University of Birjand

Journal homepage:
https://escs.birjand.ac.ir

تنشهای محیطی در علوم زراعی
Environmental Stresses In Crop Sciences

*Vol. 15, No. 4, pp. 907-920 (Winter 2023)*

http://dx.doi.org/10.22077/escs.2021.4142.1977

*Original article*

# The effect of wood vinegar and biochar on the quantitative and qualitative yield of soybean in water shortage condition

**S. Amini Pak Soltani[1], S.A.M. Modarres-Sanavy[2*], K. Sadat Asilan[3]**

*1. Master student of Crop Physiology, Department of Agrotechnology, Faculty of Agriculture, Tarbiat Modares University, Tehran, Iran*

*2. Professor in Crop Physiology, Department of Agrotechnology, Faculty of Agriculture, Tarbiat Modares University, Tehran, Iran*

*3. Associate Professor, Agrotechnology, Tehran Branch, Payame Noor University of Tehran, Tehran, Iran*

Received 16 February 2021; Accepted 13 June 2021

## *Extended abstract*

### Introduction

Iran with an average rainfall of 240 mm per year is classified as arid and semi-arid regions of the world, so the occurrence of drought stress during plant growth is inevitable. In order to investigate the effect of biochar and wood vinegar on quantitative and qualitative characteristics of soybean under low irrigation stress, an experiment was conducted as split plots in a randomized complete block design with three replications during the 1398 crop season in the research farm of Tarbiat Modares, Faculty of Agriculture. The aim of this study was to investigate the effect of biochar and wood vinegar as organic sources on soybean nutrition as an important plant in the production of oil and protein needed by humans, through which the effect of these two treatments on plant resistance to water deficit stress.

### Materials and methods

The main factors of this experiment were four irrigation regimes (Optimal irrigation, mild, medium, and severe irrigation deficit: withholding irrigation until the soil moisture content at plant root zone reaches 85, 65, 45 and 25%, of the soil available water respectively, and then irrigation to the field capacity). Water deficit stress was applied at the beginning of flowering of the plant and the sub-factors were anti-stress materials, ie three concentrations of wood vinegar (concentrations of 5000 ppm, 10000 ppm and 15000 ppm) and a biochar surface (5 t / ha) and control treatment (without anti-stress materials). Before planting, wood and biochar treatments were sprayed on soil surface according to the ratio of each experimental unit and post-growing wood vinegar treatment was applied at three-leaf, early flowering and podding stages as foliar application. Yield and yield components including plant height, plant leaf area, number of plant pods, 1000-seed weight and biological yields, seeds, straw and oil and greenness index were measured.

### Results and discussion

The results showed that drought stress had a significant effect on height, plant leaf area, number of pods per plant, biological yields, grain yield, straw and oil yield and 1000-seed weight and decreased with the application of water deficit stress. Fertilizer treatments were not significant on plant height, pod number

[*] Corresponding author: Seyed Ali Mohammad Modarres-Sanavy; E-Mail: modaresa@modares.ac.ir

and straw yield but had a significant effect on other traits. The interaction effects of irrigation and fertilizer treatments on plant leaf area, biological yield, grain yield and oil yield were significant .

## Conclusions

The results of this study showed that the occurrence of drought stress has a negative effect on yield and yield components of soybeans. The highest plant leaf area, biological, grain and oil yield in optimal irrigation were related to biochar fertilizer treatment. According to the results of the study, it seems that in conditions of water shortage stress, the use of biochar will not be very beneficial. In these conditions, the use of wood vinegar is recommended for mild, moderate and severe water deficiency, maximum plant leaf area and biological, grain and oil yields were observed with the use of wood vinegar. Researchers have identified pyroligneous acid as a turning point in organic farming that has a major impact on the management and growth of maize and soybeans (Coffman et al., 2005). Wood vinegar and biochar, as organic matter and naturally derived habitat, can be redirected to improve crop yields under environmental stress.

