EFFECT OF THE FOLIAR APPLICATION OF HUMIC ACID ON RED BEAN CULTIVARS (*Phaseolus vulgaris* L.)

Shadisadat Mohajerani¹, Mojtaba Alavi Fazel²*, Hamid Madani³, Shahram Lak² and Adel Modhej⁴

¹Department of Agronomy, College of Agriculture, Khouzestan Science and Research Branch, Islamic Azad University, Ahvaz, Iran
²Department of Agronomy, College of Agriculture, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran
³Department of Agronomy, College of Agriculture, Arak Branch, Islamic Azad University, Arak, Iran
⁴Department of Agronomy, College of Agriculture, Shoushtar Branch, Islamic Azad University, Shoushtar, Iran

Received – April 25, 2016; Revision – July 01, 2016; Accepted – August 31, 2016
Available Online – August 31, 2016

DOI: http://dx.doi.org/10.18006/2016.4(5).519.524

**KEYWORDS**

Humic acid
Derakhshan
Goli
Seed yield
Foliar application

**ABSTRACT**

In order to evaluate the effect of foliar application of humic acid on yield and yield components of red bean cultivars this experiment was conducted at Agricultural Research Station of Arak in 2014. The experiment was in split plots Completely Randomized Block Design (CRBD) with three replications. Three level of humic acid i.e. 0, 1.5 and 3 liters per hectare in main plots and three cultivars of red bean i.e. Derakhshan, Goli and D81083 were in sub plots used as treatments. Results of study revealed that line D81083 along with 3.0 liters per hectare of humic acid application shows superiority over the other treatments and showing 13622 kg per hectare final biomass yield. Among various tested cultivars, the lowest biomass yield (10311.1 kg/hectare) was obtained from Derakhshan cultivar without humic acid application. Further, amongst various tested doses of humic acid, highest seed yield (4253.7 kg/hectare) was reported from the cultivar line D81083 at 1.5 liter per hectare of humic acid application while the lowest yield obtained in Derakhshan without humic acid. Results of current study revealed relationship between bean cultivars and humic acid application and interaction of these two affect the yield and yield attributes of red bean.
1 Introduction

Now, in these days sustainable agricultural production and food security are the basic concerns of human societies (Majnoon Hoseini, 2008). A variety of grains, especially bean variety, are the most important protein sources of world people diet (Dorri, 2008). 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 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). 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 (Neri et al., 2002; Abdel et al., 2007; Yildirim, 2007).

Abdel et al. (2007) also reported a significant improvement in the level of various phytohormones such as auxin, cytokinin and gibberellic on the foliar or soil application of humic acids. Similarly, Yildirim (2007) has been proved that 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. 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). Further, Turkmen et al. (2005) applied three concentration i.e. 500, 1000 and 2000 mg/kg 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. Similarly, 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. In other study, 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. Further, Haghparast & Maleki-Farahani (2013) have reported that 50mg/liter humic acid can caused elongation in the root cell of pea plants. The aim of this was to access the effects of foliar application of humic acid on yield and yield components of red bean.

2 Materials and Methods

This experiment was conducted in agricultural year of 2013-2014 at Agricultural Research Station of Arak with longitude of 59°23’E and latitude of 36°15’ N and height of 1708 m above sea level. 100g of soil samples were collected in triplicate from the 30 cm depth and analyzed for estimation of soil physicochemical properties according to the method given by Ryan et al. (2001). The results of analyzing soil physical and chemical properties are shown in Table 1.

Each plot’s had 4 and 3 meters length and width respectively. Each plot included six rows of planting at a distance of 50 cm and the distance between plants on a row was considered as 10 cm. The experiment was carried out in split plots based on completely randomized blocks design (CRBD) with three replications in a land where corn was planted last year. Seeds were sown manually on 20 June 2014 and the plant density was maintained 10 plants per square meter for all plots. Irrigation was carried out on regular interval by using drip irrigation system. Weeding was carried out by hand weeding after seedling establishment. Effect of different doses of humic acid (12% humic acid and 4% folic acid plus 10%K2O) viz 0 (control), 1.5 and 3.0 liter/hectare on three cultivar of red bean genotype i.e. Derakhshan, Goli and Line D81083 were evaluated in present study. Experimental treatments of main plots included all three level of humic acid solution while the sub-plots included red bean cultivars. Humic acid was applied two times on leaves, among these first time was before flowering stage and second time was at pod stages.

