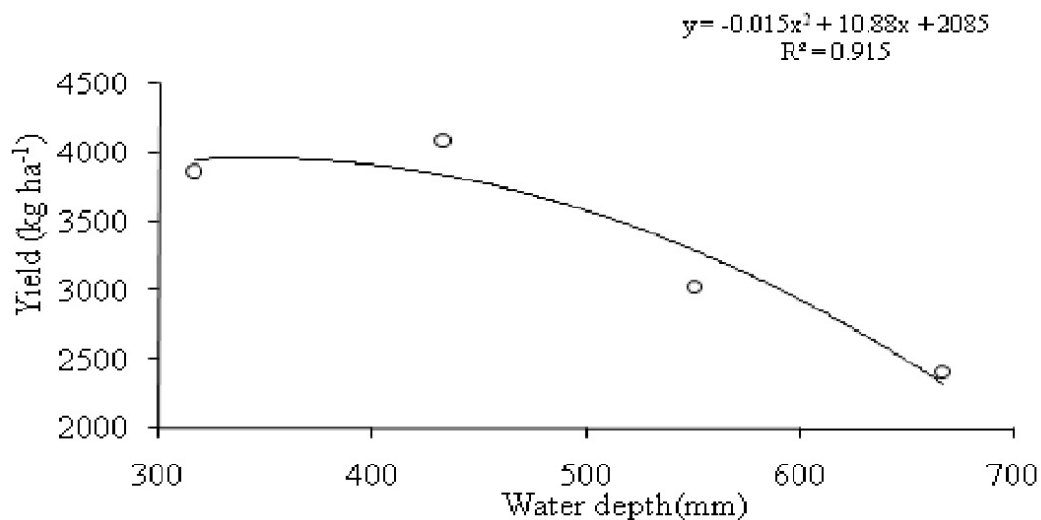$$y = -0.015x^2 + 10.88x + 2085$$
$$R^2 = 0.915$$

FIGURE 2. Bean yield of cultivar IAC Alvorada due to irrigation water depths applied. (IFTM, Uberaba, MG, 2011).
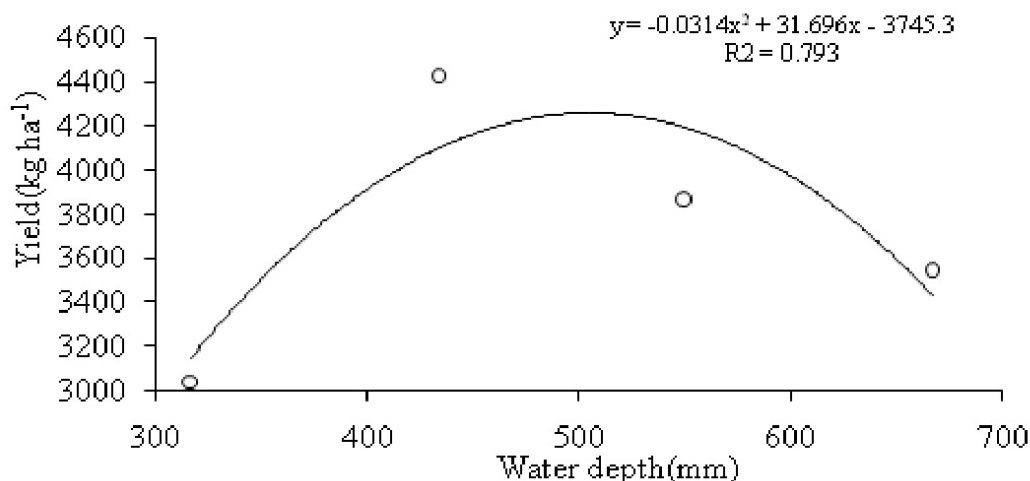
FIGURE 3.   Bean yield of cultivar BRSMG Majestoso due to irrigation water depths applied.
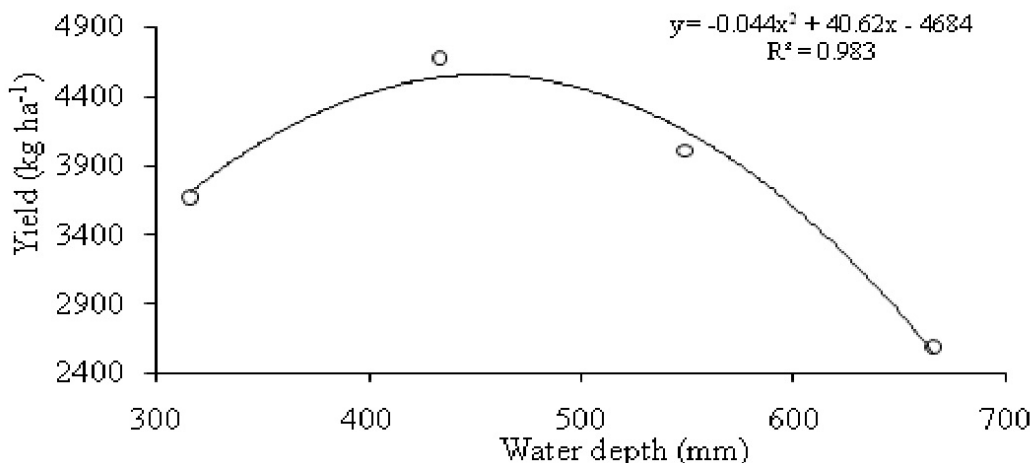(IFTM, Uberaba, MG, 2011).