***Keywords*:** Drouth stress, Irrigation Regimes, Oil seeds, Organic Fertilizers, Yield Components

**Table 1. Analysis of variance (mean squares) for morphological traits and yield components of soybean under irrigation and fertilizer regimes**

| S.O.V | d.f | plant Height | Leaf area per plant | Number of pods per plant |
|---|---|---|---|---|
| **Repetition (R)** | 2 | 721.52 | 53508.82 | 0.11* |
| **Irrigation regime (D)** | 3 | 1538.27* | 16278482.31** | 0.34** |
| **Error a** | 6 | 274.18 | 110946.06 | 0.01 |
| **Fertilizer regime (F)** | 4 | 139.71 | 340802.48* | 0.02 |
| **D*F** | 12 | 95.31 | 497148.02** | 0.02 |
| **Experimental error** | 32 | 114.81 | 104240.21 | 0.03 |
| **Coefficient of variation%** | | *11.95* | *13.82* | *9.1* |

Unsigned, ** and * indicate insignificance and significance at the statistical level of 1 and 5%, respectively

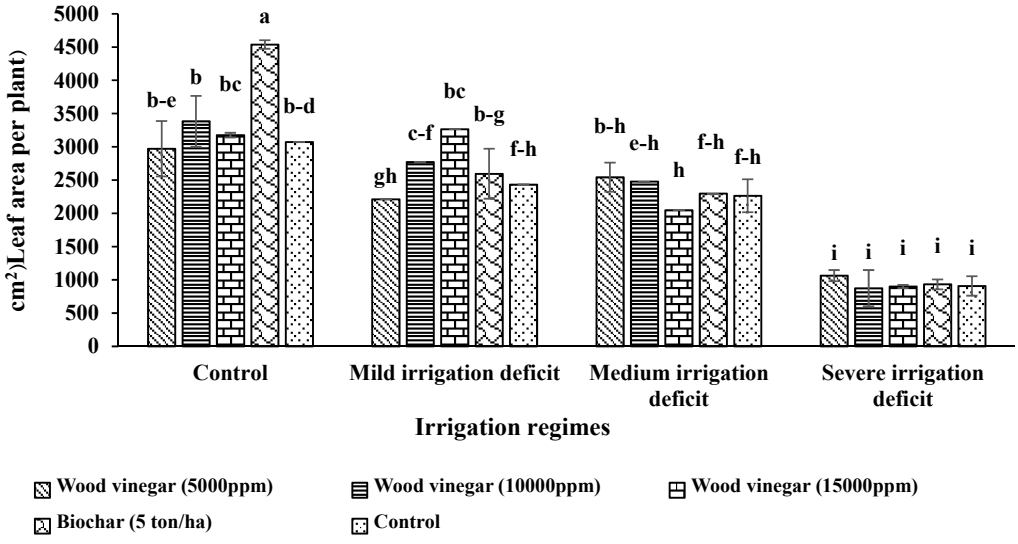


**Fig. 1. Interaction mean comparison of irrigation and fertilizer regimes on soybean leaf area**

**Table 2. Analysis of variance (mean squares) for soybean yield under irrigation and fertilizer regimes**

| S.O.V | d.f | Biological yield | Seed yield | Straw yield |
|---|---|---|---|---|
| **Repetition (R)** | 2 | 1085354.6 | 24021.82* | 1233625.02* |
| **Irrigation regime (D)** | 3 | 44958720.5** | 17639425.78** | 6771557.75** |
| **Error a** | 6 | 332577.7 | 36822.59 | 328344.22 |
| **Fertilizer regime (F)** | 4 | 278278.5 | 427705.77* | 428906.15 |
| **D*F** | 12 | 937656.00** | 621407.32** | 354512.86 |
| **Experimental error** | 32 | 222077.6 | 120907.67 | 313950.83 |
| **Coefficient of variation%** | | *9.55* | *20.10* | *16.19* |

Unsigned, ** and * indicate insignificance and significance at the statistical level of 1 and 5%, respectively

