

Effects of Irrigation Levels on bean Growth and Yield parameters

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ABSTRACT

Bean belongs to legumes, which play a significant role in human nutrition. An experiment was carried out in a greenhouse to evaluate the irrigation level which could effectively improve bean crop growth and yield parameters. It was laid out as completely randomized blocs design and has considered three treatments of irrigation levels (treatment T1 (5%), T2 (35%) and T3 (65%)) with six replications for each. The recorded parameters were the leaves number, stem diameter, plant height, leaf area, and production attributes. The results highlighted treatment T2 as the most effective treatment. It has significantly improved the leaves number, stem diameter, plant height and leaf area. Moreover, treatment T2 has enhanced the fresh and dry weight of leaves, stem and roots. This treatment T2 can be used to improve the bean growth and yield parameters in Bujumbura peri - urban zone.

Key words: Irrigation levels, Bean crop, Growth, Yield parameters.

1. INTRODUCTION

The crop bean belongs to legumes which play a significant role in human nutrition ^[1]. It is a good source of vitamins such as thiamine, riboflavin, niacin, vitamin B6, and folic acid. Xu and Chang (2008) revealed higher beans nutrients component such as phenolics and antioxidant components ^[2], whereas other researchers reported that beans are nutritional with protein, fiber, B vitamins and potassium ^[3]. Beans contain several vital nutrients, including folate which helps to prevent neural tube defects in a fetus during pregnancy ^[4]. Foregoing research affirmed that bean is the first source of vitamins and micronutrients as iron and zinc ^[5]. It is recognized as an important source of human dietary protein and calories ^[6]. Moreover, bean production and marketing can be a potential pathway for improving rural livelihoods. In Burundi, it is the major culture which is daily consumed for the whole population. Recent research revealed that consumption demand of beans in this country is expected to increase due to high population growth, lack of protein animal source and the higher prevalence of HIV/AIDS that necessitates an improved intake to maintain good health ^[5]. Whence finding a technology for improving bean growth and yield is more appreciable for the whole country. Based on the climate changing nowadays and that the soil water deficit is a principal factor that limits plant growth and yield, this study has proposed irrigation technology to evaluate the rate which could effectively improve this crop. It intends to analyze the effects of different irrigation levels on bean growth and yield parameters.

2. MATERIALS AND METHODS

2.1. Experimental site localization

The experiment was carried out in 2016, in greenhouse of Agronomy and Bio Engineering Sciences Faculty at Burundi University where the maximum temperature varies between 35 and 37 ° C, while the annual volume of precipitation is always less than 1000 mm with an average of 660mm ^[7]. The experiment soil characteristics were summed up in the following table.

Table 1. Soil characteristics

$P^H_{H_2O}$	P^H_{KCl}	C en %	N-NH ₄ ⁺ en mg/kg	N-NO ₃ ⁻ en mg/kg	P en mg/kg
7,28	7,25	1,45	25,2	31,5	242

2.2. Experiment design

The experiment was undertaken in pots and has considered three different irrigation levels as different treatments: T1 treatment (5%), T2 treatment (35%) and T3 treatment (65%). These agents were set in randomized complete blocks design with 6 replications for each as shown in this figure 1.

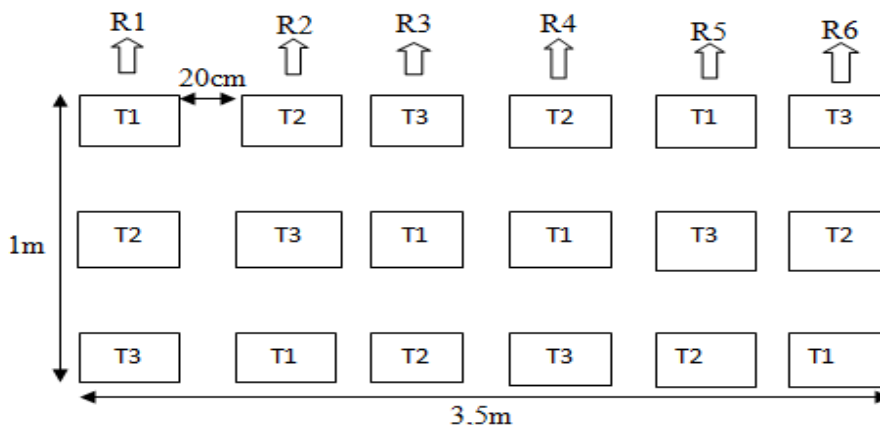


Figure 1. Experiment design of the study

The rates and frequencies of irrigation are shown in the table 2.

