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INFLUENCE OF THE WATER DISTRIBUTION UNIFORMITY AND IRRIGATION DEPTH ON THE YIELD OF IRRIGATED BEAN CROP

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1 ABSCTRACT

This study aimed to evaluate the influence of the water distribution uniformity and three irrigation depths on the production variables for the bean crop, using a conventional sprinkler irrigation system, during the winter season. The treatments consisted of three irrigation depths and two uniformity levels of water distribution represented by the Christiansen uniformity coefficient (CUC). In the treatments L1A and L1B a sufficient water depth was applied to raise the soil water content to field capacity. The distribution uniformities (CUCs) were higher and lower than 80%, respectively. In treatments L2A and L3A, and L2B and L3B, the applied water depths corresponded to 50% and 150% of that applied to the LIA treatment. Because of rainfall events until the sampling date, no significant differences at 5% probability were found among treatments, when the variables were: leaf number, leaf area and dry matter. The F test for the contrast among the treatments with high and low uniformity was significant at 5% probability, when using 50% replacement of the water depth required by the crop. Significant differences were observed at 5% probability for pod number per plant among the treatments, when using 150, 100 and 50% replacement of the water depth required by the crop

KEYWORDS: irrigation uniformity, sprinkler irrigation, yield.

MANTOVANI, E. C.; FACCIOLI, G. G.; LEAL, B. G.; SOARES, A. A.; COSTA, L. C.; FREITAS, P. S. L. INFLUÊNCIA DA UNIFORMIDADE DE DISTRIBUIÇÃO DE ÁGUA E LÂMINA DE IRRIGAÇÃO NA PRODUTIVIDADE DO FEIJÃO

2 RESUMO

O presente trabalho teve como objetivo avaliar a influência da uniformidade de distribuição de água e de três lâminas de irrigação nas variáveis de produção da cultura do feijão, utilizando um sistema de aspersão convencional, no período de inverno. Os tratamentos constaram de três lâminas de irrigação e dois níveis de uniformidade de distribuição de água, representados pelo coeficiente de uniformidade de Christiansen (CUC). Nos tratamentos L1A e L1B foi aplicada uma lâmina de água suficiente para elevar a umidade do solo à capacidade de campo, com uniformidade de distribuição (CUC) maior e menor que 80%, respectivamente. Nos tratamentos L2A e L3A, e L2B e L3B as lâminas aplicadas foram, respectivamente, 50% e 150% da lâmina aplicada no tratamento L1A. Não existiram diferenças significativas, a 5% de probabilidade, nos tratamentos para seguintes variáveis:

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número de folhas, área foliar e matéria seca, em razão das chuvas ocorridas até a data da amostragem. O teste F para o contraste entre os tratamentos de alta e baixa uniformidade com 50% de reposição da lâmina requerida pela cultura foi significativo a 5% de probabilidade. Observou-se diferenças significativas, a 5% de probabilidade entre os tratamentos com 150, 100 e 50% de reposição da lâmina requerida pela cultura, para o número de vagens por planta.

UNITERMOS: Uniformidade de irrigação, irrigação por aspersão, produtividade.

3 INTRODUCTION

One of the most important challenges of present-day agriculture is to increase product competitiveness and quality while preserving the environment and permitting sustainable benefits in agricultural undertakings. In this context, it is important to assess and fit each one of the factors that make up a production system, including irrigation water efficiency and management.

Currently there is a great concern with preserving water resources and proper water use is increasingly valued and demanded. Agriculture has been responsible for a large part of the water used, so efficient irrigation systems need to be implanted in addition to using methods that quantify crop water requirements so there is no waste. This quantification system allows more efficient irrigation systems to be designed and consequently reduces water and energy consumption.

Water use in agriculture represents, at a global scale, about 70% of all freshwater consumed, whereas industry uses 23% and human requirements are of 7% (Santos, 1988). This fact shows the need for irrigators, the main users, to use it with the greatest efficiency possible because usable water reserves are increasingly scarce, especially at sites regions where they are badly distributed over time, as it is in the semiarid region of the Brazilian Northeast.