Foliar application was carried out at sunset time by using a spraying machine in 400 liters of water per hectare. Crop was fertilized by urea at a rate of 50 kg per hectare in order to meet the beans crop nitrogen requirement. Also, necessary monitoring was conducted during growth stage in order to control pests and plant diseases in accordance with technical advices. Taking into account margins, all plants within two meters of central rows of each plot were harvested in order to determine the seed yield at the end of cropping season and after physiologic maturity of plants, this was carried out in September, 2014 of each experimental unit; then, biomass and seed yield of each plot was weighted.

| Soil texture | Percent % | Parts per million (ppm) | Percent % | pH | EC |
|--------------|-----------|-------------------------|-----------|----|----|
| Loam         | 22.4 35.0 41.0 1.26 1.04 6.72 4.16 2.98 400 25.60 0.15 1.50 11.50 31.0 7.1.20 |

Table 1 Soil physical and chemical characteristics.
The following equation was used in order to measure harvest index.

Harvesting index (HI) = \frac{\text{seed yield} (Y_e)}{\text{biomass yield} (Y_b)} \times 100

Ten plants were selected randomly from each plot and number of pods per plant, number of seeds per pod and weight of seeds were calculated in order to measure traits related to seed yield. Also, in order to calculate seeds weight, the weight of 100 seeds was determined by ten times scaling for each plot. The data related to studied traits were analyzed using version 10 SAS software and data were compared using LSD test at statistical probability level of 1% and 5%.

3 Results and discussion

3.1 Biomass yield

The results of analysis of variance for red bean biomass yield revealed that the effects of humic acid foliar application and three red beans were having significant differences (Table 2). The results of comparing mean biomass of various experimental treatments showed that highest biomass (12507 kg/ha) was obtained in the case of applying 3 liters/ hectare humic acid solutions. Further, interactions between experimental treatments revealed that the highest biomass yield (13622 kg/ha) was obtained from the treatment containing the foliar application of 3 liters/ha humic acid along with Line D81083. Among various tested interactions, lowest biomass (10311.1 kg/ha) was reported from Derakhshan red bean cultivar without humic acid application.

Results of biomass yield study suggested that uses of humic acid in red bean cultivation have significant effect on biologic yield of red bean. Similar type of biomass increases was reported by Yildirim (2007). According to Yildirim (2007) this improvement in biomass yield may be related to the stimulation in the metabolism of micronutrients and macronutrients, activation of enzymes, changes in membrane permeability and protein synthesis.

Table 2 Effect of the interaction of humic acid (H) foliar application and red been cultivars (C) on yield and yield components of red bean.

| S.O.V | Df | Mean square |
|-------|----|-------------|
|       |    | Biomass yield | Seed yield | Harvesting index | No. pod per plant | No. Seed per pod | 100 seeds weight |
| Replication | 2 | 400572**** | 7468** | 0.001** | 1.15* | 0.005** | 0.25** |
| H | 2 | 7909549**** | 218702 | 0.010 | 64.01* | 2.23** | 30.36** |
| E | 4 | 217485 | 18877 | 0.0001 | 5.24 | 0.006 | 1.15 |
| C | 2 | 547092**** | 2740671**** | 0.033** | 28.74** | 0.200** | 160.13** |
| Int. H*C | 4 | 11005746**** | 20889* | 0.020** | 11.23** | 0.27** | 27.81** |
| Eb (Error) | 12 | 159859 | 56137 | 0.001 | 1.12 | 0.02 | 2.51 |
| (CV%) | 3.44 | 6.85 | 8.94 | 6.82 | 10.08 | 5.37 |

ns, non-significant, * and ** significant at 0.05 and 0.01 probability level respectively.