Table 2. Treatment rates and frequencies of irrigation

Treatments	Irrigation Levels	Irrigation frequencies
T1	5%	2
T2	35%	2
T3	65%	2

2.3. Data sampling and analysis

During the experiment, growth parameters (plant height, number of leaves, leaf area and stem diameter) were measured at 12 d, 19 d, 26 d, and 33 d (d means the days number after transplanting) while at harvest, yield and roots fresh weight were recorded. However the fresh matter was kept in a forced-air oven at 70°C for two days to get dry weight for analysis. Furthermore, root length was evaluated in this research.

2.4 Data analysis

The data were analyzed statistically with applied Excel and Genstat discovery software edition 4. A comparison among treatments were conducted (P< 0.05) by using least significant difference (LSD) and Newman-Keuil test at 5% level.

3. RESULTS AND DISCUSSION

3.1. Effects irrigation different rates on plant height

Results for the plant height were summarized in the following table 3.

Table 3. Effects of irrigation levels on plant height

Treatments	8/7/2016	15/7/2016	22/7/2016	29/07/2016
T1	42,5a	51 b	62,1 b	72,7 b
T2	58,5a	67,1 b	129,8 a	180,8 a
T3	57,4a	73,1 a	67,7 b	67,7 b

From this table, the plant height changes with the irrigation level and the day of data record. Specifically, at 8th July, there was no significance difference between. However the treatment T2 effectively improves the plant height with 58.5 cm. It was followed by treatment T2 of 57.4 cm, while treatment T1 was the last with 42.5cm. On the 15th July, a significance difference (P<0.05) between treatments was observed, treatment T3 (73.1cm) was the first highest with and significantly differed from other treatments. The second highest was Treatment T2 (67.1cm) which was followed by treatment T1, the last treatment with minimum value of 51 cm. At 22nd July, the trend change, treatments T2 was the most effective of 129.8 cm and showed a very higher significant difference (P<0.001) from other treatments. The following was T3 with 67.7cm, whereas treatment T3 was the last of 62.1 cm. Similarly, on the 29th July, the maximum plant height was observed for treatment T2 (180.8 cm) with a very higher significance difference from others. The second was T1 (72.7 cm), while treatment T3 (67.7) was the last. This effectiveness of T2 treatment was due to the supplied normally irrigation water level that the plant needs during development. This supports the results of Leban (2006) which found an improvement in plant height growth for normally irrigated treatments than those under stress [8]. In addition, the results support those of Chaves et al (2002) who revealed an improved plant height for irrigated treatments than those under stress [9]. However, the reduced plant height for treatment T1 could be attributed to limited nutrient uptake as revealed by Wu et al. (2011) who reported decreased crop height due to limited nutrient uptake for treatment under water stress [10].

3.2. Respond of leaf area to applied irrigation levels

In the present study, leaf area increases in the first time, and was reduced after ways. The details are displayed in the table 4.

Table 4. Respond of leaf area to applied irrigation levels

Treatments	08/07/2016	15/07/2016	22/07/2016	29/07/2016
T1	64,4 b	97,5 a	61,3 b	60,2 a
T2	88,7 a	108,8 a	96,3 a	67,2 a
T3	88,6 a	66,3 b	0,0 c	0,0 b

The outcomes displayed in table 4 showed treatments T2 as the first effective treatment in increasing leaf area than others. Specifically, in the first days after transplanting (8th July), T2 (88.7 cm²) occupied the first place with bigger leaf area. Treatment T3 (88.6 cm²) was the second, while T1 (64.4 cm²) was the last. Likewise, on the 15th July, the maximum leaf area was recorded for treatment T2 with 108.8 cm². It was followed by treatment T1 of 97.5 cm², whereas the minimum was observed for treatment T3 with 66.3 cm². The same trend was observed on the 22nd and 29th July, where treatment T3 got the highest leaf area of 96.3 cm² and 67.2 cm² respectively. On one hand, the minimum leaf area was obtained for treatment T3 with 0.00 cm². This null value was due to the used higher irrigation level T3 which has impaired growth and all the plants have withered in these last days. This supports the results of Juan C. Diaz-Perez who reported that excessive irrigations negatively affect plants [11]. On the other hand, the treatment T2 was the most effective treatment in enhancing the leaf area. This improved leaf area for treatment T2 could be due to leaf cell division and elongation resulting in leaf area expansion as reported by Vurayai et al. (2011) [12]. These results endorse those of Pincard (2000) who reported improved leaf area for irrigated treatments at a medium level comparatively to those under stress [13].