The increase on the cost of energy, drought periods, increasing competition for water by urban interests and growing concern with problems related to water quality, in conjunction with the return flows of irrigation, are only a few of the reasons to maximize irrigation efficiency. Unfortunately, even if all the other factors in the irrigation system management were known precisely, water could not be applied uniformly on the field with the existing irrigation systems. An irrigator should, therefore, consider the advantages and disadvantages between applying sufficient water to properly irrigate the whole area (causing excessive irrigation in some spots, increasing pumping costs and nutrient lixiviation) or applying less water in some areas and allowing them to be improperly irrigated (bring about reduced yields) (Walker, 1979).

Climate is a preponderant factor in plant development because it determines conditions for maintaining the dynamic of life. In the case of bean crop, the factors that most interfere in the generation of the development stages are temperature and water. The ideal average temperature for bean plant cultivation is of 21°C, and regions considered suitable for such crop are these that present mean air temperatures changing from 15 and 29.5°C (Neto & Fancelli, 2000).

High temperatures increase the fiber content in the pods. Germination requires a soil temperature of 15°C or more, taking approximately 12 days to germinate at 18°C and about 7 days at 25°C. Most bean plant varieties are not affected by day length (Doorenbos & Kassan, 1979).

The bean crop develops well in zones with moderate rainfall, but it is not suitable for cropping in wet tropical zones. Excessive rain and hot climate cause flower and pod fall and increase diseases incidence (Doorenbos & Kassan, 1979).

Regarding water, the bean crop is considered as a species that is not very tolerant to water shortages that can affect the generation of some stages of its development, frequently culminating to a reduced biological cycle of the plant. The crop requires a minimum of 300 mm rainfall to produce satisfactorily without irrigation.

Thus, regions with precipitations oscillating between 250 and 500 mm annually are considered suitable for the establishment of the crop, although such limitation is more directly conditioned to distribution than to the total quantity of rain occurring throughout the crop growing season (Neto & Fancelli, 2000).

Cropwater requirements to obtain maximum yields with a 60 to 120 days range from 300 to 500 mm, depending on climate. The water requirements during the maturation period depend greatly on the fact that the plant can be harvested green or dry. When cultivated for fresh marketable yield, the production formation stage is relatively short, and during maturation (which lasts for roughly 10 days) evapotranspiration is relatively low because the leaves got dry. When the crop is for green production, the maturation period is longer and a decrease in evapotranspiration is relatively pronounced (Doorenbos & Kassan, 1979).

Several authors (Doorenbos & Pruitt, 1977; Mantovani, 1986; Vieira, 1978) reported that the critical periods for water shortage are: the start of germination, flowering and pod swelling. Regarding the soil moisture content, the bean crop is sensitive to shortage and excess. The flowering and start of fructification stages are the most sensitive to poor soil aeration and the bean crop does not withstand even a minimum of two days flooding in the root zone without loss in the production and yield.

The first water distribution uniformity concept was developed by Christiansen (1942), and is commonly called the Christiansen Uniformity Coefficient (CUC) (Walker 1979). It is one of the most used to quantify water application uniformity by a conventional type of irrigation system, and is expressed by the following equation:

$$CUC = 100\left[1 - \frac{\sum_{i=1}^{n}\left|X_I - X_m\right|}{n\,X_m}\right] \qquad (1)$$

Where

CUC – Christiansen Uniformity Coefficient, in %

N - number of collectors in the area among four emitters

Xi - water depth collected in the i-eth collector, in mm

Xm - mean value of collected water depths, in mm

Freitas (2000) studied the effect of water distribution uniformity and irrigation depths on yield in corn cropping. The author worked with two CUC levels, one over (84%) and another under (67%) the recommended for conventional sprinkler irrigation and with five irrigation depths (50, 75, 100, 125 and 150% of the irrigation depth to meet the water needs of the crop). For the treatments with 100% recommended water depth replenishment to meet the water needs of the crop and 84 and 67% CUC, the author observed the influence of water distribution uniformity on crop yield which were of 6,413 and 4,675 kg ha^{-1}, respectively, with statistical differences at the level of 5% probability faced with the application of the

Tukey test. For the treatments with 50% water depth replacement to meet the water requirements of the crop and 84 and 67% CUC, the opposite was observed, because the treatment with low application uniformity resulted in an yield of 3.035 kg ha^{-1} whereas under the treatments with high distribution uniformity yield was of 2,085 kg ha^{-1}, again presenting significant differences by the Tukey test at 5% probability.

