Journal of Crop Nutrition Science
ISSN: 2423-7353 (Print) 2538-2470 (Online)
Vol. 4, No. 2, 2018
http://JCNS.iauahvaz.ac.ir
OPEN ACCESS

Study of Irrigation Halt and Humic Acid on Seed Yield, Its Components and Correlation between Traits of Red Bean

Shadi Sadat Mohjerani[1], Mojtaba Alavi Fazel*[2], Hamid Madani[3], Shahram Lack[4], Adel Modhej[5]

1- Graduated PhD, Department of Agronomy, Khuzestan Science and Research Branch, Islamic Azad University, Ahvaz, Iran.
2- Associate Professor, Department of Agronomy, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran.
3- Associate Professor, Department of Agronomy, Arak Branch, Islamic Azad University, Arak, Iran.
4- Professor, Department of Agronomy, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran.
5- Associate Professor, Department of Agronomy and Plant Breeding, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran.

RESEARCH ARTICLE

ARTICLE INFO.
Received Date: *2 April. 2018*
Received in revised form: *30 May. 2018*
Accepted Date: *10 Jun. 2018*
Available online: *23 Jun. 2018*

To Cite This Article: Shadi Sadat Mohjerani, Mojtaba Alavi Fazel, Hamid Madani, Shahram Lack, Adel Modhej. Study of Irrigation Halt and Humic Acid on Seed Yield, Its Components and Correlation between Traits of Red Bean. ***J. Crop. Nutr. Sci.,*** 4(2): 67-79, 2018.

ABSTRACT

BACKGROUND: Humic acid is a natural polymeric composition which is produced as a result of decaying organic matters in soil, peat and lignin to increase crop product.

OBJECTIVES: Assessment the effect of different irrigation regime and humic acid on red bean production and correlation coefficient between measured traits.

METHODS: Current research was done via split plots experiment based on completely randomized blocks design with three replications. Main factor consisted irrigation halt at three levels (I_1: Complete irrigation or control, I_2: halt irrigation at flowering stage, I_3: halt irrigation at pod stage) and humic acid foliar application dosages at three levels (H_1: Control, H_2: using 1.5 $L.ha^{-1}$, H_3: 3 $L.ha^{-1}$ humic acid) belonged to subplots.

RESULT: The effect of irrigation halt and humic acid on biological yield, seed yield, harvest index, number of pods per plant and seeds per pod and 100 seed weight were significant. Mean comparison result of interactions effect of treatments revealed the highest seed yield (3758.4 $kg.ha^{-1}$) was in complete irrigation with 3 $L.ha^{-1}$ humic acid consumption and the lowest one (2170.1 $kg.ha^{-1}$) belonged to irrigation halt at flowering stage. So, this reduction in the irrigation at flowering stage was about 6% by consumption of 3 $L.ha^{-1}$, and was improved to 38%.

CONCLUSION: flowering stage is the most critical stage of growth of red beans in response to irrigation regimes and foliar application of humic acid could be used as a new method to decrease damage caused by halt irrigation, so halt irrigation in pod stage with use 3 $L.ha^{-1}$ humic acid is recommended to achieve maximum yield.