FIGURE 4. Bean yield of cultivar BRSMG Madrepérola due to irrigation water depths applied.
(IFTM, Uberaba, MG, 2011).

Table 3 shows the average productivity values  according to the cultivars implanted. The irrigation was performed with 70% of evapotranspiration, the cultivar BRSMG Majestoso showed lower average productivity. Irrigations with higher replacements hindered the productivity of cultivar IAC Alvorada. SANTANA et al. (2008) found that the cultivar BRSMG Talismã when subjected to the water depths considered deficient as well as excessive, reduced most of its evaluated variables. LOPES et al. (2011) evaluated the productivity of bean crop under different methods of irrigation management, verified that the highest yields were 3031.11 kg ha$^{-1}$ and 3005.02 kg ha$^{-1}$ with management performed by Class A pan and Hargreaves-Samani equation (to obtain the reference evapotranspiration). FARINELLE & LEMOS (2010) found an average yield of 4157 kg ha$^{-1}$ and 4564 kg ha$^{-1}$ of growing bean in the dry season in two years of production, when evaluating different genotypes in the city of Botucatu, SP. These authors also concluded that the

bean productive potential was higher than those obtained in the literature, especially for the State of São Paulo according to the seasons studied. The cultivar Pérola in irrigated system in Cassilândia, MS, obtained yields of 3567 kg ha^{-1} and 3420 kg ha^{-1} when was applied molybdenum at 15 DAE and 26 DAE, respectively (ASCOLI et al., 2008). PAVANI et al. (2008) testing methods of irrigation management in tillage and conventional system found average yield of 1865.6 kg ha^{-1} and 2805.8 kg ha^{-1}, when the irrigation management was carried out by tensiometry in conventional and tillage system, respectively; 3394.6 kg ha^{-1} and 2755.0 kg ha^{-1} when irrigation management was performed by Class A pan (conventional and tillage system, respectively); it was used the cultivar IAC Carioca.

TABLE 3. The average bean yield (kg ha^{-1}) for each water replacement according to the cultivars. (IFTM, Uberaba, MG, 2011).

| Cultivars | Water Replacement (%)* | | | |
|---|---|---|---|---|
| | 70 | 100 | 130 | 160 |
| Pérola | 3993.43 a[1] | 4775.03 a | 4090.48 a | 3327.85 a |
| IAC Alvorada | 3861.69 a | 4097.42 a | 3034.47 b | 2412.69 b |
| BRSMG Majestoso | 3036.66 b | 4422.54 a | 3859.82 a | 3539.49 a |
| BRSMG Madrepérola | 3657.90 a | 4659.00 a | 4006.56 a | 2579.03 b |

[1] The means followed by the same letter in vertical not differ by Scott-Knott test; * compared to the crop evapotranspiration.