The objective of the present study was to assess the influence of water distribution uniformity and several variable irrigation depths on bean crop yield, using a conventional sprinkler system throughout the winter season at the state of Minas Gerais, Brazil.

4 MATERIAL AND METHODS

The study was carried out at the Coimbra Experimental Station of the Department of Plant Science at the Federal University of Viçosa, located in Coimbra – MG (20º 51´S, 42º 47´W and 720 m altitude), from July to December 2000.

An experiment was setup in a randomized block design to verify the influence of water distribution uniformity and water depth on irrigated bean crop yield. Figure 1 shows the experimental plan with the statistical design.

The treatments consisted of three irrigation depths and two water distribution uniformity levels, represented by the Christiansen uniformity coefficient (CUC). Each treatment or experimental plot consisted of three blocks or three replications 12 m wide and 12 m long, in a total area with a 12 m width and 36 m length

Table 1. Granulometry analysis

Depth (cm)	Sand (%)	Silt (%)	clay (%)
0 – 20	11	18	71
20 – 40	08	06	86
40 – 60	02	27	69
60 – 80	03	39	58

The treatments were called L1A, L1B, L2A, L2B, L3A and L3B. In the treatments L1A and L1B, a sufficient water depth was applied to raise soil moisture to field capacity, with a water distribution uniformity (CUC) greater and lower than 80%, respectively. The water depths applied in treatments L2A and L3A were respectively 50% and 150% of the water depth applied in the L1A treatment, with a water distribution uniformity (CUC) greater than 80%. In the L2B and L3B treatments, the water depths applied were, respectively, 50% and 150% of the water depth applied in the L1A treatment with a water distribution uniformity (CUC) lower than 80%.

Nine water collectors were installed in each block at a height of 1 m from the soil surface, spaced 3 m apart totaling 27 for each experimental plot and 162 for the whole area to determine the precipitated water depth and the CUC (Figure 1).

The experimental data taken into account to analyze the production variables were collected in 1m^2 areas around the collectors and the results obtained from each replication of each plot were considered for the statistical analysis.

For the treatments with CUC greater than 80%, that is, with a high water distribution uniformity, four sectorial sprinklers were used within each block, with a turning angle of 180°, placed as shown in Figure 2(A). For the treatments with a CUC less than 80%, that is, with a low water distribution uniformity, two sectorial sprinklers were used within each block, with a turning angle of 90°, on one of the diagonals, as shown in Figure 2 (B).

To obtain a low water distribution uniformity, the deflector of only one of the sprinklers in the block was activated. Thus the water jet was fractioned and did not reach all the collectors but the water jet from the other sprinklers located on the opposite diagonal, reached in all the collectors. In the following irrigation, only the deflector of the other sprinkler was activated, always preventing the same areas of the block from receiving a much greater water depth.

The soil was plowed and graded to cultivate the Common Bean, cultivar Pérola. The sowing and fertilization with 700 kg ha^{-1} fertilizer of the 4-14-8 formulation were mechanized and performed on August 10, 2000, with spacing of 50 cm between row spacing and 8 cm between plants along the sow , totaling 12 seeds per meter. Emergence occurred on August 20, 2000. The crop was mulched 20 days after emergence with 100 kg ha^{-1} urea and 100 g ha^{-1} molybdenum.

A fixed conventional sprinkler irrigation system was used, with a 12x 12m spacing between the lateral rows as well as between sprinklers (Figure 1). A 30 m^3 h^{-1} capacity hydrometer was installed at the system entry to monitor the water volume and at the entry of each experimental plot, a slide valve and a manometer were installed to control and monitor the working at pressure of the system, operating at a pressure of 285 kPa and 0.68 m^3 h^{-1} flow.

To establish the crop, all the treatments were irrigated with the same irrigation depth on August 11, 14, 18, 21 and 25. The water depths applied were sufficient to return the soil moisture to field capacity.

Irrigation with the different specific water depths for each treatment was to be weekly starting from September 22. Five irrigation applications were made on September 22, October 5, 13, 20 and 28. The irrigation on September 29 was not performed owing to a 10.6 mm rainfall on the previous day.