KEYWORDS: *Foliar application, Humus, Phaseolous vulgaris, Phenology.*

***Corresponding Author:** Mojtaba Alavi Fazel ✉ Mojtaba_alavifazel@yahoo.com

BACKGROUND

In arid and semi-arid area due to excessive exploitation of water resources, the water shortage is constantly evolving and according to the climatic conditions that are considered hot and dry, and sensitivity of bean to drought further research in this field is clear (Ghadimian *et al*., 2017). Generally lack of water in vegetative and reproductive stages was reduces seed weight with increased due to competition for water and nutrients in sinks. This could be due to reduce duration of vegetative and reproductive growth during moisture stress which shortens the effective grain filling period and to reduce manufacturing and assimilate translocation the seeds and reduced the seed weight (Turk *et al*., 2004). Severe water deficiency in vegetative stage is causing a delay in growth and cause non uniform growth. Drought is one of the important abiotic stresses that significant changes induction in physiological and biochemical characteristics of the plants (Zobayed *et al*., 2007). A large part of the farm lands in arid and semi-arid regions are affected by water stress and water deficit (Rezaei *et al*., 2009). In fact, drought stress is a common issue throughout the world, posing challenges for crops including beans (Munoz-Perea *et al*., 2006). It is believed that water stress is the most important factor in arid and semi-arid areas limiting bean production as a summer crop (Teran and Singh, 2002). Effects of drought on beans depend on the severity, type, and duration of stress in plant growth stages (Munoz-Perea *et al*., 2006). Thus, it is crucial to investigate the response of these crops to drought stress conditions and determine the sensitivity of crops to water deficit at different growth stages of the plants. The use of modern methods to improve irrigation may increase water use efficiency and crop production in arid and semi-arid regions (Mintesinot *et al*. 2002). In addition to improved irrigation systems and implementation of new irrigation methods introduced to conserve water resources, there are other water management strategies that can increase water use efficiency in agriculture (Horst *et al*., 2005). One of these methods is deficit irrigation. This approach to the management and exploitation of water is has been reported to increase yields in a number of crops (Haouari and Azaiez, 2001). Hindrance in the evolution of flowers, young pods, and seeds occur due to drought stress during and before flowering stage (10 to 12 days before pollination) and reproductive stage. Severe drought stress reduces biomass and grain yield (from 20 to 90%), harvest index, the number of pods and seeds, grain weight, and remaining days to maturity (Nunez- Barrios *et al*., 2005). According to some researchers, the appropriate time for full irrigation is an important factor to achieve full production and without taking into account the most appropriate irrigation time for each crops, full irrigation is just a waste of water (Mousavi, 2005). Rapid of growth population in developing countries has resulted to adverse effect such as food shortages and malnutrition. Lack of protein in the diet is accounted for the largest portion. Pulses with high amounts of protein are the second largest source of food after cereals. Among pulses, beans as a supplier of plant proteins in many countries, particularly developing countries has high consumption. Area under cultivation of bean is 240000 hectares with an average yield of 1500 kg per hectare in Iran (Ghadimian *et al*., 2017). In legumes, the flowering and pod development stages are the most sensitive to drought. Water deficit by interfering with the normal metabolism of the plants during flowering and early pod filling will cause the greatest reduction in bean yield (Singh, 2007). Organic and inorganic fertilizers are widely used for increasing crop production. Among these foliar applications of organic compounds are widely used for increasing crop production in modern agriculture system. Among various chemicals used for sustainable crop production, humic acid is one of them (Shafeek *et al*., 2013). Humic acid is extracted from different sources, such as humus and, soil and using chelating essential elements improve and increase fertility and productivity of soil, especially in conditions of stress (Ghadimian *et al*., 2017). Humic acid is a natural polymeric composition which is produced as a result of decaying organic matters in soil, peat and lignin and can be used in order to increase crop product (Sabzevari *et al*., 2008). Humic acid is a natural polymer consisting H^+ positions related to carboxyl-benzoic and phenolate groups acids (cation exchange capacity). This acid is a complicated organic macromolecule which is produced by the chemical and bacterial phenomena in the soil and is the final product of humification process. This acid possesses a relatively high molecular weight (mw) 104 to 106 Dalton in which carbon consists 50% of it. There are several reports regarding the effects of humic acid on plants which can be classified as direct action which is hormonal in nature together with an indirect action on the metabolism of microorganisms and uptake dynamic of soil nutrients and substrate physical conditions, through positive effects on seed germination, seedling growth, root growth, and shoot development (Nasiri *et al*., 2008). Humic compounds such as fulvic acid and humic acid are formed by chemical and microbial degradation of plant and animal material and are a principal component of soil organic matter. In general, the application of fulvic and humic acid fertilizer amendments have been shown to enhance root growth, increase nutrient uptake, alleviate stress, and increase yield in various crops (Canellas *et al*., 2015). Humic acid is a vital constituent and an intimate part of soil organic structure. It has been used by many scientists, agronomists and farmers for improving soil conditions and plant growth. In plants, humic acids have positive effects on enzyme activity, plant nutrients, and growth stimulant and are considered as a plant food. Humates are most responsive in high carbohydrate crops like potato, carrot, maize, rice, wheat, etc (Fagbenro *et al*., 1993). Humic acid contains 51% to 57% C, 4% to 6% N and 0.2% to 1% P and other micronutrients in minute amounts. Application of 1.0 $kg.ha^{-1}$ to the soil can bring appreciable increase (up to 20%) in yields of wheat, maize, cotton, sugar beet and groundnut and improvement in soil physico-chemical conditions (Khattak and Muhammad, 2006). Application of such minute amounts of humic acid suggests its enzymatic characteristics. Treating seeds with humic acid may further increase its beneficial effects to enhance crop yield (Kaya and Khawar, 2005). Humic acid has several advantages and benefits and all farmers across the world have come to this conclusion that humic acid is considered as an inseparable and integral part of fertilization program and soil fertility (El-Ghamri, 2009). Usually humic acid applied to soil as organic amendment but it was reported that foliar application of humic acid can also improve the plant growth and accumulated photosynthetic matters. Further, it was reported that humic acid has positive effect on the quality of crops though increasing the amount of sugar and reducing decay. Also foliar application of humic acid not only increased the plant growth, root growth but also increased the rate of photosynthesis, nutrient uptake, leaf area development and production of biomass (Yildirim, 2007). Further, Turkmen *et al*. (2005) applied three concentrations i.e. 500, 1000 and 2000 $mg.kg^{-1}$ of humic acid in to soil and reported that humic acid leads to elongation of hypocotyle, stem diameter, stem length, dry weight, nutrient content and pepper yield. Shafeek and colleges (2013) evaluated the effects of humic acid on wheat shoot and root growth and found that 300 mg humic acid has the greatest effects on roots and shoot growth. Haghparast and Maleki-Farahani (2013) have reported that 50 $mg.L^{-1}$ humic acid can caused elongation in the root cell of pea plants.

2. OBJECTIVES

Present study was done to evaluate the effect different irrigation regime in several growth stages and foliar application of different amounts of humic acid on red bean production and correlation coefficient between measured traits.