With increasing replacement of water in the soil it can be observed a decrease in the efficiency of water use (Figure 5). The water excess in the soil promotes among others the roots choking decreasing absorption, resulting in decreased productivity and reduced efficiency of water use (SANTANA et al., 2010). MUNOZ-PEREA et al., (2007) found a water use efficiency of 10 kg ha^{-1} mm^{-1}. SANTANA et al. (2008) reported values of water efficiency use ranging from 2.66 to 10 kg ha^{-1} mm^{-1} according to the replacement of water in the soil and seasons without irrigation, and the highest averages found occurred when irrigation was performed with 40% of crop evapotranspiration. The distribution of water and the maintenance of optimal levels of the soil moisture throughout the growing cycle reduce water losses by drainage and the periods of crop water stress which increases the efficiency of water use (SOUSA et al., 2000). It was proposed to find the optimal water depths and the point of maximum productivity from the first derivatives of the equations of Figures 1 to 4 equaling to zero (SANTANA et al., 2009). The larger water depth was applied when it was used the cultivar BRSMG Majestoso. The highest yield was obtained when the cultivar Pérola was cultivated (Table 4). Similar results were found by SANTANA (2007). SANTANA et al (2009) found great water depths to cultivar BRSMG Talismã of 605.31; 598.58 and 623.97 mm when irrigation was interrupted in the stages R9, R9 plus 7 days and R9 plus 14 days, respectively.
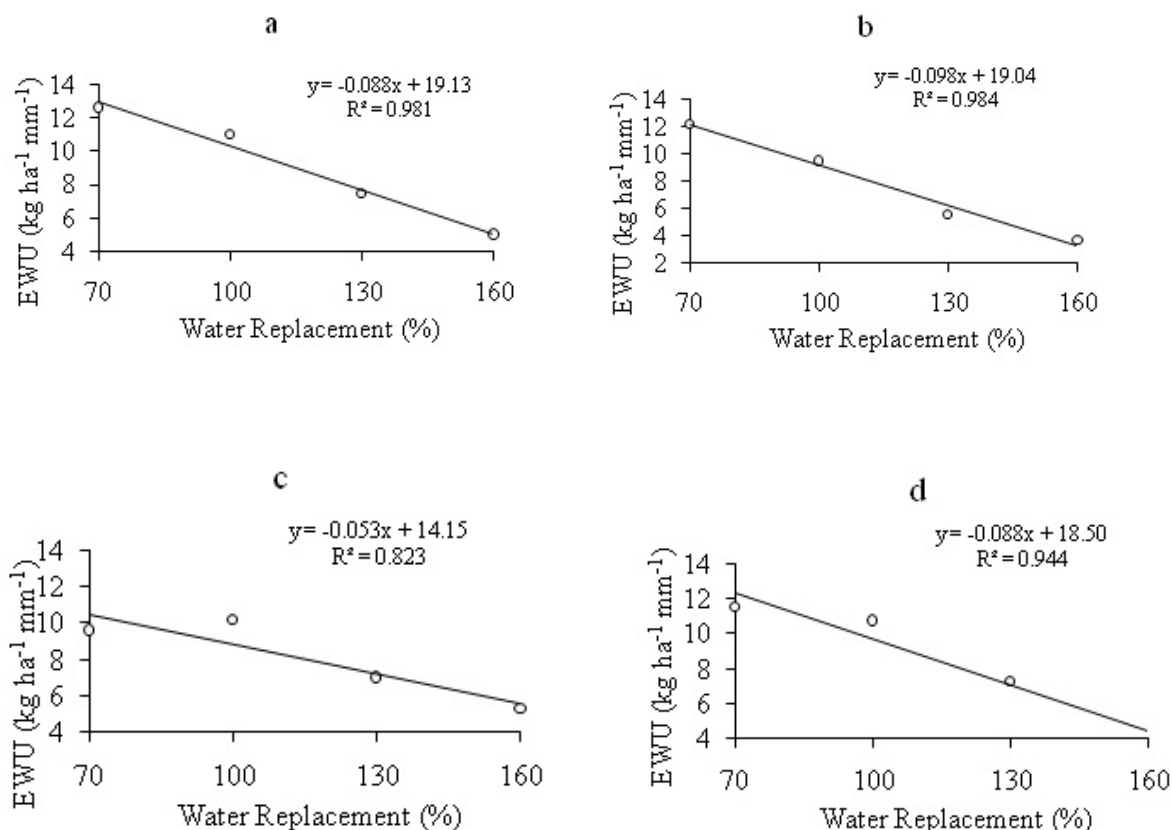
FIGURE 5. Efficiency of water use (EWU) for the cultivars: a)Pérola b) IAC Alvorada c) BRSMG Majestoso and d) BRSMG Madrepérola.