The water depths were differentiated only after September 22, because of the rainfall and operational problems. Heavy rains damage the water capture system, precluding the irrigation system at the experimental farm from being used. An alternative pumping system was installed (diesel motor pump), whose precarious operation compromised the first irrigation episode on September 22. After the first irrigation episode, the electric motor pump system was used at the Coimbra Experimental Station.

Throughout the period at which irrigation could not be applied, events of precipitation occurred on September 2, 3, 4, and 6 at amounts of 22.8; 19.4; 2.2; and 7.4 mm, respectively. The maximum period of time brief of irrigation was 15 days and occurred during the initial crop development stage. At this phase the evapotranspiration demand was low and the soil could meet the water requirements of the crop because of its good water storage capacity.

A NAAN sectorial sprinkler, model AG 427, was used a long with a 3.5 mm nozzle.

The soil moisture was determined by the standard chamber method, using samples taken from the 0-20, 20-40 and 40-60 cm layer, at the moisture monitoring points. Figure 1 shows that for the L1A and L2A treatments, the moisture monitoring points were located beside three collectors in block 2 whereas for the L1B and L2B treatments the monitoring points were located right beside the nine collectors in block 2. There were, therefore, 24 moisture monitoring points along the experimental units.

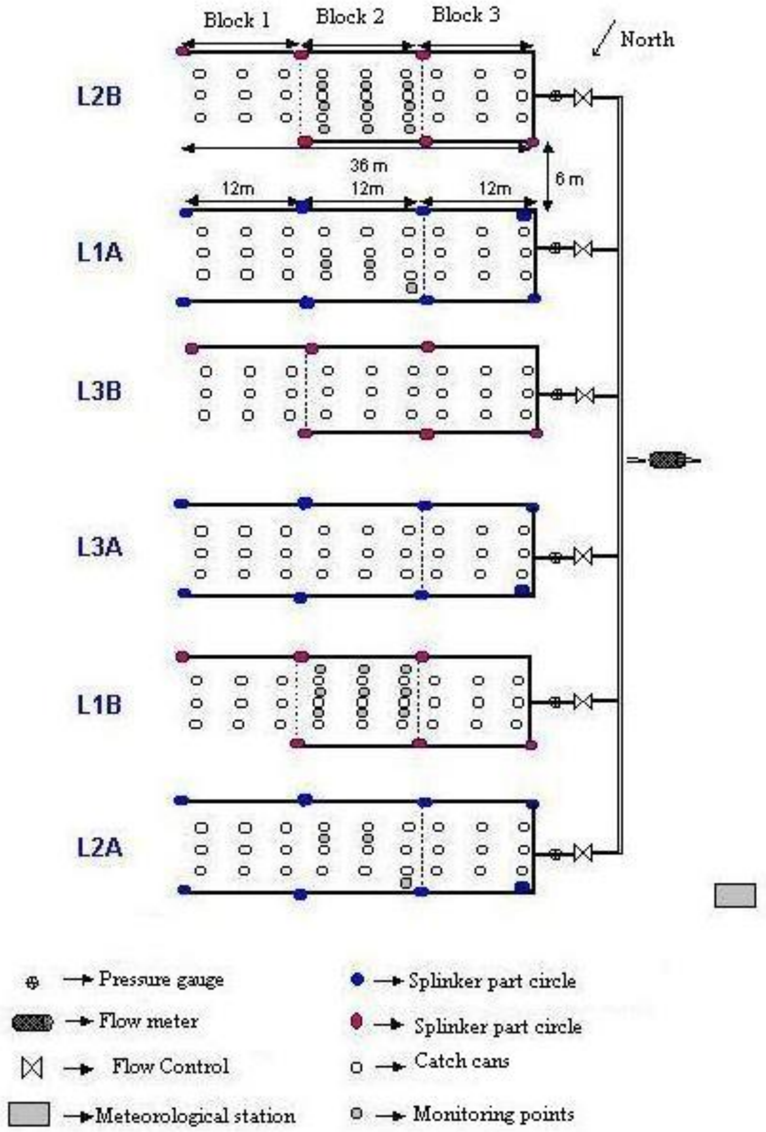

Figure 1. Experimental Scheme.