3.3. Effects of irrigation different levels on leaves number

The outcomes on leaves number has been summed up in the Table 5

Table 5. Irrigation level’s effects on leaves number

Treatments	08/07/2016	15/07/2016	22/07/2016	29/07/2016
T1	12a	12 b	18a	18 b
T2	12a	18a	27a	33a
T3	9a	18a	0c	0c

The results from the above table 5 showed no significance difference on the 8th July with highest value of 12 leaves for both treatment T1 and T2. The minimum leaves number was recorded for treatment T3 with 9 leaves. On the 15th July, both treatment

T2 (18 leaves) and T3 (18 leaves) got the same and highest leaves number, while T1 (12 leaves) got the lowest value. On the 22nd July, the first placed still occupied by treatment T2 with 27 leaves and significantly differed from others. The second was treatment T1 of 18 leaves and the last T3 of 0 leaves. The same trend was observed on the 29th July, where treatment T2 was the first highest with 33 leaves and significantly differed from others. Treatment T1 was the following and lastly T3 of 0 leaves. As for leaf area, the null value of leaves number for treatment T3 was due to the used irrigation level which has impaired growth and all the plants have withered in these last days. In general, the outcomes highlighted significant effects of T2 treatment as compared to T1 and T3. They support those of Pincard (2000) as well as those of Kramer and Boyer (1995) who affirmed an increased leaves number for normally irrigated treatments than those under stress which recorded a decreased leaves number [13-14]. Furthermore, these results support those of Bouchabke, O. et al. (2006) who reported an increased leaves number for normally irrigated treatments than those under stress [15].

3.4. Influences of irrigation different levels on bean stem diameter

The outcomes on stem diameter evolution due to applied irrigation rates are synthesized in the following figure.

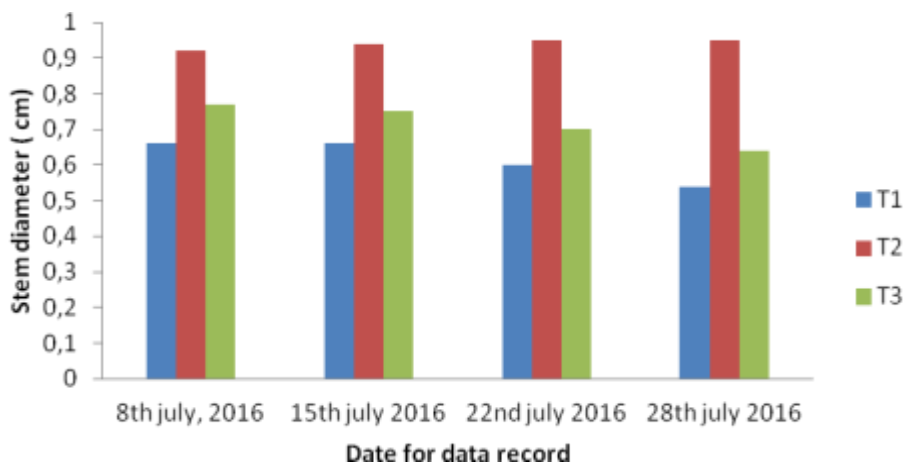


Figure 2: Effects of irrigation different rates on bean stem girth

Considering this figure 2, the irrigation has significantly influenced the stem diameter evolution. Specifically, the highest increase was observed for treatment T2 (0.92 cm), which significantly differed ($P < 0.05$) from other treatments. This was followed by treatment T3 (0.77 cm), while treatment T1 (0.66 cm) was the last and recorded a minimum value of stem diameter. The same pattern was observed on the other tested date where treatment T2 got 0.94 cm, 0.95 cm and 0.95cm on the 15th, 22nd, and 28th respectively. The minimum was recorded for treatment T1 of 0.66 cm, 0.60 cm and 0.54 cm successively. The effectiveness of T2 treatment on stem girth was due to the improved soil environment for this treatment resulting in a good nutrients dissolution and absorption by the plant, ending in improved stem girth and other growth parameters. These results support those of Vurayai al. (2011) who reported increased stem diameter for treatment with a medium level [12].

