University of Birjand

تنش‌های محیطی در علوم زراعی
Environmental Stresses In Crop Sciences
Vol. 14, No. 2, pp. 375-386
Summer 2021
http://dx.doi.org/10.22077/escs.2019.2645.1687

Original article

Study the effect of drought stress and iron oxide nanoparticle foliar application on quantitative and qualitative traits of sesame (*Sesamum indicum* L.)

Z. Karamian Hasan Abadi[1], H.R. Eisvand[2*], M. Daneshvar[3], O.A. Akbarpour[3]

1. MSc Student of Agronomy, Department of Plant Production and Genetic Engineering, Faculty of Agriculture, Lorestan University, Iran

2. Associate Prof., Department of Plant Production and Genetic Engineering, Faculty of Agriculture, Lorestan University, Iran

3. Assistant Prof., Department of Plant Production and Genetic Engineering, Faculty of Agriculture, Lorestan University, Iran

Received 6 July 2019; Accepted 2 October 2019

Extended abstract

Introduction

Sesame (*Sesamum indicum* L.) is one of the oldest oil seed crops, growing widely in tropical and subtropical areas. Drought is a polygenic stress and is considered as one of the most important factors limiting crop yields around the world. Most of the Iranian soils have a high pH and calcareous nature, and micronutrients solubility in these soils is low. Micronutrient deficiency, especially iron, is widespread where soil is calcareous with high pH, low organic matter, continuous drought, high bicarbonate content in irrigation water, and imbalanced application of NPK fertilizers. Foliar nutrition is an option when nutrient deficiencies cannot be corrected by applications of nutrients to the soil. Microelements Foliar application is very helpful when the roots cannot provide necessary nutrients. Iron is an important element in crops, because it is essential for many enzymes including cytochromes, which is involved in the electron transport chain, chlorophyll synthesis, and maintains the structure of chloroplasts. Nowadays, nanoparticles of metals are widely used in many sections, such as medicine, agriculture, and industry. Iron oxide nanoparticles have a large surface area and high reactivity. Moreover, when compared to many other metallic nanoparticles, the iron oxide nanoparticles are constant, less expensive, and less toxic. Iron oxide nanoparticles have high magnetization amounts, a size smaller than 100 nm and a thin particle size distribution. These particles also have a special surface cover of magnetic particles, which has to be harmless and biocompatible.

Materials and methods

To study the effect of drought stress and iron oxide nanoparticle foliar application on quantitative and qualitative traits of sesame (*Sesamum indicum* L.), an experiment was conducted as split-plot with three replications at the research farm of Agricultural Faculty, Lorestan University in 2016. The experimental factors were included drought stress in two levels of non-stress (Irrigation to reach soil water to FC 100%) and drought stress (Irrigation to reach soil water to FC 50%) as the main factor, and iron oxide nanoparticle foliar application in five levels of non-foliar application (Control), foliar application by water (1000 liters of water per hectare), iron oxide nanoparticle 0.05% (0.5 kg/1000 L of water per

*Correspondent author: Hamid Reza Eisvand; E-Mail: eisvand.hr@lu.ac.ir.

hectare), iron oxide nanoparticle 0.1% (1.0 kg/1000 L of water per hectare) and iron oxide nanoparticle 0.15% (1.5 kg/1000 L of water per hectare) as the sub factor. The measured traits included number of capsules per plant, 1000 grain weight, grain yield, biological yield, harvest index, grain oil content, grain oil yield, grain protein content and grain protein yield. Analysis of variance was performed using general linear model (GLM) procedure of statistical analysis system (SAS version: 9.3). The means were analyzed using the Tukey test at P=0.05.

Results and discussion

Results showed that the drought stress decreased significantly traits of 1000 grain weight (18.51%), grain yield (26.52%), biological yield (9.42%), harvest index (3.94%), grain oil content (10.30%), grain oil yield (40.47%) and grain protein yield (24.90%) except for the number of capsules per plant and grain protein content. However, the iron oxide nanoparticle application improved significantly traits of 1000 grain weight (19.86%), grain yield (37.43%), biological yield (22.91%), harvest index (3.86%), grain oil content (6.49%), grain oil yield (45.70%) and grain protein yield (40.93%) under drought stress except for the number of capsules per plant, and grain protein content. Among different levels of foliar application, iron oxide nanoparticle 0.15% had the most effect on increasing the measured traits except for the harvest index.

Conclusions

In general, iron oxide nanoparticle foliar application can be used, especially at a concentration of 0.15%, to reduce the harmful effects of drought stress and improve the quantitative and qualitative traits of sesame in Khorramabad city.

Keywords**:** Crop characteristics, Environmental stresses, Micronutrients, Oilseeds

Table 1. Soil physical and chemical properties of experimental location

E.C	pH	Soil texture	Clay	Silt	Sand	O.C	P	K	Fe	Zn	Mn
$dS.m^{-1}$			-------------------	%	------------------		--------------------		$mg.kg^{-1}$		----------------------
0.59	7.51	Silty clay	33	45	22	0.53	2.10	235.00	5.00	1.26	5.80

Table 2. Weather statistics of Khorramabad city during the experimental period

Month	Mean of air temperature (℃)		RH	Precipitation
	Maximum	Minimum	(%)	(mm)
July	39.9	18.9	20.8	0.0
August	40.2	20.2	19.3	0.0
September	36.9	15.6	22.6	0.0
October	32.0	5.4	55.0	0.0
November	26.1	6.5	61.0	15.0