Sampling was carried out weekly, starting on September 20 in the morning of the day prior to the irrigation events, at the 24 monitoring points and in the three layers studied. Immediately after sampling, the 72 recipients, containing the soil material, were taken to the Water and Soil Laboratory at the Department of Agricultural Engineering and placed in a chamber at 105°C for a period of 24 hours.

The net water depth to be replaced in the soil, at each irrigation, was calculated using the mean moisture obtained at the three monitoring points of the L1A treatment at the 0-20, 20-40 and 40-60 cm layers and was determined by the following equation:

$$L = \frac{(CC - UA)}{10} Z \quad (2)$$

where

L - net water depth applied at each irrigation, in mm

CC - field capacity (% volume)

UA - soil moisture on the day prior to irrigation, within the roots effective depth (% volume)

Z - roots effective depth determined by the water extraction profile, cm

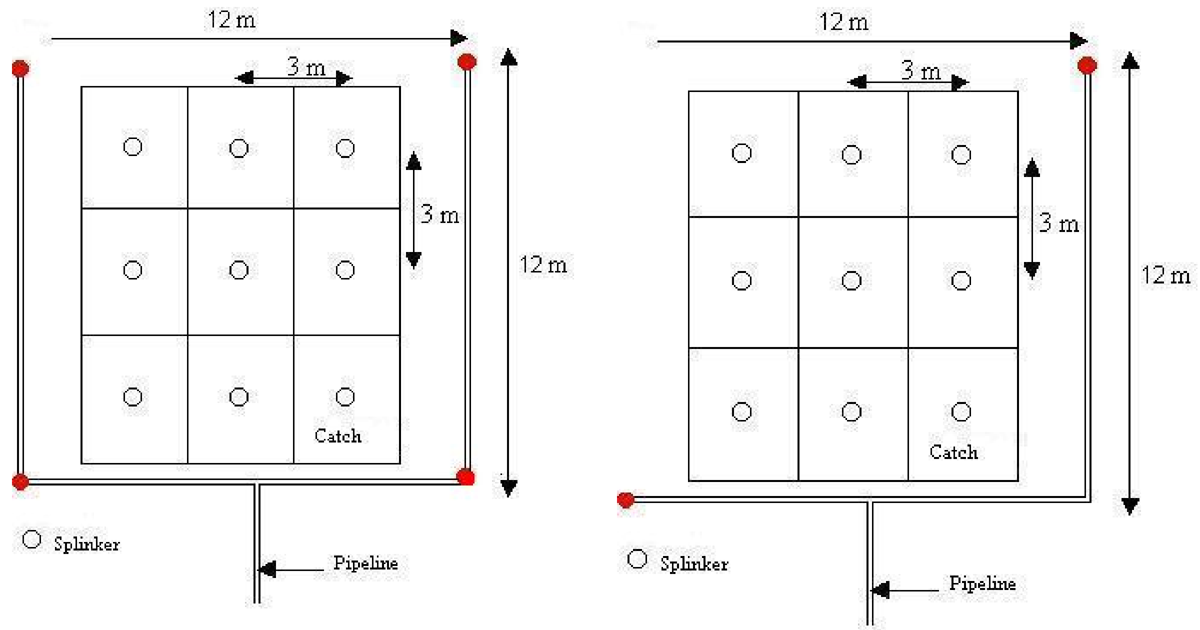

Figure 2. Experimental design plan with high and low water distribution uniformities, with four sprinklers on the sides.

As the irrigation applications were made at similar times, the gross water depth to be applied was determined using the application potential efficiency, estimated from the previous irrigation applications.

After determining the gross water depth to be applied to the L1A and L1B treatments, the other water depths were determined for the other treatments, and were 50% lower for the L2A and L2B treatments and 50% greater for the L3A and L3B treatments.

The water volume applied at each treatment was calculated considering its area of influence, depending directly on the turning angle of the sprinklers (Figure 1). The treatment areas with high and low water distribution uniformities were, respectively, of 576 m^2 and 432 m^2.