3. MATERIALS AND METHODS

3.1. Field and Treatment Information

Current study carried out during two agronomic years along 2014 and 2015 at Research Farm of Islamic Azad University, Arak Iran (59° 23' E and of 36° 15' N and 985 meters above sea level). The research was done via split plots experiment based on completely randomized blocks with three replications in a field that corn planted as previous crop before each year. Main factor consisted irrigation halt in three levels (Complete irrigation or control: I_1, halt irrigation at flowering stage I_2, and in the pod stage: I_3) and humic acid foliar application dosages in three levels (non use of humic acid or control: H_1, using 1.5: H_2 and 3.0 liters per hectare: H_3) belonged to subplots. The summary of climatic condition of studied year shown in Table 1. In order to determine the physical and chemical characteristics of studied soil, samples of soils were analyzed before conducted research project. The results of soil properties were mentioned in Table 2.

Table 1. Climate and weather information of studied year

Months	**The average of 50 years**			**Monthly precipitation (mm)**		**Average of mean daily temperature (^{0}C)**		**Monthly sunshine (hr)**	
	Monthly precipitation (mm)	Average of mean daily temperature (^{0}C)	Monthly sunshine (hr)	2014	2015	2014	2015	2014	2015
Jan.	41.6	-0.8	152.0	41	62	3.3	-2.5	179.8	170.8
Feb.	38.6	1.9	170.0	22.5	34	0.9	3.3	154	147.0
Mar.	49.1	7.8	206.2	85.6	56.9	8.9	12.2	165.9	158.7
Apr.	50.6	13.4	225.7	61.6	70	14.1	18.4	230.1	222.6
May	25.6	18.2	288.3	30.5	34.1	19.0	24.8	249	245.0
Jun.	2.8	24	345.0	0.0	0	25.9	28.3	323.1	317.2
Jul.	1.2	27.3	334.8	1.0	1.8	29.0	29.9	369.2	358.1
Aug.	1.6	26.4	330.9	0.0	0.0	27.7	23.1	306.1	306.5
Sep.	0.9	21.9	305.1	0.0	0.0	23.6	17.3	310	300.5
Oct.	14.5	15.6	259.3	47.4	20	14.6	4.00	290.7	282.9
Nov.	30.7	8.4	185.9	23.5	29.9	5.9	8.00	246.4	239.0
Dec.	40.1	2.8	154.3	15.8	19.8	3.9	5.5	212.3	205.7

Table 2. Soil physical and chemical characteristics

EC ($ds.m^{-1}$)	pH	SP (%)	T.N.V (%)	O.C (%)	N (%)	P (ppm)	K (ppm)	Fe (ppm)
1.20	7.70	31.00	11.50	1.50	0.15	25.60	400.00	2.98

Continue Table 2.

Zn (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Sand (%)	Silt (%)	Clay (%)	Soil texture
4.16	6.72	1.04	1.26	41.00	35.00	22.40	Lime

3.2. Farm Management

Planting date and first irrigation in the first year were done on 10th June and in the second year on 13th June. Irrigation practice was tape system and was based on irrigation treatments. Irrigation halt in the years took place at 50% of flowering stage and 50% of pod stage on 7th August and 19th August in 2014 respectively, and in 2015 after 47 and 63 days after planting respectively. Treatments included halt irrigation (I) in two growth stages of 50% of flowering and 50% of pod stage along with the control (full irrigation) in the main plots and the treatment of humic acid (H) were in three levels such as Non-application of humic acid (control), 1.5 liters and 3 liters of humic acid 12% foliar application per hectare in sub plots. To ensure the effective humic acid application, the spraying on the plants was done twice within two days interval. Final harvesting was performed at the end of the growing season, on 14th September of the first year and on 19th September of the second year, i.e. 96 and 99 days after planting, respectively. Each plot's length and width were four in three meters and included six rows by 50 cm distance and the distance between plants on a row was considered as 10 cm. The plant density per square meter was considered as forty for all plots. Irrigation practice continued by regular and drip systems and using plastic irrigation tape until the end of growth and development process. Controlling weeds was done by hand weeding and within a few steps during the development of beans.

3.3. Measured Traits

Taking into account margins, all plants within two square meters of central rows of each plot from experimental units were harvested in order to determine the seed yield at the end of growth .biological and seed yield of each plot was weighted. The following equation was used in order to measure harvest index (Beebe, 2010) by fallowing equation: **Equ. 1.** Harvest index (HI) = [seed yield/biologic yield] ×100.

10 plants were selected from each plot and number of pods per plant, number of seeds per pod and seed weight of were calculated to measure traits related to seed yield (Beebe, 2008).

3.4. Statistical Analysis

The data related to studied traits were analyzed with using SAS software (Ver.10) and data were compared by using LSD test at 5% probability level.

4. RESULTS AND DISCUSSION

Combined analysis of variance showed there was no significant difference between the years except for 100 seed weight. The effect of irrigation halt treatments on biologic and seed yield, harvest index, number of pods per plant and seeds per pod and 100 seed weight were significant. Humic acid also have a significant effect on all traits. Interaction effects of year and irrigation halt as well as interaction between irrigation halt and humic acid and also triple interactions between years, irrigation halt and humic acid did not show significant differences for all traits (Table 3).