Table 3. Analysis of variance (Mean squares) of measured traits affected by experiment factors

S.O.V	df	Number of capsules per plant	1000-grain weight	Grain Yield	Biological Yield	Harvest index
Block	2	35.33^{ns}	0.01^{ns}	7589.03^{ns}	103669.43^{ns}	1.00^{ns}
Drought stress (A)	1	943.45**	0.63**	748131.5**	6745226.9**	19.76**
Error a	2	75.48	0.01	7395.51	135660.86	0.88
Foliar application (B)	4	526.95**	0.23**	623012.5**	12762356**	7.52**
A×B	4	159.54*	0.058*	12154.34*	723021.72*	3.19*
Error b	16	43.18	0.004	4024.72	200251.76	0.91
CV (%)		*11.53*	*4.0*	*3.74*	*3.9*	*6.49*

Table 3. Continued

S.O.V	df	Grain oil content	Grain oil yield	Grain protein content	Grain protein yield
Block	2	1.50^{ns}	231.12^{ns}	0.10^{ns}	175.60^{ns}
Drought stress (A)	1	420.22**	626105.11**	3.09**	25709.91**
Error a	2	2.38	6370.35	0.14	136.53
Foliar application (B)	4	31.21**	259528.88**	2.35**	38507.24**
A×B	4	6.78*	4235.10*	0.05$^{n.s}$	654.40*
Error b	16	2.06	1300.06	0.40	198.10
CV (%)		*2.73*	*4.02*	*2.88*	*3.74*

ns, * and **: Non significant and significant at P<0.05 and P<0.01, respectively

Table 4. Comparison of mean the effect of iron oxide nanoparticle foliar application on measured traits under non-drought stress condition

Foliar application of iron oxide nanoparticle	number of capsules per plant	1000-grain weight	Grain yield	Biological yield
(FAION)		(g)	----------(kg.ha^{-1})------------	
Control	48.10^{e}	3.02^{b}	1501.08^{e}	10112.14^{e}
Water	55.39^{d}	2.97^{b}	1691.40^{cd}	11017.71^{d}
FAION 0.05%	62.67^{c}	3.11^{ab}	1830.97^{c}	11878.11^{c}
FAION 0.10%	73.24^{b}	3.16^{ab}	2041.79^{b}	12516.85^{b}
FAION 0.15%	80.30^{a}	3.27^{a}	2205.76^{a}	14132.52^{a}

Table 4. Continued

Foliar application of iron oxide nanoparticle	Harvest index	Grain oil content	Grain oil yield	Grain protein yield
(FAION)	--------------------(%)--------------------		--------------------(kg.ha^{-1})---------------	
Control	14.85^{c}	54.26^{c}	814.48^{e}	315.78^{e}
Water	15.35^{b}	55.26^{bc}	934.66^{d}	362.51^{d}
FAION 0.05%	15.41^{b}	55.86^{abc}	1022.77^{c}	402.42^{c}
FAION 0.10%	16.31^{a}	56.43^{ab}	1152.18^{b}	451.78^{b}
FAION 0.15%	15.60^{b}	57.54^{a}	1269.19^{a}	492.74^{a}

Means in each column followed by similar letters are not significantly different at 0.05 probability level

Table 5. Comparison of mean the effect of drought stress on grain protein content of sesame

Drought stress (DS)	Grain protein content (%)
Non Drought Stress	21.51^{b}
Drought Stress	22.36^{a}

Means in each column followed by similar letters are not significantly different at 0.05 probability level.

Table 6. Comparison of mean the effect of iron oxide nanoparticle foliar application on measured traits under drought stress conditions

Foliar application of iron oxide nanoparticle	number of capsules per plant	1000-grain weight	Grain yield	Biological yield
(FAION)		(g)	------------(kg.ha^{-1})------------	
Control	32.92^{de}	2.42^{b}	1102.88^{e}	9159.04^{e}
Water	37.40^{d}	2.56^{b}	1301.00^{d}	10113.33^{d}
FAION 0.05%	47.35^{c}	2.97^{a}	1495.23^{c}	10838.26^{c}
FAION 0.10%	59.40^{b}	3.03^{a}	1769.49^{b}	11904.26^{b}
FAION 0.15%	72.93^{a}	3.07^{a}	2023.25^{a}	12903.71^{a}

Table 6. Continued

Foliar application of iron oxide nanoparticle	Harvest index	Grain oil content	Grain oil yield	Grain protein yield
(FAION)	--------------(%)---------------		------------(kg.ha^{-1})--------------	
Control	10.91^{d}	43.96^{d}	484.82^{e}	237.13^{e}
Water	14.20^{bc}	46.67^{c}	607.17^{d}	290.93^{d}
FAION 0.05%	13.79^{c}	48.24^{bc}	721.29^{c}	337.03^{c}
FAION 0.10%	14.86^{b}	50.66^{ab}	896.42^{b}	400.43^{b}
FAION 0.15%	15.68^{a}	52.45^{a}	1061.19^{a}	466.95^{a}

Means in each column followed by similar letters are not significantly different at 0.05 probability level

Table 7. Comparison of mean the effect of iron oxide nanoparticle foliar application on sesame Grain protein content

Foliar application of iron oxide nanoparticle	Grain protein content
(FAION)	(%)
Control	21.03^{c}
Water	21.61^{b}
FAION 0.05%	22.10^{ab}
FAION 0.10%	22.26^{a}
FAION 0.15%	22.65^{a}

Means in each column followed by similar letters are not significantly different at 0.05 probability level