The hydrometer not only permitted monitoring of the volume of water applied to each treatment but also indicated the moment at which one should stop irrigation. At this moment the slide valve was activated, interrupting irrigation of a respective treatment while the operation pressure of the system was controlled by other valves.

5 RESULTS AND DISCUSSION

Table 3 shows the maximum, minimum and mean temperatures, mean relative humidity, mean wind speed, solar radiation and rainfall throughout the crop growing season.

The average temperature during the crop cycle was of 19.32°C, considered therefore within the ideal range for bean crop, According to Neto and Fancelli (2000) energetic requirements for such a crop must meet air temperature ranging from 15 to 29.5°C, under our environmental conditions the mean temperature for the whole cropcycle close to the ideal average temperature for the development of the crop, reported to be 21°C.

Table 3. Maximum, minimum and mean temperatures, mean relative humidity, mean wind speed, mean solar radiation and rainfall during the crop cycle.

T_{max} (°C)	T_{min} (°C)	T_{mean} (°C)	RH_{mean} (%)	V_{mean} (m/s)	Qg_{mean} (W m^{-2})	P (mm)
32.10	5.30	19.32	67.32	1.26	202.79	246,00

Table 4. Values of water depth applied throughout the cropping season, Christiansen uniformity coefficient (CUC) and efficiency for the six treatments.

Treatments	M_GWD (mm)	NWD (mm)	WD_{Mean} (mm)	WD_{max} (mm)	WD_{min} (mm)	MAE (%)	CUC_{mean} (%)	CUC_{acum} (%)	CV (%)
L1A	154.76	134.95	111.50	139.21	78.63	72.04	84.39	87.86	15.41
L1B	154.76	134.95	110.19	142.90	51.65	71.20	69.45	82.57	19.46
L2A	77.38	67.48	60.27	74.56	41.74	77.88	86.17	88.71	14.82
L2B	77.38	67.48	50.42	72.42	21.55	65.15	67.30	81.66	24.42
L3A	232.14	202.43	161.71	188.34	113.58	69.66	88.64	91.64	11.74
L3B	232.14	202.43	162.89	207.75	76.11	70.16	69.62	83.76	17.89

M_GWD -Mean gross water depth applied; NWD –Net water depth; WD_{Mean} Mean water depth; WD_{max} - Maximum water Depth ; WD_{min} -Minimun water depth; MAE- Mean Application
Efficiency

Figure 3(A) shows that the lowest temperature recorded during the crop cycle was 5.30°C and occurred on August 14 and 15, four and five days after planting. Emergence occurred 10 days after sowing and low temperatures were observed during this period, especially on August 13, 14 and 15. The highest temperature occurred on October 13 and was of 32.10°C.

Figure 3(B) shows that the longest time period benefit precipitation was of 17 days, occurring from October 2 to 18. The total rainfall stored up during the crop cycle was of 246mm.

Table 4 shows the values of the gross water depth applied, the net water depth, the mean, maximum and minimum water depth collected, mean application efficiency, mean Christiansen uniformity coefficient (CUC), accumulated CUC and coefficient of variation for all the treatments considered here in.

The gross water depth values applied and the net water depth are shown in Table 4 depicting the sum of the gross and net water depths of the irrigations carried out on September 22 and October 5, 13, 20 and 28. According to the methodology reported previously, the L2A and L2B treatments received 50% of the gross water depth adapted for the L1A treatment, corresponding to the water depth necessary to return the soil moisture to field capacity, and the L3A and L3B treatments received a 150% water depth. Applications of 154.76; 77.38; and 232.14 mm, were made to the L1A and L1B, L2A and L2B, L3A and L3B treatments, respectively.

The crop leaf area was measured on October 25, at 67 days after emergence, by the end of the III development phase of the crop.