4.1. Biologic Yield

According result of analysis of variance effect of halt irrigation and humic acid as well as the interaction between halt irrigation and spraying humic acid on biological yield was significant at 1% probability level (Table 3). Mean comparison interaction effect of humic acid and halt irrigation showed that the highest rate of biological yield (12438.5 $kg.ha^{-1}$) was obtain in halt irrigation at pod stage with consumption of 1.5 $L.ha^{-1}$ humic acid and the lowest one (7788.5 $kg.ha^{-1}$) belonged to halt irrigation at flowering stage and consumption of 3 $L.ha^{-1}$ humic acid (Table 4). It seems that the use of humic acid during water stress conditions in plants can maintain biological yield. According to these results, it seems that water stress in maximum flowering stage of red beans was effective on biological yield and has declined biological yield as 18.55%. Water stress reduces biomass production in plants whereas the reduction in biological yield depends on stress along the stage of plant growth (Spaeth, 1984). Ayas and Gulser (2005) reported that humic acid increases the growth, the height and consequently the biological function of plant by increasing the content of nitrogen. Delfine *et al.* (2005) tested the effect of foliar application of nitrogen and humic acid on maize growth and yield. In addition, they observed that foliar application of humic acid increases dry weight of treated plants as compared to control plants.

Table 3. Results of analysis of variance of measured traits

S.O.V	df	Biologic yield	Seed yield	Harvest index	No. pod per plant	No. seed per pod	100 seeds weight
Year (Y)	1	3964913.1 ^{ns}	69732.2 ^{ns}	25.93 ^{ns}	0.528 ^{ns}	0.0170 ^{ns}	22.82**
Year × Rep	4	671803.6	45633.9	5.33	0.717	0.0054	2.10
Halt Irrigation (I)	2	83698018.5**	12328239.5**	974.98**	71.49**	8.94**	51.55**
Y×I	2	36733303.3 ^{ns}	47240.7 ^{ns}	25.84 ^{ns}	0.038 ^{ns}	0.014 ^{ns}	0.708 ^{ns}
Error I	8	781554.9	52715.9	6.16	1.61	0.0041	0.574
Humic acid (H)	2	2243805.5**	45391.8*	47.23**	68.92**	0.2168**	7.46**
H×Y	2	27350.5 ^{ns}	12292.1 ^{ns}	0.23 ^{ns}	1.09 ^{ns}	0.0018 ^{ns}	0.114 ^{ns}
H×I	4	481292.8**	9503.60 ^{ns}	5.08**	1.44 ^{ns}	0.0442**	1.51*
H×I×Y	4	184279.9 ^{ns}	11038.8 ^{ns}	2.04 ^{ns}	0.35 ^{ns}	0.0066 ^{ns}	0.55^{ns}
Error II	24	68880.5	12236.7	0.780	1.29	0.0086	0.401
CV (%)	-	2.66	3.41	2.70	7.78	2.49	2.16

^{ns}, * and ** are non-significant and significant at 5 and 1% probability levels, respectively.

4.2. Seed Yield

Results of analysis of variance showed that the effect of different level of irrigation and humic acid on seed yield was significant at 1% and 5% probability level, respectively (Table 3). Mean comparison result of interactions effect of treatments revealed that the highest seed yield (3758.4 $kg.ha^{-1}$) was in complete irrigation with 3.0 $L.ha^{-1}$ humic acid consumption and the lowest one (2170.1 $kg.ha^{-1}$) belonged to halt irrigation at flowering stage and non use of humic acid which decreased 43%. On the other hand, this reduction in the irrigation at the flowering stage was about 6% by consumption of 3.0 $L.ha^{-1}$, and was improved to 38% (Table 4). Field observations showed that the maximum decrease of red bean seed yield accrued with irrigation halt at flowering stage that was due to the falling flowers. Also in the pod yield loss can be due to reduced 100 seed weight (Rauthan, 1981;

Mouhouche, 1998). On the other hand, it is known that spraying with humic acid significantly improve the yield and better pod growth quality of legume family (El habassa, 2012). Increased seed yield due to the effect of humic acid can be achieved by increment of photosynthesis and nutrient absorption through the leaves and leaf area index (Fujio *et al*., 1995). According to Rezai and Kamkarhaghighi (2009), irrigation halt for two weeks at flowering or pod stage or seed filling stages can reduce seed yield and number of seeds in a pod and 100seed weight. they observed no significant difference in the control (without irrigation) and irrigation halt treatments at the vegetative stage, but both treatments and irrigation halt-treatment at flowering and pod stage and pod filling showed significant difference. Ghadimian *et al*. (2017) by evaluate effect of irrigation halt and humic acid on physiological characteristics of red bean reported the highest seed yield was in complete irrigation and irrigation halt at pod stage and lowest rate was for irrigation halt at flowering stage. Use of humic acid in normal conditions and in conditions of hold irrigation at flowering and pod stage could be increasing the seed yield. Chavoshi *et al*. (2016) by evaluation responses of red bean cultivars to halt irrigation reported halt irrigation could be reduced seed yield from 2624.73 kg ha^{-1} in full irrigation to 1632.82, 1088.55 and 2301.85 kg ha^{-1} irrigation halt at vegetative growth, flowering and pod filling stages respectively. Halt irrigation at flowering stage could reduce the red bean seed yield more than 35% significantly.