TABLE 4. Optimum physical water depth (O.W.D.) and optimum productivity (O.P.) for bean cultivars. (IFTM, Uberaba, MG, 2011).

| Cultivar | O.W.D. (mm) | O.P. (kg ha$^{-1}$) |
|---|---|---|
| Pérola | 451.61 | 4597.87 |
| IAC Alvorada | 344.30 | 3958.50 |
| BRSMG Majestoso | 504.71 | 4253.39 |
| BRSMG Madrepérola | 454.41 | 4546.27 |

For the number of grains per pod per plant there were significant effect only among cultivars. BINOTTI et al. (2007) have ascribe that the number of seeds per pod is more related to the cultivar, suffering little influence of cultural practices realized on the bean crop as irrigation and fertilization, and these values are usually between 4 to 5 seeds per pod. IAC Alvorada showed the lowest averages of these variables (Table 5). ARF et al., (2004) verified no difference for the number of grains per plant and number of seeds per pod as a function of the applied water depths in two growing seasons (2001 and 2002), being applied water depths between 150 and 287 mm.

The averages were similar to those observed by FARINELLI & LEMOS (2010) who found number of seeds per pod between 4.5 and 5.1 for water and drought crops. LOPES et al. (2011) observed that the number of seeds per pod was greater when irrigation management was carried out by tensiometry (3.93) and by Hargreaves-Samani (3.81). SANTANA et al. (2008) observed that there was no influence of the time of irrigation suspension and the applied water depths in the number of grains per plant and number of seeds per pod. According to the authors for the number of seeds per pod there was influence only of the replacement blades, stating an increasing of this variable to 100% of water replacement and subsequent decrease (average of 4.95 grains per pod).

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The highest number of seeds per pod presented by FRIZZONE et al. (2007) was 6.1 when irrigation was performed with sprinkler spacing (conventional) of 18 x 18 m and cultivar IAPAR 57.

TABLE 5. Number of grains per plant and seeds per pod of bean cultivars.(IFTM, Uberaba, MG, 2011).

| Cultivars | Number of grains per plant | Number of seeds per pod |
|---|---|---|
| Pérola | 152.66 a[1] | 5.26 a[1] |
| IAC Alvorada | 58.00 b | 4.41 b |
| BRSMG Majestoso | 116.33 a | 5.29 a |
| BRSMG Madrepérola | 67.50 b | 5.21 a |

[1] The means followed by the same letter in vertical not differ by Scott-Knott test.

There was a trend of increasing evapotranspiration of bean at flowering or pod production (Figures 6 and 7), being close to 60 days after sowing. MENDONÇA et al. (2007) observed that the amount of water transpired estimated by the Penman-Monteith equation was of 259.5 mm, while the sum of precipitation and irrigation events totaled 263.5 mm, when the experiment performed in Campos dos Goytacazes, RJ with cultivar UENF 47. According to the authors the highest value of ETo observed was 4.5 mm day$^{-1}$. PAVANI et al. (2008) found average values of actual evapotranspiration in the cycle of the cultivar IAC Carioca of 3.97 mm and 4.43 mm when the irrigation management was carried out by tensiometry (conventional and no tillage systems, respectively) and of 4.82 mm and 4.66 mm when the irrigation management was performed by Class A pan (conventional and no tillage systems, respectively).
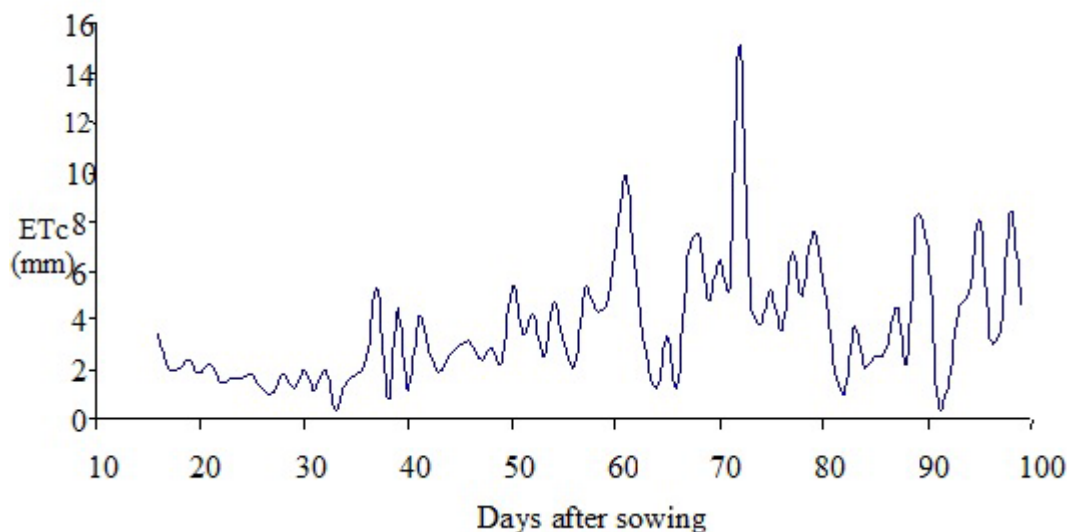