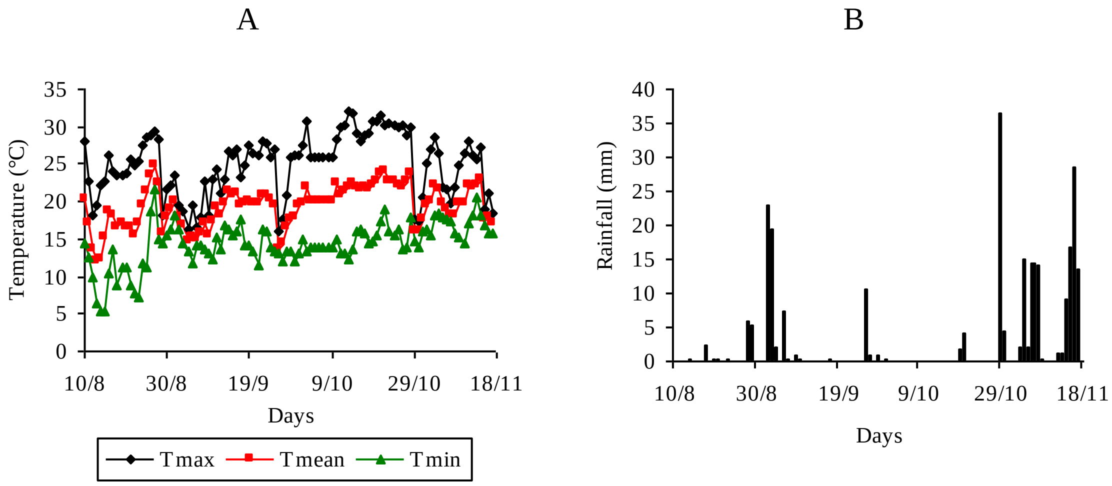

Figure 3. Mean, maximum and minimum temperatures (A) and rainfall (B) regimes throughout the entire crop growing season

Table 5 shows that there were no significant differences at 5% probability on the number of leaves and leaf area among the six treatments studied. It is important to emphasize that at sampling procedure only four irrigations had been performed, totaling a 110.54 mm gross water depth on the treatments that received the amount of water required by the crop plus the rainfall observed in the plantation until the sampling date totaled 86.8 mm. Therefore, the application of water depth 50% lower and 50% greater than the water depth required by the crop, with different water distribution uniformity levels, did not affect the plant growth of the crop. These results are in compliance with the ones reported by Doorenbos & Pruitt (1977); Vieira (1978). These authors demonstrated that the vegetative phase is not critical for the bean crop in terms of soil water supply.

Plants selected for analysis of yield variables were harvested at 1m^2 areas around the collectors in the three blocks for all treatments, totaling 27 samples per treatment and 162 in the whole experimental unit.

Table 5. Comparison on the number of leaves per plant (NLP) and leaves area (LA) along with means measured at 67 days after sowing (DAS) among all treatments by provided the analysis of variance.

Treatments	NLP	LA(cm^2)
L1A	61,7 A	1.391,4 A
L1B	56,0 A	1.264,9 A
L2A	48,7 A	973,0 A
L2B	48,3 A	1.091,0 A
L3A	64,3 A	1.411,9 A
L3B	61,0 A	1.505,7 A

Table 6 shows the maximum, minimum and mean dry matter values (DM), the standard deviation and the coefficient of variation, for all treatments.

Table 6 shows that for the treatments that received a gross water depth 50% lower and 50% greater than the water depth required by the crop (L2A and L2B, L3A and L3B, respectively), the dry matter values presented greater variability under the low uniformity conditions. Table 6 shows that there were no significant differences at 5% probability in the dry matter. For the L1A and L1B treatments, the variation coefficient of variation was greater under the high uniformity conditions.

Table 6. Dry matter (DM) kg ha^{-1}, standard deviation and coefficient of variation for the treatments.

Treatments	DM Maximum (kg ha^{-1})	DM Minimum (kg ha^{-1})	DM Mean (kg ha^{-1})	standard deviation	VC (%)
L1A	1.748,00	821,00	1.084,74 A	202,89	18,70
L1B	1.338,00	789,00	1.018,70 A	162,37	15,94
L2A	1.187,00	624,00	861,00 A	134,09	15,57
L2B	1.636,00	889,00	1.134,11 A	191,53	16,89
L3A	1.420,00	954,00	1.145,89 A	144,43	12,60
L3B	1.761,00	756,00	1.105,96 A	214,65	19,41

Table 7 presents the comparison among the NPP means, using the Tukey test at a 5% probability.

The results detected for the number of pods of plant (NPP) for the L3A and L3B treatments were greater than the results of the L1A and L1B treatments and these were greater than the results for the L2A and L2B treatments.