Table 4. Means comparison of measured traits affected treatments

Treatment	Biologic yield (kg.ha^{1})	Seed yield (kg.ha^{-1})	Harvest index (%)	No. pod per plant.	No. seed per pod	100 seeds weight (g)
I_1	9101.5	3728.7	40.92	16.25	4.21	30.48
I_2	8181.5	2279.07	26.77	12.32	2.92	30.01
I_3	12290.6	3695.7	30.35	14.84	4.04	27.34
LSD_I	2748.8	311.73	7.29	0.28	0.175	1.20
H_1	10248.8	3178.10	30.93	12.87	3.60	29.94
H_2	9762.9	3251.4	33	13.89	3.75	29.23
H_3	9562.17	3274.10	34.12	16.65	3.82	28.66
LSD_H	180.56	76.10	0.607	0.784	0.064	0.436
I_1H_1	9562.2	3700	38.61	14.88	4.19	30.03
I_1H_2	8944.9	3727	41.49	15.20	4.21	30.52
I_1H_3	8797.3	3758.4	42.68	18.68	4.24	30.90
I_2H_1	8851.06	2170.1	24.40	10.56	2.71	26.16
I_2H_2	7905.3	2328.3	27.67	12.33	2.97	27.29
I_2H_3	7788.5	2338.1	28.24	14.06	3.07	28.58
I_3H_1	12100.7	3663.2	29.77	13.18	3.91	29.79
I_3H_2	12438.5	3698.5	29.84	14.13	4.07	29.89
I_3H_3	12330.7	3725	31.44	17.22	4.14	30.35
$LSD_{5\%}$	131.81	312.73	1.05	1.35	0.1108	0.755

I_1: Control, **I_2**: Halt irrigation at flowering stage, **I_3**: Halt irrigation at pod stage, **H_1**: Control, **H_2**: 1.5 L.ha^{-1} humic acid, **H_3**:3.0 L.ha^{-1} humic acid

4.3. Harvest Index

According result of analysis of variance effect of halt irrigation and humic acid as well as the interaction between halt irrigation and spraying humic acid on harvest index was significant at 1% probability level (Table 3). It was observed in by comparison of interaction effects of treatments that the greatest impact of normal irrigation was on harvest index in treatment with consumption of 3.0 $L.ha^{-1}$ humic acid by 42.68% to 24.4% in halt irrigation at the flowering stage and non use of humic acid (Table 4). At halt irrigation stress at pod stage and consumption of 3 $L.ha^{-1}$ humic acid, harvest index has the minimum distance with harvest index by 31.44% in the treatment with no irrigation halt and 3 $L.ha^{-1}$ humic acid. It should be noted that in terms of irrigation halt, consumption of 3 liters of humic acid per hectare increases harvest index as 4%. In relation to the impact of moisture on economic yield and biomass it is under stood that the relationship between vegetative and reproductive stages has balanced stress impact on the vegetative and reproductive parts and finally decreases harvest index stability (Spaeth, 1984). A study showed that the drought reduced harvest index in beans (German and Teran, 2006). Ghadimian *et al.* (2017) reported the highest harvest index was in complete irrigation and irrigation halt at pod stage. Results of studies conducted by Sibi and Mirzakhani (2012) with regard to the harvest index of chickpea as affected by the consumption of salicylic acid of seaweed extract and Humic acid in dry-farming land condition showed that use of Humic acid was significant on weight of 100 seeds in 5% level.

Table 5. Correlation between measured traits

Traits	Seed yield	Biologic yield	Harvest index	No. pod per plant	No. seed per pod	100 Seed weight
Seed yield	1.00					
Biologic yield	0.577^{**}	1.00				
Harvest index	0.664^{**}	0.188^{ns}	1.00			
No. pod per plant	0.625^{**}	0.142^{ns}	0.664^{**}	1.00		
No. seed per pod	0.957^{**}	0.503^{**}	0.732^{**}	0.708^{**}	1.00	
100 Seed weight	0.853^{**}	0.378^{**}	0.691^{**}	0.700^{**}	0.875^{**}	1.00

^{ns}, * and ** are non-significant and significant at 5 and 1% probability levels, respectively.

4.4. Number of Pods per Plant

Results of analysis of variance showed that the effect of different level of irrigation and humic acid on number of pods per plant was significant at 1% probability level (Table 3). Mean comparison result revealed the highest number of pod per plant (18.68) was observed in control treatment (full irrigation) associated with consumption 3 $L.ha^{-1}$ humic acid, also the lowest one (10.56) was belonged to halt irrigation at flowering stage with non use of humic acid (Table 4). The survey found, however, that irrigation halt in flowering stage of red bean has the most negative impact on the number of pods per plant compared to irrigation halt at grain filling stage and also the application of humic acid at a higher rate per unit area would significantly increase the number of pod per plant. One reason for the reduced number of pods per plant is reduced growing period in such circumstances that as a result, the production of photosynthetic diminishes. Reduction of photosynthetic material production and increased competition within the plant and also flowers falling due to the water stress cause a significant reduction in the number of pods per bean plant at flowering stage (Mouhouche, 1988). It has been reported about beans that foliar application of humic acid than soil application can increase the number of pods per the plant and pod weight. (El-Bassiony *et al*., 2010). Ghadimian *et al*. (2017) by evaluate effect of irrigation halt and humic acid on physiological characteristics of red bean reported the effect of irrigation halt at pod stage was the same as complete irrigation treatment which this point can be used in saving water. Also, spraying with different amounts of humic acid improved the agronomic characteristics and quality of the beans in range of 1.5 $L.ha^{-1}$.