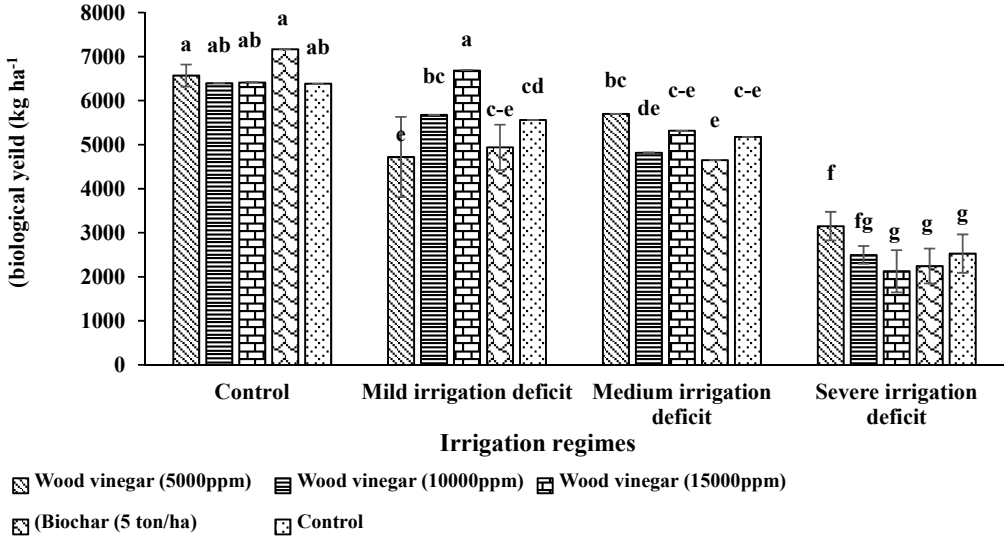


**Fig. 2. Comparison of the average interaction effects of irrigation and fertilizer regimes on the biological yield of soybean plant**

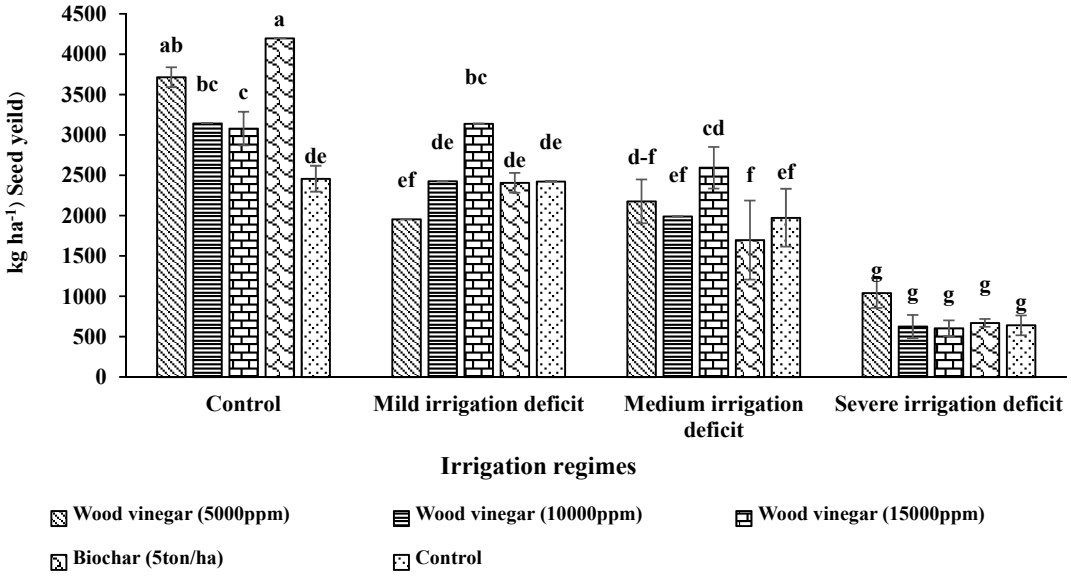


**Fig. 3. Comparison of the mean interactions of irrigation and fertilizer regimes on soybean grain yield**

**Table 3. Analysis variance (mean squre) of yield variance and yield components for soybeans under irrigation and fertilizer regimes**

| S.O.V | d.f | Oil yield | Weight of 1000 seeds | Leaf greenness |
|---|---|---|---|---|
| **Repetition (R)** | 2 | 3104.02 | 1270.02 | 177.20* |
| **Irrigation regime (D)** | 3 | 933221.45** | 15999.26** | 354.51** |
| **Error a** | 6 | 2044.53 | 441.66 | 23.37 |
| **Fertilizer regime (F)** | 4 | 26338.07* | 713.21* | 32.92 |
| **D*F** | 12 | 36030.04** | 210.66 | 45.48 |
| **Experimental error** | 32 | 7013.49 | 199.94 | 32.36 |
| **Coefficient of variation%** | | *16.69* | *7.73* | *13.25* |