3.5 Influences of irrigation levels on root length

Roots length is an important parameter that relate to the nutrients and water absorption. In this study, the roots length (RL) has been effectively influenced by irrigation level (Figure 3).

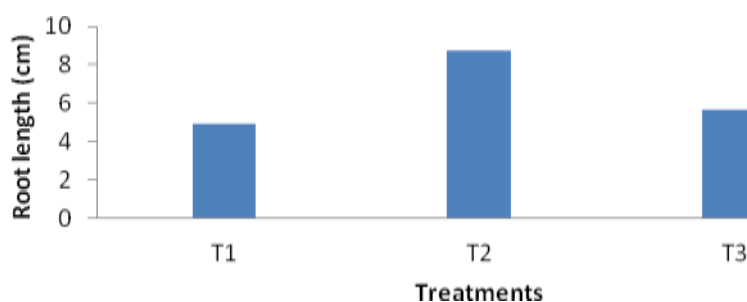


Figure 3. Effects of irrigation levels on roots length (cm)

As can be seen in this figure, treatment T2 was the most effective treatment, it showed longest root with a mean of 8.75cm. This treatment significantly ($P < 0.05$) differed from T3 which was the following with 5.65 cm, While the treatment T1 got the minimum value of 4.9 cm. The higher performance of T2 may be attributed to the irrigation level used which has created a conducive environment for plant whence root elongation resulting in more nutrient and water absorption for plant growth and development. Previous research have also reported increased root length due to medium irrigation level than those under stress ^[16]

3.6. Impact of irrigation levels on yield

Based on results in table 6, the irrigation levels have effectively influenced yield with significance difference among the treatments. Specifically, treatment T2, with 584.22 kg/ha, got the maximum weight of LFW than other treatment and highly differed ($P < 0.001$) from others which received the same value of 292.11 kg/ha.

Table 6. Impact of irrigation on yield parameters

Treatments	LFW	RFW	SFW	LDW	SDW	RDW
T1	292,11a	13.72a	218.98a	85,67a	57,25a	2,75a
T2	584,22b	21.22b	518.74b	203,50b	162,33b	4,31b
T3	292,11a	6.08a	218.59a	85,28a	77,83a	2,16a

LFW : Leaves fresh weight ; RFW : Root fresh weight ; SFW :Stem fresh weight ; LDW : Leaf dry weight ; SDW : Stem dry weight ; RDW : Root dry weight ;

Regarding RFW, the highest value was recorded for treatment T2 (21.22cm), followed by treatment T1 (13.72kg/ha), while minimum was obtained for treatment T3of 6.08 kg/ha. Similarly, the SFW was significantly influenced by the irrigation. The optimum was observed for T2 with 518 kg/ha, followed by T1 of 218.98 kg/ha, and lowest foe treatment T3 with 218.28 kg/ha. The same trend was observed for LDW where the treatment T2 got the highest value of 203.50 kg/ha and highly differed from other with $P < 0.001$. It was followed by treatment T1 with 85.67 kg/ha, and minimum for T3 of 85.28 kg/ha. . Likewise, this treatment T2 has effectively enhanced SDW and RDW with highest values of 162.33 kg/ha and 4.31 ha/kg respectively. The effectiveness of T2 by improving all yield parameters may be ascribed to the applied irrigation level (35%) which could improve nutrient dissolution and absorption resulting in enhanced synthesis of sufficient photosyntheses as reported by Di Paolo E and Rinaldi M (2007) ^[17].

4. CONCLUSIONS

The experiment results revealed significant effects of different irrigation levels on bean growth and yield parameters. They highlighted treatment T2 as the most efficient treatment which could effectively and significantly improved the plant height, leaf area, leaves number and stem girth. Moreover, this treatment T2 has positively enhanced the root length, total fresh and dry yield weight. Considering all tested index in this research, T2 (35%), was the most effective treatment in improving the growth and yield parameters of bean at Burundi in Bujumbura peri urban zone. Through this improvement, human nutrition and livelihoods will be a little bit enhanced.