4.5. Number of Seeds per Pod

According result of analysis of variance effect of halt irrigation and humic acid as well as the interaction between halt irrigation and spraying humic acid on number of seeds per pod was significant at 1% probability level (Table 3). Result of mean comparison of interaction effects of treatments revealed the maximum number of seeds per pod (4.24) was observed in normal irrigation with consumption of 3 $L.ha^{-1}$ humic acid, also minimum number of seeds per pods (2.71) belonged to halt irrigation at flowering stage and avoiding the use of humic acid (Table 4). Irrigation halt in the flowering stage has the most affected on the number of seeds per pod among different levels of irrigation halt stages in bean implanting. The impact is significantly reduced by consumption of 3 liters of humic acid per hectare. According to the results obtained, less water stress in the pod stage has not much effect on the number of seeds per pod which can be used for optimum consumption of water. Increasing number of seeds per plant is influenced by genetic factors as it is associated with the length of the pod. Humic acid in take also can increase the number of seeds per pod. The occurrence of drought stress at the reproductive stage can reduce the number of seeds per pod of beans. The increase in the number of seeds per pod of bean is limited and depends on the length of the pod which is influenced by genetic factors, but according to existing environmental conditions, the flowering stage is not without effect in increasing the number of seeds per pod (Mendham *et al*., 1981). Ghadimian *et al*. (2017) reported among yield components, seeds per pod had significant correlation with yield. The highest number of pods per plant during irrigation halt was at flowering stage and control treatment and irrigation halt at pod stage had the lowest rate of pods per plant. Khan *et al*. (2012) reported that application of 15 ppm humic acid produces maximum economic yield, highest number of pods per plant, number of seeds per pod and the highest concentration of potassium, phosphorus and ferrous. Similarly, Yildirim (2007) reported higher number of seed and spike per plant on the application of humic acid in wheat crops. Waqas *et al*. (2014) by evaluate effect of humic acid on yield of Mungbean reported 3 $kg.ha^{-1}$ humic acid resulted in a higher number of pods per plant, thousand grain weights and grain yield, however it was statistically similar to the treatments where humic acid was soil applied at rate of 1 and 2 $kg.ha^{-1}$, seed priming with, 0%, 1%, 2% of humic acid solution and foliar spray with 0.01%, 0.05% and 0.1% of humic acid solution.

4.6. 100-Seed Weight

Result of analysis of variance indicated effect of halt irrigation and humic acid on 100-seed weight was significant at 1% probability level but interaction effect of halt irrigation and spraying humic acid was significant at 5% probability level (Table 3). According result of mean comparison of interaction effects of treatments however, the highest 100 seed weight (30.90 g) was found in full irrigation with consumption of 3 $L.ha^{-1}$ humic acid and the lowest one (26.16 gr) belonged to halt irrigation at flowering stage and without application of humic acid (Table 4). Other studies show that seed yield in pea plants under well-watered condition was more compared with the limited irrigation conditions and it's most important reason was the presence of more yield components such as the number of pods per plant and 100 seed weight (Kazemi and habibi, 2008). It was also showed that 100 seed weight of beans was low on best treatments and water stress in vegetative stage and was high in water stress at flowering stage (Shekari, 2000). Ghadimian *et al*. (2017) reported the highest 100 seed weight was from control and irrigation halt at pod stage treatment and the least weight was from irrigation halt at flowering stage which shows the sensitive stage for bean is cut-irrigation at flowering stage and maybe the need for water is low in pod stage. In a study El-Habbasha *et al.* (2012) also reported that foliar application of humic acid on peas pods (*Cicer arientinum* L.) improve the growth and quality of pea crops. Foliar application of humic acid on beans (*Phaseolus vulgaris* L.), crops leads to increased plant growth, pods per plant, pod weight, protein rate and chlorophyll of plants through increased rate and extent of nutrients absorption (El-Bassiony, 2010).

4.7. Correlation coefficients between Measured Traits

Correlation coefficients between traits in the study showed that seed yield had a significant positive correlation with the number of seeds per pod and 100 seed weight (Table 5). This is well demonstrated the relationship between photosynthesis efficiency and seed yield, because seed yield increases when plants can have higher photosynthetic material accumulation. Also, there was a significant correlation between the number of seeds per pod and the number of pods per plant. These traits are the most important characteristics that constituted the bean yield. A positive and significant correlation between seed yield and harvest index was expected, given that seed yield is one of the components in the seed harvest index. So that when the seed yield increases by the number of seeds per pod and the number of pods per plant, itis a factor to achieve higher harvest index.