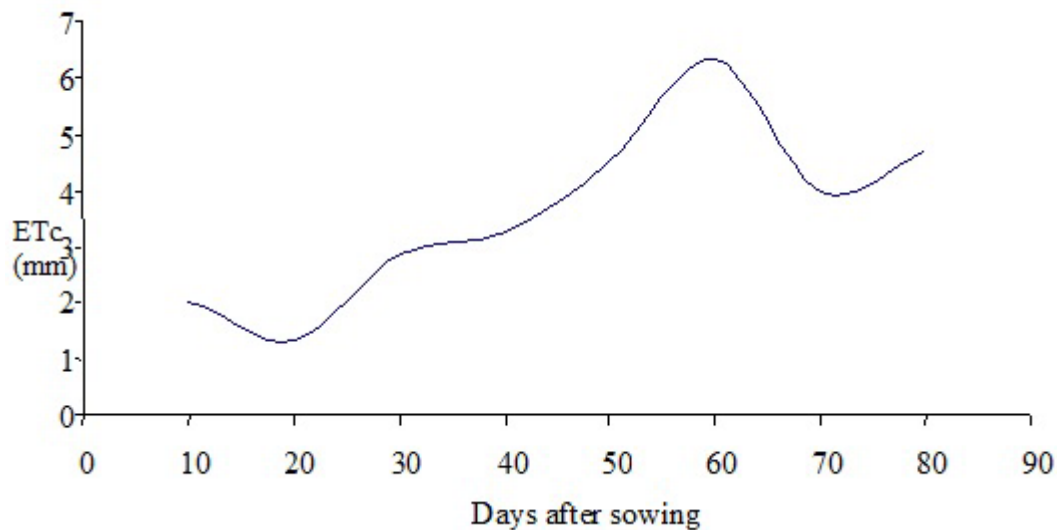FIGURE 6. Daily evapotranspiration observed. (IFTM, Uberaba, MG, 2011).

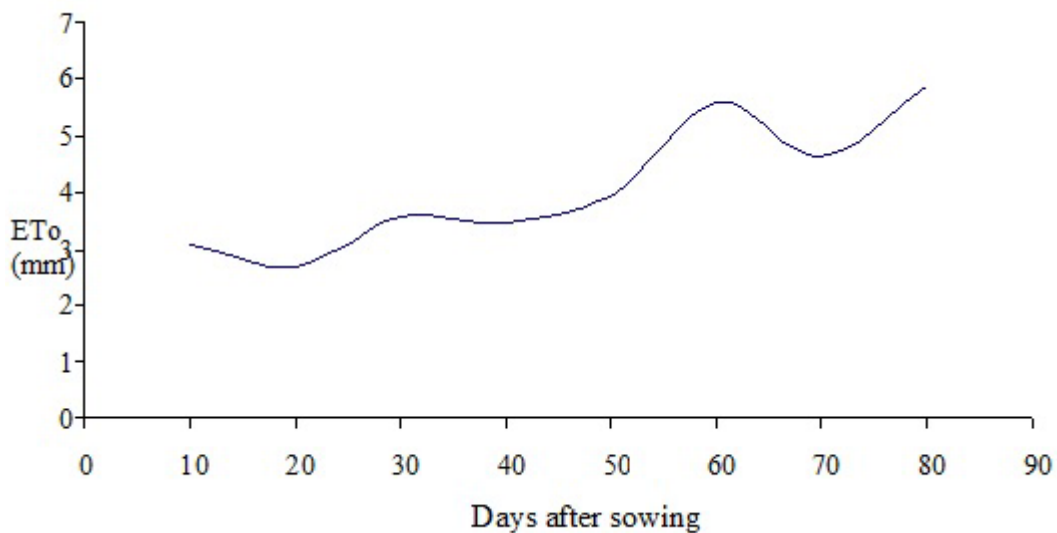FIGURA 7. Bean crop evapotranspiration (decendial mean). (IFTM, Uberaba, MG, 2011).