These results were consonance with the outcomes obtained by Doorenbos & Pruitt (1977) and Vieira (1978) who reported that for bean, the third phenological stage (comprising flowering and pod formation) was very sensitive to soil water shortage under their experimental conditions.

Table 7. Comparison among the NPP means, using the Tukey test at a 5% probability level.

treatments	NPP
L3A	11,39 A
L3B	11,53 A
L1A	9,60 B
L1B	8,90 B
L2A	6,75 C
L2B	7,65 D

It is important to emphasize that all the irrigation applications were made during this phase. While the gross water depths applied were 154.76 mm for the L1A and L1B treatments, 77.38 mm for the L2A and L2B treatments and 232.14 mm for the L3A and L3B treatments, the rainfall observed in this period totaled 18.6 mm.

Therefore, the water depth applications 50% lower and 50% greater than the water depth required by the crop along with the low rainfall indices observed during the third phenological stage affected significantly number of pods per plant among treatments a 5% probability level.

Table 8 shows that for the treatments that received a gross water depth 50% greater than the water depth required by the crop (L3A and L3B) the yield presented greater variability under low uniformity conditions, because under these conditions the coefficients of variation were greater. For the L1A and L1B treatments as well as the L2A and L2B treatments the coefficient of variation of was greater under high uniformity conditions.

The yields obtained for the L1A, L1B, L2A, L2B, L3A and L3B treatments were 2,576.42; 2,228.68; 1,206.85; 1,693.22; 3,401.44 and 3,189.63 kg ha^{-1}, respectively, and the values detected for the (L1A and L1B) treatments, where the water depth necessary for the soil moisture to return to field capacity was adequate, were within the yield range expected under irrigated agricultural conditions.

Table 8. Shows the values of the maximum, minimum and mean yield (P), standard deviation and coefficient of variation for all treatments.

Treatments	Yield maximum (kg ha^{-1})	Yield minimum (kg ha^{-1})	Yield Mean (kg ha^{-1})	Standard Deviation	cv (%)
L3A	4,617.57	2,283.84	3,401.44 A	569,08	16,73
L3B	4,115.69	1,725.61	3,189.63 A B	600,98	18,84
L1A	4,497.99	1,785.90	2,576.42 A B C	592,71	23,01
L1B	2,886.80	1,475.37	2,228.68 B C	402,01	18,04
L2B	2,600.93	1,106.91	1,693.22 C D	309,52	18,28
L2A	1,624.20	773.04	1,206.85 D	250,17	20,73

In Table 8, the treatments followed by the same letter were not significantly different at a 5% probability level. Mean yields obtained for the L3A, L3B and L1A treatments were similar but highest than the others. We concluded that the gross water depth applied for the L1A treatment necessary to cause the soil moisture to return to field capacity was adequate, because the yields obtained from this treatment were statistically similar to those assessed for the treatments that received a 50% greater gross water depth. These results corroborate those reported by Freitas (2000).

Mean yields obtained from the L3B, L1A and L1B treatments were similar and highest from those for the L2A and L2B treatments, while from the L1A, L1B and L2A treatments mean yields were similar and highest from productivities obtained from the L2A treatment.

Rainfall was well distributed throughout the fourth phenological stage of the bean crop, corresponding to the grain filling and harvest sub periods. The total rainfall was 159.2 mm. However, application of water depths 50% lower and 50% greater than the water depth of required by the crop during the third phenological phase, the most sensitive one to water deficit, along with low rainfall amounts observed at such crop growth stage significantly affected yield at 5% among the treatments.

6 CONCLUSIONS

Based on the environmental conditions under which the current study was carried out, we concluded that:

There were no significant differences at 5% probability for the number of leaves, leaf area and dry matter among the six treatments defined here in as a function of the rainfall regime until the beginning of the sampling date.

With regard to the number of pods per plant significant differences were observed at 5% probability among the treatments with 150, 100 and 50% replacement of the water depth required by the crop.

From the high and low uniformity treatments with 150% replacement of the water depth required by the crop, as well as from the high uniformity treatment with 100% replacement, mean yields were similar and highest than those obtained for other treatments .

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