5. CONCLUSION

The final results showed that although the highest number of traits including seed yield in control treatment (full irrigation) was observed, the foliar application of 3 liter per hectare humic acid can a little improve indexes significantly compared to control. This improvement in the seed yield was 58 $kg.ha^{-1}$, i.e. 1.5%, for harvest index it was 11.60% and for 100 seed weight was approximately 1 g means 2.81%. Negative impact of red beans implanting also in halt irrigation at flowering stage was more than halt irrigation at pod stage and at the rate of 1500 $kg.ha^{-1}$ i.e. 43.38% it decreases seed yield. It is due to the decline in the number of pod per plant and seeds per pod than the thousand weights of seeds. In summary, halt irrigation practice in the pod stage with spraying 3 liter per hectare of humic acid is recommended to achieve the maximum yield in Red beans production.

ACKNOWLEDGMENT

Authors wish to thank researchers and staff who consultant to conduct current research.

FOOTNOTES

CONFLICT OF INTEREST: Authors declared no conflict of interest.

REFERENCES

Ayas, H. and F. Gulser. 2005. The effect of sulfur and humic acid on yield components and macronutrient contents of spinach. J. Biol. Sci. 5(6): 801-804.

Beebe, S. E., I. M. Rao, C. Cajiao. and M. Grajales. 2008. Selection for drought resistance in common bean also improves yield in phosphorus limited and favorable environments. Crop Sci. 48(2): 582-592.

Beebe, S. E., I. M. Rao, M. W. Blair. and J. A. Acosta-Gallegos. 2010. Phenotyping common beans for adaptation to drought. Drought Phenotyping in Crops: From Theory to Practice. pp. 311-334.

Canellas, L. P., F. L. Olivares, N. O. Aguiar, D. L. Jones, A. Nebbioso, P. Mazzei. and A. Piccolo. 2015. Humic and fulvic acids as biostimulants in horticulture. Sci. Hortic. 196: 15-27. Doi:10.1016/j. scienta.2015.09.013

Chavoshia, S., Gh. Nourmohammadi, H. Madani, H. Heidari sharif abad. and M. Alavi fazel. 2016. Halt irrigation and red bean (*Phaseolus vulgaris* L.) cultivars responses. Natl. Acad. Agri. Sci. 4(7): 2203-2211.

Delfine, S., R. Tognetti, E. Desiderio. and A. Alvino. 2005. Effect of foliar application of N and humic acids on growth and yield of durum wheat. Agronomy for Sustainable Development, Springer Verlag, EDP Sciences, INRA. 25: 183-191.

El-Bassiony, A. M., Z. F. Fawzy, M. M. H. Abd El-Baky. and A. R. Mahmoud. 2010. Response of snap bean plants to mineral fertilizers and humic acid application. Res. J. Agri. Biomass Sci. 6: 169-175.

El–Ghamry, A. M., K. M. Abd El–Haiand. and K. M. Ghoneem. 2009. Amino and humic acids promote growth, yield and disease resistance of *Faba bean* cultivated in clayey soil. Aust. J. Basic and Appl. Sci. 3(2): 731–739.

El-Habbasha, S. F., A. G. Ahmed. and M. H. Mohamed. 2012. Response of some chickpea varieties to compound foliar fertilizer under sandy soil conditions. J. Appl. Sci. Res. 8: 5177-5183.

Fagbenro, J. A. and A. A. Agboola. 1993. Effect of different levels of humic acid on the growth and nutrient uptake of teak seedlings. J. Plant Nutr. 16: 1465-1483.

Fujio, C., Y. Daoqi, W. Qingsheng. 1995. Physiological effects of humic acids on drought resistance of wheat. China J. Appl. Ecol. pp: 363-373.

German, C. and H. Teran. 2006. Selection for drought resistance in dry bean landraces and cultivars. Crop Sci. 46: 2111-2120.

Ghadimian, T., H. Madani. and M. Gomarian. 2017. Effect of irrigation halt and humic acid foliar application on agronomic, qualitative and physiological characteristics in red bean cultivar D_{81083}. Iranian J. Pulses Res. 8(2): 141-155. (Abstract in English) DOI: 10.22067/ijpr.v8i2.53136

Haghparast, M. and S. Maleki Farahani. 2013. Effect of water deficit irrigation and natural vegetative characteristics of different products on Chickpea (*Cicer arietinum* L.) varieties. Iranian J. Pulses Res. 4: 77-86. (Abstract in English)

Haouari, M. and M. N. Azaiez. 2001. Optimal cropping pattern under water deficits. Europe. J. Operation Res. 130: 133-146.

Horst, M. G., S. S. Shamutalov, L. S. Pereira. and J. M. Goncalves. 2005. Field assessment of the water saving potential with furrow irrigation in Fergana, Aral Sea basin. Agri. Water Manage. 77: 210-231.

Kaya, M. and K. M. Khawar. 2005. Effect of pre-sowing seed treatment with zinc and foliar spray of humic acids on yield of common bean. Intl. J. Agri. Biol. 7: 875-878.

Kazemi, N. and D. Habibi. 2008. Effect of drought stress on yield, yield components and antioxidant enzymes activity in different varieties of red bean (*Phaseolus vulgaris* L.). Agri. Res. 1(1): 10-19. (Abstract in English)

Khan, A., M. Z. Khan, F. Hussain, M. E. Akhtar, A. R. Gurmani. and S. Khan. 2012. Effect of humic acid on the growth, yield, nutrient composition, photosynthetic pigment and total sugar contents of peas (*Pisum sativum* L.). J. Chemical Soc. Pakistan. 35: 206-211.