FIGURE 8. Reference evapotranspiration (decendial mean). (IFTM, Uberaba, MG, 2011).

There was an increase of the ETc in the implanted bean cultivars during the experimental conduction (Figures 9 to 12). The highest ETc was observed for cultivar Pérola, being a total in the cultivar cycle of 441.30 mm and average of 5.25 mm day$^{-1}$. The average and total values are shown in Table 6.
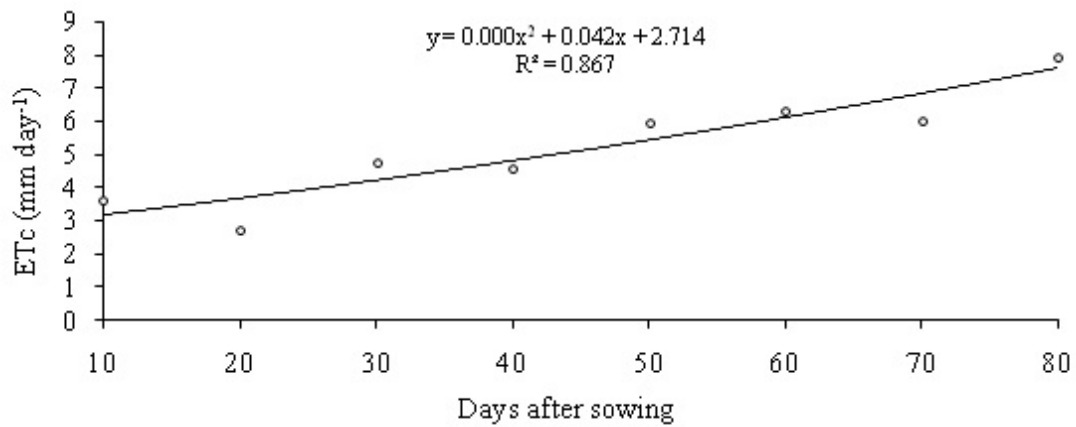
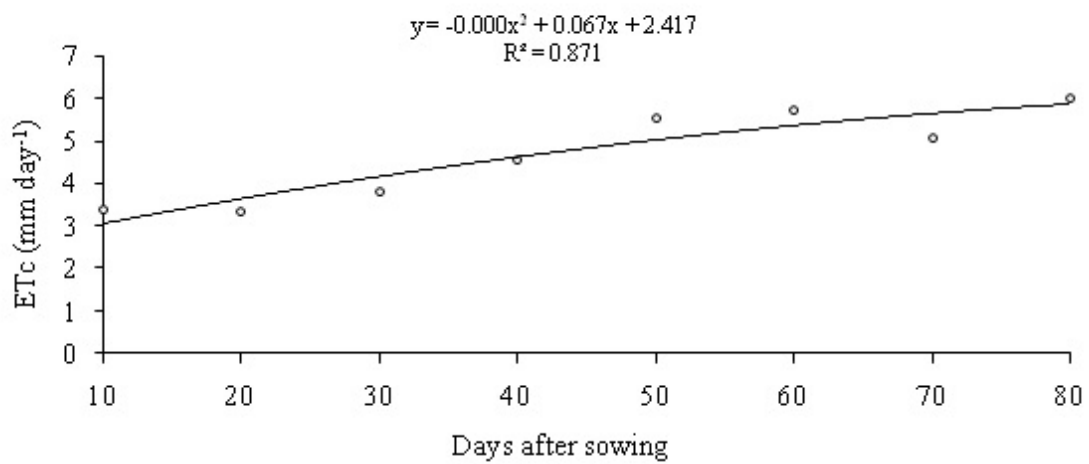FIGURE 9. Average evapotranspiration obtained by means of water balance in the soil for cultivar Pérola.



