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Influence of humic acid and mycorrhiza on some characteristics of safflower (*Carthamus tinctorius*)

Authors:
Ahmad Mehraban[1] and Mohammad Miri[2]

Institution:
1. Department of Agronomy, Islamic Azad University, Zahedan Branch, Zahedan, Iran.

2. Ph.D. Student, Department of Agronomy, Islamic Azad University, Zahedan Branch, Zahedan, Iran.

Corresponding author:
Ahmad Mehraban

ABSTRACT:

In this study, maximum positive effect of bio fertilizers was observed. All studied characteristics including branch number, grain yield and capitulum diameter increased after using biofertilizers. The field trial was done with randomized complete block pattern with three repeats. Treatments consisted of mycorrhiza in three levels (M_1: Control, M_2: *Glomus mosseae* and M_3: *Glomus etunicatum*) and humic acid (S_1: Once a week, S_2: once in every two weeks, S_3: Once in every three weeks). Analysis of variance showed that the effect of mycorrhiza and humic acid on capitulum number, branch number, grain yield and capitulum diameter in plant was significant.

Keywords:

Humic acid, Mycorrhiza, Branch number, Grain yield

Email Id:

Ahmadmehraban6@gmail.com

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INTRODUCTION

Traditionally, safflower (*Carthamus tinctorius*) is being grown for its flower to extract dyes, which are being used as coloring of foods and textiles (Badiger *et al*., 2009). However, for the last fifty years, this crop had been primarily cultivated for production of high-quality vegetable oil in semiarid regions in Asia, Australia, Americas and Europe (Yau, 2009). Safflower, which has many usage areas and certain superior characteristics than other oil plants, may play a significant role to complete the vegetable oil shortage if the growers give adequate importance. The most two important points why safflower cultivation is not progressing is that; the low seed yield and oil content of present varieties.

Currently, safflower plants are grown under non-irrigation owing to its resistance to drought and the yield is exposed less than 1000 kg ha^{-1}. In order to promote safflower-growing areas and to increase production, high quality seed plants with high yield must be identified firstly (Sakir and Basalma, 2005). Safflower seeds contain from 13 to 46 % oil, and approximately 90 % of this oil is composed of unsaturated fatty acids, which are called as oleic, and linoleic acids (Johnson *et al*., 1999). Due to rapid drying, the oil is being high demanded in paint and emulsion industries (Karakaya *et al*. 2004). Ogut and Oguz (2006) reported that safflower oil is quite suitable for biodiesel production. Safflower oil cake is also a valuable feed for animals (Weiss, 2000). Safflower is used in a variety of ways for home consumption, medicinal and industrial uses. The crop is however most suited for tropical climate with high humidity and temperature of about 25°C to 35°C (Hikosaka, 2004). Safflower requires an optimum pH of 6-7 and rainfall of about 450-500mm which should be well distributed over 90-120 days during the growing season. It can tolerate relatively high temperature throughout the growing and fruiting periods (Rao, 1996).

Recently, it has become common to apply organic acids to improve the quantity and quality of horticultural products. Very small amount of organic acids have a considerable effect on improving the physical, chemical and biological characteristics of soil and they have suitable effects in increasing production and quality of agricultural products because of hormone based compounds (Samavat and Malakooti, 2005). Soil fertility is heavily dependent upon its organic content (Liu and Cooper, 2000). Integrated nutrient management strategies involving chemical fertilizers and bio-fertilizers have been suggested to enhance the sustainability of crop production. The bio inoculants help the expansion of root systems and better seed germination and plant growth (Manske *et al*., 1995 and 1998). In African soils, legume as a pre-crop also affects the biological properties: legume pre-crops result in earlier colonisation of cereal roots by AM fungi (Bagayoko *et al.*, 2000). Inoculation of plant roots with Arbuscular Mycorrhizal (AM) fungi may be effective in improving crop production under drought conditions. Colonization of roots by AM fungi has been shown to improve productivity of numerous crop plants in soils under drought stress (Al-Karaki and Al-Raddad 1997; Al -Karaki and Clark 1998; Faber *et al*., 1990; Sylvia *et al*., 1993). Improved productivity of AM plants was attributed to enhanced uptake of immobile nutrients such as phosphorus, zinc and copper. In addition, other factors associated with AM fungal colonization may influence plant resistance to drought. These include changes in leaf elasticity (Auge *et al*., 1987), improved leaf water and turgor potentials, maintenance of stomatal opening and transpiration, increased root length and depth and development of external hyphae (Ellis *et al*., 1985). The organic manures are in different types and they prepared initially from either animal or plant residues.