Khattak, R. A. and D. Muhammad. 2006. Effect of pre-sowing seed treatments with humic acid on seedling growth and nutrient uptake. Internship Report. Department of Soil and Environmental Science. NWFP Agriculture Univ. Peshawar. Pakistan.

Mendham, N. J., P. A. Shipway. and R. K. Scot. 1981. The effects of delayed sowing and weather on growth, development and yield of winter oilseed rape. J. Agri. Sci. 96: 389-416.

Mintesinot, B., H. Verplancke. and E. Van Ranst. 2002. Assessment and optimization of traditional irrigation of Vertisols in northern Ethiopia: a case study at Gumselasa microdam using maize as an indicator crop. Ph.D. Thesis. Ghent Univ. Belgium.

Mouhouche, B., F. Ruget. and R. Delecolle. 1998. Effects of water stress applied at different phenological phases on yield components of dwarf bean. Agron. J. 18(3): 197-207.

Mousavi, S. F. 2005. Agricultural drought management in Iran. *In*: National Research Council, Water Conservation, Reuse, and Recycling. Proc. Iranian American Workshop. National Academies Press. USA. pp. 106-113.

Munoz-Perea, C. G., H. Teran, R. G. Allen, J. L. Wright, D. T. Westermann. and S. P. Singh. 2006. Selection for drought resistance in dry bean landraces and cultivars. Crop Sci. 46: 2111-2120.

Nasiri, Z., A. Khalighi. and E. Matlabi. 2015. The effect of humic acid, fulvic acid, and Kristal on quantitative and qualitative characteristics of geranium. Intl. J. Biosci. 6(5): 34-41.

Nunez-Barrios, A., G. Hoogenboom. and D. S. Nesmith. 2005. Drought stress and the distribution of vegetative and reproductive traits of a bean cultivar. Scientia Agricola. 62: 18-22.

Rauthan, B. S. and M. Schnitzer. 1981. Effect of soil fulvic acid on the growth and nutrient content of growth and yield of durum wheat. Agron. Sust. 25: 183-191.

Rezaei, A. R., A. A. Kamkarhaghighi. 2009. Effects of water stress in different growth stages on yield of cowpea. J. Soil Res. Water Sci. 23(1): 117-124. (Abstract in English)

Sabzevari, S., H. R. Khazaie. and M. Kafi. 2008. Effect of humic acid on root and shoot growth of two wheat cultivars. J. Water and Soil. 23: 87-94. (Abstract in English)

Sibi, M. and M. Mirzakhani. 2012. Studying index of harvesting chickpea affected by consumption of Salicylic acid of seaweed extract and humic acid. Proc. 12th Iranian Plant Breed. Agri. Sci. Cong. Islamic Azad Univ. Karaj Branch. pp: 19-24.

Singh, S. P. 2007. Drought resistance in the race Durango dry bean landraces and cultivars. Agron. J. 99(5): 1219-1225.

Shafeek, M. R., Y. I. Helmy, M. Nadia. A. R. Omer. and Fatma. 2013. Effect of foliar fertilizer with nutritional compound and humic acid on growth and yield of broad bean plants under sandy soil conditions. J. Appl. Sci. Res. 9: 3674-3680.

Shekari, F. 2000. Study traits related to drought tolerance in beans. Res. Rep. Physiol. Biotech. Center. Zanjan Univ. p. 53.

Spaeth, S. C., H. C. Randall, T. R. Sinclair. and J. S. Vendeland. 1984. Stability of soybean (*Glycine max* L.) harvest index. Agron. J. 76: 482-486.

Teran, H. and S. P. Singh. 2002. Comparison of sources and lines selected for drought resistance in common bean. Crop Sci. 421: 64-70.

Turk, M. A., A. Rahman, M. Tawaha. and K. D. Lee. 2004. Seed germination and seedling growth of three lentil cultivars under moisture stress. Asian J. Plant Sci. 3(3): 394-397.

Turkmen, O., S. Demir, S. Ensoy. and A. Dursun. 2005. Effects of arbuscular mycorrhizal fungus and humic acid on the seedling development and nutrient content of pepper grown under saline soil conditions. J. Biomass Sci. 5: 565-574. DOI: 10.3923/ jbs. 2005. 568. 574

Waqas, M., B. Ahmad, M. Arif, F. Munsif, A. L. Khan, M. Amin, S. M. Kang, Y. H. Kim. and I. J. Lee. 2014. Evaluation of humic acid application methods for yield and yield components of mungbean. Am. J. Plant Sci. 5: 2269-2276.

Yildirim, E. 2007. Foliar and soil fertilization of humic acid affect productivity and quality of tomato. Acta Agriculturae Scandinavica Section B-Soil and Plant Science. 57: 182-186. DOI: 10.1080/09064710600813107.

Zobayed, S. M. A., F. Afreen. and T. Kozai. 2007. Phytochemical and physiological changes in the leaves of St. John's wort plants under a water stress condition. Environ. Exp. Bot. 59(2): 109-116.