FIGURE 10. Average evapotranspiration obtained by means of water balance in the soil for cultivar IAC Alvorada.
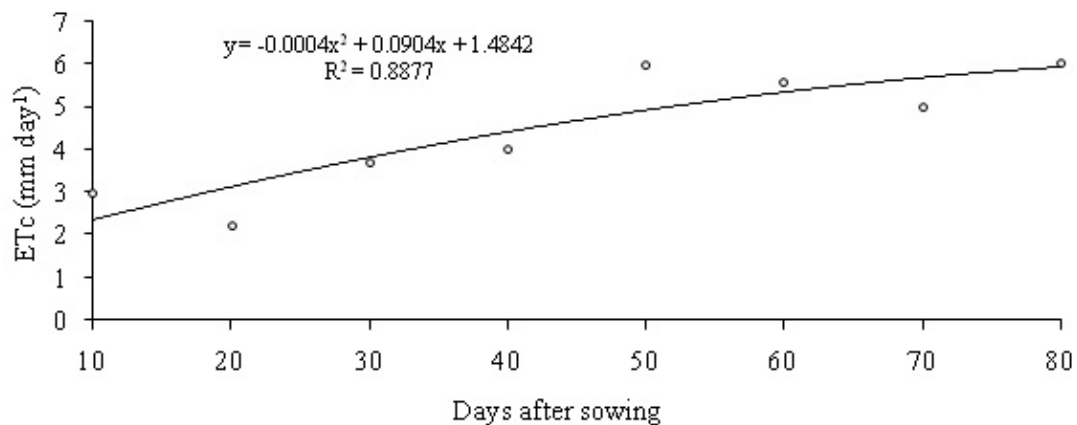
FIGURE 11. Average evapotranspiration obtained by means of water balance in the soil for cultivar BRSMG Majestoso.
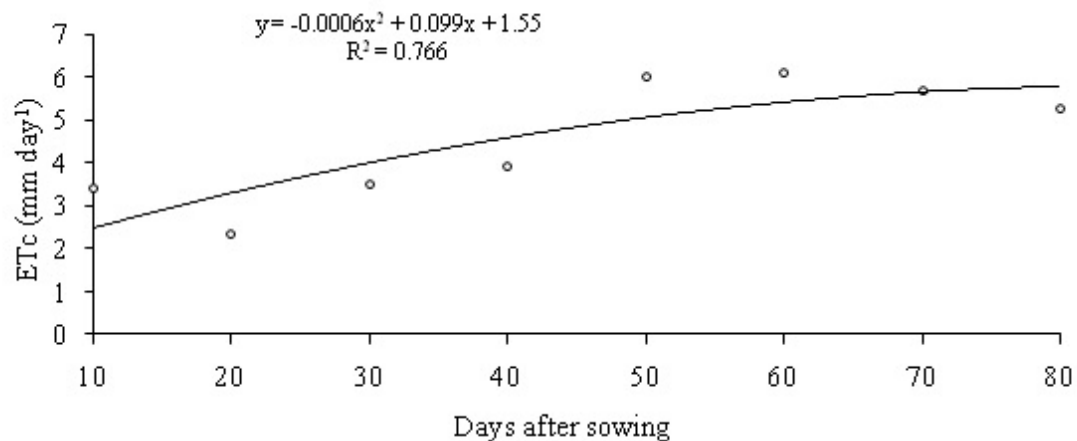


FIGURE 12. Average evapotranspiration obtained by means of water balance in the soil for cultivar BRSMG Madrepérola.

TABLE 6. Values (total and average) of the crop evapotranspiration obtained by the water balance in the soil for bean cultivars. (IFTM, Uberaba, MG, 2011).

| Cultivars | ETc (mm day$^{-1}$) | ETc average (mm day$^{-1}$) |
|---|---|---|
| Pérola | 441.30 | 5.25 |
| BRSMG Madrepérola | 386.04 | 4.59 |
| BRSMG Majestoso | 381.60 | 4.54 |
| IAC Alvorada | 400.37 | 4.77 |

**CONCLUSIONS**

The water depths that provided the maximum yield for the cultivars Pérola, IAC Alvorada, BRSMG Majestoso and BRSMG Madrepérola were respectively 451.61 mm (4597.87 kg ha$^{-1}$), 344.30 mm (3958.50 kg ha$^{-1}$), 504.71 mm (4253.39 kg ha$^{-1}$) and 454.41 mm (4546.27 kg ha$^{-1}$). The average evapotranspiration of the bean was 5.25, 4.59, 4.54 and 4.77 for the cultivars Pérola, BRSMG Madrepérola, BRSMG Majestoso and IAC Alvorada, respectively.

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