Table 3 Effect of humic acid (H) foliar application and red been cultivars (C) interactions on yield and yield components of red bean.

| Treatments | Biomass yield (Kg/ha) | Seed yield (Kg/ha) | Harvesting index | No. pod per plant | No. Seed per pod | 100 seeds weight (g) |
|------------|-----------------------|-------------------|------------------|-------------------|-----------------|---------------------|
| H1C1       | 10311.1*              | 2615.2*           | 25.00*           | 9.73*             | 2.11*           | 32.40*              |
| H1C2       | 12419.5*              | 3502.7**          | 28.00*           | 16.75*            | 2.92*           | 24.64*              |
| H1C3       | 12305.15**            | 3840.7**          | 31.00*           | 14.13**           | 2.72**          | 25.18**             |
| H2C1       | 11638.4**             | 2859.2**          | 24.30*           | 14.86**           | 2.17**          | 32.61*              |
| H2C2       | 12068.3**             | 3182.7**          | 26.00**          | 14.36**           | 2.73**          | 24.3**              |
| H2C3       | 12204.4**             | 4253.7**          | 51.30*           | 14.20**           | 2.13**          | 34.13*              |
| H3C1       | 12786.4**             | 3314.3**          | 26.00**          | 16.36**           | 3.15**          | 32.55*              |
| H3C2       | 11115.2**             | 3569.9**          | 31.70**          | 20.43**           | 3.07**          | 25.25**             |
| H3C3       | 13622.0**             | 3998.4**          | 28.70**          | 18.76*            | 3.43**          | 34.50**             |

Here H1: Control, H2: 1.5 l/ha and H3:3.0 l/ha. C1: Derakhshan, C2: Goli and C3:D81083 Mean with similar letters is not significantly difference at the 0.05 probability level according LSD test.
Further, Turkmen et al. (2005) reported that application of humic acid increased the nitrogen content of shoot and root and which may lead to increases biomass of the crops. Similarly, improvement in the dry weight of wheat root and shoot of humic acid application was reported by Shafeek et al. (2013)

3.2 Seed yield

As per the results of mean comparison, highest seed yield (3627.56 kg/ha) was reported from the application of 3 liters/ha of humic acid while the lowest seed yield was related to control treatment (Table 3). Among various tested red bean cultivars, cultivar Line D81083 gave highest yield of 4030.93 kg/ha while the lowest yield (2929.57 kg/ha) was reported from the Derakhshan cultivar. Comparing interaction effects between various cultivars and humic acid, the lowest yield was reported from of the cultivar Derakhshan without humic acid application while in interaction study, the highest yield was obtained in line D81083 and using 3 liters per hectare humic acid but it was not significantly different from using 1.5 liters per hectare of humic acid (Table 3).

Results of study suggested that application of humic acid have significant effect on the seed yield and this effect varies according to the bean cultivars and level of humic acid application. Similarly, significant effect of half to one kilogram per hectare of humic acid application on wheat and corn yield and yield components was reported by Tan & Nopamornbodi (1979). Foliar application of humic acid not only increased pea plant growth but also significantly improved the yield and quality of pea pods (El-Habbasha et al., 2012). Similar type of results was obtained Yildirim (2007) on tomato crop. Further, Sharif et al. (2002) reported improvement in the red bean yield by foliar application of 4 grams per liter humic acid.

3.3 Harvesting index

Variance analysis of this trait showed that difference between cultivars and foliar application of humic acid and their interaction on harvest index was significant at 1% level (Table 2). Comparing of mean harvesting index showed that using 1.5 liters per hectare of humic acid led to the most harvest index of 34 percent. Harvest index for Line G81083 was reported 37 percent it was reported highest. In interaction of humic acid and various bean cultivars, highest harvesting index was reported in Goli bean cultivar using 1.5 liters per hectare humic acid in the interaction of cultivars and humic acid (Table 3). Harvest index difference of cultivars is due to their compatibility difference in effective use of humic acid that is related to their genetic structure. Results of this study correspond with the results of Kaya et al. (2005).