All organic manures improve the behavior of several elements in soils through that active group (fulvic and humic acids) which have the ability to retain the elements in complex and chelate form. These materials release the elements over a period of time and are broken down slowly by soil microorganisms. The extent of availability of such nutrients depends on the type of organic materials and microorganisms. Humic acid improves the physical, chemical and biological properties of the soil and influences plant growth. Humic substances are recognized as a key component of soil fertility properties, since they control chemical and biological properties of the rhizosphere (Rengrudkij and Partida, 2003; Nardi *et al*., 2005; Trevisan *et al*., 2009). The effects of humic substances have been directly correlated with enhanced uptake of macronutrients, such as N, P, S and micronutrients like Fe, Zn, Cu and Mn (Chen *et al*., 2001). The mechanism of humic acid activity in promoting plant growth is not completely known, but several explanations have been proposed by some researchers such as increasing cell membrane permeability, oxygen uptake, respiration and photosynthesis, phosphate uptake, and root cell elongation (Turkmen *et al*., 2004).

MATERIAL AND METHODS

Location of trial

The trial was conducted at Zabol in 2016 which is situated between 30° North and 61° East.

Composite soil sampling

Composite soil sampling was made in the trial area before the imposition of treatments and was analyzed for physical and chemical characteristics. WB-C method (Rowell and Florence, 1993) was used to measure soil organic matter. The oxidation reaction is similar to that above but the method differs in that the amount of reduced chromium is estimated calorimetrically using a modification of the high volume version described. For the determination of the total nitrogen, Kjeldahl method was applied (Bremner, 1996). In the Kjeldahl method, the organic N is converted into NH_4 through digestion with H_2SO_4 and metals that act as catalyzers [copper (Cu) and selenium (Se)] or that further the conversion and help maintaining high temperatures during digestion ($NaSO_4$). NH4 is separated after distillation by vapor carrying, resulting from the addition of concentrated NaOH solution to the digestion extract. The ammonia produced is carried by water vapor and collected in a boric acid solution containing the detection substance. The borate is retro titrated with H_2SO_4 standardized solution. The amount of acid used in the titration is proportional to the N-NH_4 present in the sample (Bremner, 1996). pH meter was used to measure pH. soil properties of field were: pH 7.7, 1.19% Organic Matter (OM), 0.21% total nitrogen, 8.44 mg kg^{-1} Olsen phosphorous, 257 mg kg^{-1} extractable K^+ ammonium acetate ($NH_4CH_3CO_2$), 0.824 mg kg^{-1} zinc and 73.3 mg kg^{-1} iron and clay-loam texture (28% sand, 42% clay and 30% silt).

Field trial

The field trial was laid out in factorials with randomized complete block pattern with three repeats. Treatments included mycorrhiza in three levels (M_1: Control, M_2: *Glomus mosseae* and M_3: *Glomus etunicatum*) and humic acid (S_1: Once a week, S_2: Once in every two weeks, S_3: Once in every three weeks).

Table 1. Effect of mycorrhiza and humic acid on safflower

Sov	df	Capitulum number	Branch number	Grain yield	Capitulum diameter
R	2	0.1360	0.0764	36.5925	0.001348
Mycorrhiza (A)	2	39.9433**	9.6018**	54203.2592**	0.4278**
humic acid (B)	2	14.8084*	0.8221*	11699.5925*	0.11085*
A*B	4	8.3919*	1.1387**	15788.5370**	0.2782**
Error	-	2.6299	0.1426	3136.0509	0.0275
CV		8.32	10.19	4.97	8.61

*, **, ns: significant at $p<0.05$ and $p<0.01$ and non-significant, respectively.

Table 2. Effect of mycorrhiza and humic acid on different safflower traits

Treatment	Capitulum number	Branch number	Grain yield (kg.ha^{-1})	Capitulum diameter (cm)
Mycorrhiza				
Control	18.21^{b}	2.98^{b}	1073.78^{b}	1.74^{b}
G. mossea	21.91^{a}	4.88^{a}	1215.11^{a}	2.17^{a}
G. etunicatum	18.32^{b}	3.23^{b}	1088.89^{b}	1.86^{b}
Humic acid				
S_1	18.01^{b}	3.44^{b}	1085.11^{b}	1.80^{b}
S_2	20.35^{a}	4.03^{a}	1153.44^{a}	1.9933^{a}
S_3	20.08^{a}	3.62^{b}	1139.22^{ab}	1.9911^{a}

Any two means not sharing a common letter differ significantly from each other at 5% probability

Irrigation and fertilization

Irrigation was proceeded according to the propose design throughout the growing season. A identical basic dose of 30 kg nitrogen per hectare was blended with the dirt during seedbed preparation to all piece. Phosphor fertilizer was used at the time of planting. Entire other agricultural practices were accomplished equally within the growth season. Weeds were manually eradicated whenever they were observed in the field.