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REFERENCES

- [1] Nirmal Sinha, T.H. Hui, E. Ozgul Evrnuz, Muhammad Siddig, Jasim Ahmed, 2010. Hand book of vegetables and Vegetable processing. Wiley .com, Amazon France 2010
- [2] Xu and wang, 2008 cited in Hand book of vegetables and Vegetable processing by Nirmal Sinha, T.H. Hui, E. Ozgul Evrnuz, Muhammad Siddig, Jasim Ahmed, 2010
- [3] <https://www.rd.com/health/conditions/health-benefits-of-beans/>. Visited on the 14th October 2018.
- [4] [<https://www.medicalnewstoday.com/articles/320192.php>]. Visited on the 14th october 2018

[5] Bernard Vanlauwe, Piet Van Asten, Guy Blomme, 2014. Challenges and opportunities for agricultural intensification of the humid highland Systems of Sub-Saharan Africa. Springer Cham Heidelberg New York Dordrecht London, 2014. DOI: 10.1007/978-3-319-07662-1

[6] Birachi, j. Ochieng¹, d. Wozemba. Factors influencing smallholder farmers' bean production and supply to market in burundi. Online at : <http://www.bioline.org.br/pdf?cs11031>. Visited the 14th october 2018

[7] NDIKUMANA E., 2013. Etude de l'effet de trois fongicides et deux insecticides sur les maladies et ravageurs de la pomme de terre en conditions de températures élevées de la plaine de l'Imbo. Cas du site FACAGRO. U.B. Mémoire FACAGRO, 57p.

[8] E. Leban, " Effect of vine water deficit on couver function, yield and quality formation ". INERA sup Agro, UMR, ecophysiology laboratory of plants under environmental stress, 2006, 4p Effet du stress hydrique de la vigne sur le fonctionnement du couvert, l'élaboration du rendement et la qualité". INERA sup Agro, UMR, laboratoire d'écophysologie des plantes sous stress environnementaux, 2006, 4P

[9] Chaves, M.M., Pereira J.S., Maroco, C., Rodrigues, M.L., Ricardo, C.P.P., Osorio, M.L., Carvalho, I., Faria, T. et Pinheiro, C., 2002: How plant cope with water stress field. photosynthesis and growth. *annals of botany*, 89P : 907-916

[10] Wu, F., Yang, W., Zhang, J. and Zhou, L., " Growth responses and metal accumulation in an ornamental plant (*Osmanthus fragrans* var. *thunbergii*) submitted to different Cd levels". International Scholarly Research Network ISRN, 2011, Ecology:1-7.

[11] Juan C. Diaz-Perez. Drip irrigation levels affect plant growth and fruit yield of bell pepper. Online at : https://smartech.gatech.edu/bitstream/handle/1853/47069/3.3.4_Diaz-Perez.pdf. Visited on the 15th october 2018.

[12] Vurayai, R., Emongor, V. and Moseki, B., (2011). Physiological responses of Bambara groundnut to short periods of water stress during different development stages. *Asian Journal of Agriculture Science*, 3: 37-43

[13] Pincard A., 2000. Water stress and yield relation; what spacialisation perspective? Usage of crop simulator (STICS). Memory of Engineer. National College of Dijon higher Agronomic education (France). 61P. La relation stress-hydrique-rendement ; quelle perspective de la spatialisaton ? utilisation d'un simulateur de cultures (STICS). Mémoire d'Ingénieur. Etablissement National d'Enseignement supérieur Agronomique de Dijon (France). 61P.

[14] Kramer J.P et Boyer J.S, 1995. Water relation of plants and soil Academic press. Inc .A Divion of Harcourt Brace and company 525B street, suite 1900, son Diego, California 92101-4495. 482P

[15] Bouchabke, O. ,Tardieu F. et Simonneau T., 2006 Leaf growth and turgor in growing cells of maize *Zea mays* L. respond to evaporative demand under moderate irrigation but not in water saturated soil. *Plant cell and Environnement*, 29(6) 1138 1148p

[16] P.R Gajri., S. S.Prihar, H. S. Cheema, and A.Kapoor , " Irrigation and tillage effects on root development, water use and yield of wheat on coarse textured soils ". *Irrig Sci*, 1991, 12: 161.

[17] Di Paolo E and Rinaldi M, 2007. Yield response of corn to irrigation and nitrogen fertilization in a Mediterranean environment. *Field Crops Res*. 2008;105:202–210. doi: 10.1016/j.fcr.2007.10.004