3.4 Number of pods per plant

Variance analysis of pod number per plant showed that foliar application of humic acid was significant at 5% probability level and differences between cultivars and their interaction effect on number of pods per plant was significant at 1% probability level (Table 2). Using 3 liters per hectare of humic acid increased number of pods per plant and it was reported 18.55 pod/plant which was reported maximum among various tested doses. In case of mean results of various cultivars, Goli red beans showed highest pod number (17.21 pods/plant) amongst various tested beans cultivars. In case of interaction effects, highest pod number was reported in the combination of Goli bean cultivars and 3 liter/ha humic acid foliar application but this effect was not significantly different from Line D81083 and 3 liters/ha humic acid combination (Table 3).

Results of this experiment suggested that bean cultivars have been interacted positively to the foliar application of humic acid and increased number of pods per plant; this showed that suitable production of photosynthesis materials and their transfer were effective in this combination. It has been reported that foliar application of humic acid on bean crops increased growth, number of pods per plant, pod weight, protein and chlorophyll of plants through increasing the rate and extent of nutrients absorption compared to soil usage (El-Bassiony, 2010).

3.5 Number of seeds per pod

As shown in table 2, number of seeds per pod was significantly affected by the foliar application of humic acid, type’s cultivars and their interaction at probability level of 1% (Table 2). Mean comparison for seed per pod revealed that using 3 liters/ha humic acid led to the highest number (3.22 seed/pod) of seeds per pod while in case of different cultivars, highest seed number was reported from Line D81083 (2.76 seed/pod) and it was immediately followed by Goli cultivars (2.70 seeds/pod), these two treatments are par and did not show any significant differences.

In case of cultivars and humic acid interaction, highest number of seeds per pod was reported from the combination of Line D81083 and 3 liters/ha and this value was reported 3.43 seeds/pod. Similar yb detroper saw snidnif fo seyt Mendham et al. (1981) and Khan et al. (2012), according to these researchers humic acid intake has significant effect on seeds per pod and affect this trait affect the particular crop through increasing the leaf area, leaf area duration, photosynthesis and maintaining flowers in bloom stage. Khan et al. (2012) reported that application of 15ppm 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.

3.6 100 Seeds weight

Variance analysis of seed weight showed that there is a significant difference between cultivars and different levels of foliar application of humic acid as well as their interaction at probability level of 1% (Table 2).
Comparing the means (Table 3) it was found that the highest seed weight (30.77g) was reported from the plants treated by 3 liter/ha humic acid treatment but this weight was not statistically different from the 1.5 liters/ha humic acid application. Among various cultivars, cultivar Derakhshan shows superiority over the rest two cultivars and it was showing 32.38g seed weight. While the lowest seed weight was reported from the Goli cultivar and it was reported 25.24g for 100 seeds. In interaction study, highest seed weight was observed in the combination of 3 liters/ha humic acid and Line D81083 cultivars and this combination were showing significant difference as compared to control group. According to test results, it can be conclude that using hemic acid in this study improved seed weight, and there was significant difference between control group and different levels of hemic acid. The foliar application of hemic acid increased seed weight and improved seed yield of red bean cultivars. The results of this study are consistent with results of Sabzevari et al. (2008). Further, using hemic acid also increased leaf area and provided more photosynthetic materials which help in the fill grains that can increase yield through seed weight (Yildirim, 2007).

**Conclusion**

Hemic acid improved agricultural traits of red beans cultivars among the various tested cultivars, highest seed yield of red bean as 4253.7 kg per hectare was obtained in Line D81083 using 1.5 liter per hectare of hemic acid. The lowest yield of seeds was obtained as 2615.2 kg per hectare in Derakhshan cultivars without using hemic acid. Moreover, there was significant relationship between the response of bean cultivars and application of hemic acid. The 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. This is well demonstrated the relationship between photosynthesis efficiency and seed yield, because grain 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 grain yield and harvest index was expected, given that grain yield is one of the components in the grain harvest index. So that when the seed yield increases by the number of seeds per pod and the number of pods per plant, it is a factor to achieve higher harvest index (Table 4).

**Conflict of interest**

Authors would hereby like to declare that there is no conflict of interests that could possibly arise.

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