Data analysis

Data collected were subjected to statistical analysis by using a computer program SAS (Mervyn *et al*., 2008). Least Significant Difference test (LSD) at 5 % probability level was applied to compare the differences among means of the treatment.

RESULTS AND DISCUSSION

Capitulum number

Analysis of variance showed that the effect of mycorrhiza on capitulum number in plant at the probability level of 1% ($p<0.01$) was significant (Table 1). The maximum capitulum number (21.91) was obtained in M_2 treatment (Table 2). The minimum capitulum number (18.21) was recorded in control (Table 2). Analysis of variance showed that the effect of humic acid on capitulum number at the probability level of 5% ($p<0.05$) was significant (Table 1). The maximum capitulum number (20.35) was recorded in S_2 treatment (Table 2). The minimum capitulum number (18.01) was noted in S_1 treatment (Table 2). Farnia and Moayedi (2015) found that application of biofertilizers increased capitulum number of sun flower. Bahamin *et al.* (2014) showed that when seeds were inoculated with Nitroxin biologic fertilizer, seed yield reached 3840 kg per hectare, showing 28% increase compared to non-un-inoculated treatment.

Branch number

Analysis of variance showed that the effect of mycorrhiza on branch number at the probability level of 1% ($p<0.01$) was significant (Table 1). The maximum branch number (4.88) was obtained *G. mosseae* treatment whereas minimum branch number (2.98) was recorded in control (Table 2). Analysis of variance showed that the effect of humic acid on branch number at the probability level of 5% ($p<0.05$) was significant (Table 1). The maximum branch number (4.03) was noted in S_2 whereas minimum values (3.44) were obtained in S_1 treatment (Table 2). Ahmad *et al*. (2010) showed that higher yield due to bio fertilizers might be because of the increase in metabolic activities of biologic fertilizers and production of growth stimulating hormones by bacteria. Also Farnia and Moayedi (2015) found that application of biofertilizers increased branch number of sun flower.

Grain yield

Analysis of variance showed that the effect of mycorrhiza on grain yield at the probability level of 1% ($p<0.01$) was significant (Table 1). The maximum grain yield (1215.11 kg ha^{-1}) was noted in *G. mosseae* treatment, whereas minimum yield (1073.78 kg.ha^{-1}) was recorded in control (Table 2). Analysis of variance showed that the effect of humic acid on grain yield at the probability level of 5% ($p<0.05$) was significant (Table 1). The maximum grain yield (1153.44 kg.ha^{-1}) was in S_2 treatment whereas minimum grain yield (1085.11kg.ha^{-1}) was in S_1 (Table 2). The positive effect of biofertiizers on sunflower plants observed in the present study was due to the increase of the yield. Beyranvand *et al*. (2013) reviled that application nitrogen and phosphate biofertilizers increased yield and yield components of maize under Boroujerd environmental condition. Farnia and Moayedi (2015) found that application of bio fertilizers increased grain yield of sun flower.

Capitulum diameter

Analysis of variance showed that the effect of Mycorrhiza on capitulum diameter at the probability level of 1% ($p<0.01$) was significant (Table 1). The maximum capitulum diameter (2.17cm) was obtained *G. mosseae* treatment, whereas minimum capitulum diameter (1.74 cm) was in control (Table 2). Analysis of variance showed that the effect of humic acid on capitulum diameter at the probability level of 1% ($p<0.01$) was significant (Table 1). The maximum capitulum diameter (1.99 cm) was in S_2 treatments, whereas minimum capitulum diameter (1.80 cm) was noted in S_1 treatment (Table 2). Farnia and Moayedi (2015) found that application of biofertilizers increased capitulum diameter of sun flower. Also Azimi *et al*. (2013) found that application of biofertilizers increased yield and yield components of barley under Borujerd environmental condition.

CONCLUSION

The present study shows that application of humic acid and mycorrhiza biofertilizers improved morphological traits compared to non application of humic acid and mycorrhiza biofertilizers. Thus, we can use this biofertilizers instead of chemical fertilizers for production of health food for human nutrition.

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