Unsigned, ** and * indicate insignificance and significance at the statistical level of 1 and 5%, respectively

**Table 4. Mean comparison of soybean physiological traits under irrigation regimes**

| Irrigation regime | Shoot Hight | Number of pods per plant | Straw yield |
|---|---|---|---|
| | cm | | kg ha$^{-1}$ |
| **Optimal irrigation** | 98.27±4.07$^{a}$ | 106.73±9.27$^{a}$ | 3267.7±124.05$^{a}$ |
| **Mild irrigation deficit** | 93.00±3.00$^{a}$ | 82.80±7.94$^{b}$ | 3046.00±1955.54$^{a}$ |
| **Medium irrigation deficit** | 92.40±3.45$^{a}$ | 70.93±6.10$^{b}$ | 3044.7±142.64$^{a}$ |
| **Severe irrigation deficit** | 75.00±1.68$^{b}$ | 46.60±3.60$^{c}$ | 1792.3±153.06$^{b}$ |

Means with at least one common letter in each column using LSD test have no significant difference at the 5% probability level. After the sign ± is the standard error

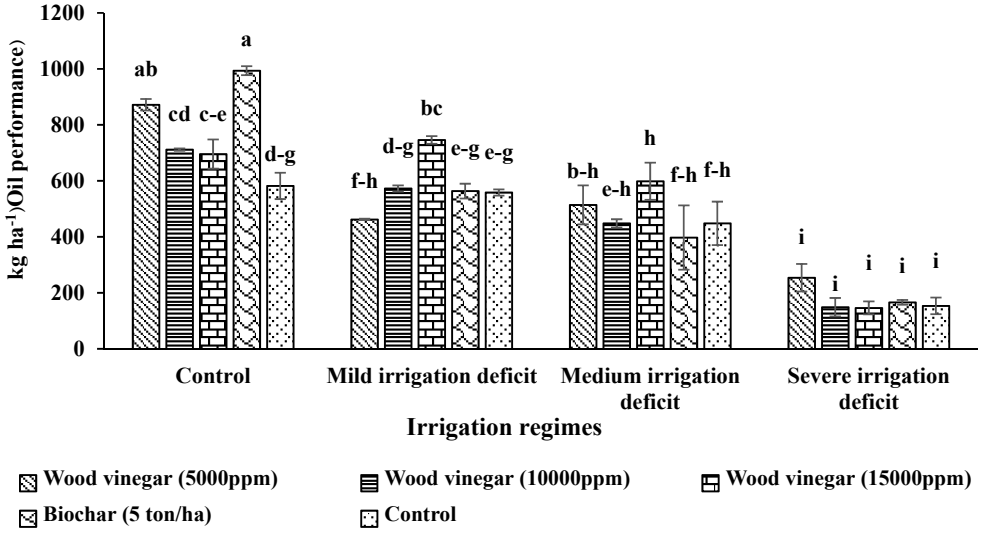


**Fig. 4. Comparison of the mean interactions of irrigation and fertilizer regimes on soybean oil yield**

**Table 5. Mean comparison of soybean physiological traits under irrigation regimes**

| Irrigation regime | Weight of 1000 seeds | Leaf greenness |
|---|---|---|
| | kg ha$^{-1}$ | spad |
| **Optimal irrigation** | 193.67±3.33$^{a}$ | 42.85±1.47$^{b}$ |
| **Mild irrigation deficit** | 199.80±4.77$^{a}$ | 44.36±0.69$^{ab}$ |
| **Medium irrigation deficit** | 203.87±3.94$^{a}$ | 48.07±2.56$^{a}$ |
| **Severe irrigation deficit** | 134.33±5.60$^{b}$ | 36.41±1.15$^{c}$ |

Means with at least one common letter in each column using LSD test have no significant difference at the 5% probability level. After the sign ± is the standard error