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Efficacy of Magnetic Water and Methanol on Agronomic Traits of Soybean (*Glycine max* L.)

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ABSTRACT

Background: The major part of the edible oil used in Iran is supplied through imports. It is important to increase the yield of oilseed crops, especially soybeans, in non-chemical and environmentally friendly ways, along with its easy availability and low cost. The use of magnetic water as a new method, increases the yield of plants by improving solubility and access the nutrients. On the other hand, in recent years, methanol spraying as a source of carbon dioxide, which increases the concentration of this gas around the plant, enhancing the photosynthesis and plant yield. This study was conducted to study the efficacy of different intensities of magnetic water and various concentrations of methanol foliar application on agronomic traits of soybean.

Methods: This experiment was carried out as split plot in a randomized complete block design with 3 replications during two consecutive years 2016-17. The main plot was irrigated with magnetic water in 4 intensity (0: control, 4, 8, 12mTesla) and a subplot was methanol spraying in 4 volumetric percentage (distilled water: control, 10, 20 and 30% v/v).

Result: Photosynthetic pigments *viz.* (Chlorophyll a, b, carotenoid), yield attributes, seed yield, biological yield, seed protein and soybean economics were significantly affected by the magnetic water and methanol spraying. Seed yield and net return, as the most important traits increased by magnetic irrigated with 8 and 12mTesla intensities, compared to control, by 70.05-72.19% and 122.37-126.05%, respectively. Furthermore the maximum biological, stover yields and protein obtained by 8mTesla magnetic irrigation, compared to control, it showed 59.54, 54.9 and 10.07% superiority, respectively. Also, methanol foliar application at 20% concentration increased seed yield, biological yield, seed protein and net return by 19.01, 13.73, 5.24 and 26.43%, respectively.

Key words: Magnetic water, Methanol, Soybean, Yield.

INTRODUCTION

Increasing the performance of oil seed plants, especially soybeans, is very important. The total harvested area and the average production of soybean (*Glycine max*. L) in Iran are 83000 ha and 2409 kg/ha (FAO, 2017). Increasing the seed yield and consequently the oil of this plant without the use of chemical inputs that has a harmful effect on the environment, as well as at a cheap price and easy to prepare, is noticeable. In recent years, the application of magnetic water has been considered as one of the most desirable and eco-friendly methods for increasing the yield of agricultural products (Silva and Dobránszki 2014). The normal water which treated with the magnetic field or passes through a magnetic device, known as magnetic water, exhibits different physical and chemical properties (Grewal and Maheshwari 2011).

The favorable effects of magnetic water on the quality and quantity of various crops as well documented in literatures, such as increasing water use efficiency, yield, yield components and seed protein in faba bean (Hozayn *et al.* 2016a), booster dry weight of maize (Al Janaby 2014), increase yield and counteract the drought stress (Hasan *et al.* 2018), increase the seed germination percentage (El-Yazied *et al.* 2011; Abedinpour and Rohani 2017), increase nitrogen fixation and absorption, phosphorus absorption and accelerate the seedling emergence (Aliverdi *et al.* 2015), early canopy cover and a better competition against weeds, photosynthetic activity, carbohydrates, protein contents and yield in broad bean (El Sayed 2014).

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Low concentrations of carbon dioxide in the microclimate surround plants (less than 340 ppm), especially during the hours when photosynthesis reaches its maximum, restrict photosynthesis and thus plant growth, so supply and increase CO_2 surrounds canopy plants (up to 500-1000ppm) have been introduced as promising technique to increase photosynthesis, plant growth and yield (Zbieć *et al.* 2003; Tavassoli and Galavi 2011). Methanol foliar application was accounted as a CO_2 source that increased photosynthesis rate and crop yield (Madhaiyan *et al.* 2006; Moghadas *et al.* 2013; Tavassoli and Galavi 2011; Zbieć *et al.* 2003). When methanol is sprayed on the surface of the leaves of the plant, it is converted to water and carbon dioxide by the methylotrophic bacteria present on the surface of the leaves. The resulting carbon dioxide enters the leaves directly through the stomata and participates in photosynthesis (Madhaiyan *et al.* 2006).

The desirable effects of methanol foliar application declared by researchers such as enhancing the plant water relation, growth, yield and also ameliorate the water stress (Tavassoli and Galavi 2011), reducing photorespiration rates, stimulation of serine amino acid, improving CO_2 stock and fixation inside the leaf that enhance the photosynthesis and crop yield (Nonomura and Benson 1992a, 1992b).

Therefore, in this study, assumed that increasing the availability and uptake of nutrient from the soil by magnetic water and increasing the absorption and stabilization of CO_2 by methanol spraying could increase the soybean seed, biological and stover yields.

MATERIALS AND METHODS

This experiment was carried out as split plot in a randomized complete block design with 3 replications during two consecutive years 2016-17 in the northwest of Iran (35°10′ 23″N and 46°59′ 23″E and 1312m above sea level). The climatic conditions of the test area are shown in Table 1 during the two growing years. The main plot was irrigation with magnetic water in 4 intensity (0: control, 4, 8, 12mTesla) and subplot was methanol spraying in 4 volumetric percentage (distilled water: control, 10, 20 and 30% v/v).

In order to conduct the experiment, after the initial plowing in autumn, several soil samples were randomly selected to determine the physical and chemical properties of the soil (Table 2) and fertilization was carried out based on the results of soil tests.

Each experimental plot consisted of 4 planting lines with a length of 4m and a line spacing of 50 cm. The planted soybean cultivar was 'Katoul' that originated from a genotype named DPX_{3589} imported from the USA. Soybean seed was planted in late May and before planting inoculated precisely with nitrogen fixation bacteria (*Rhizobium japonicum*). Plant spacing was 7cm and 5cm sowing depth.

The drip irrigation method was set up for plant watering and the amount of the same used water for each experimental plot were precisely measured by the installation of the counter at the water entrance. Irrigation with magnetic water (water passed through a device that induces different quantities of magnetic field) began from 30 days after planting and continued until the end of the growing season.

The magnetic field induction device consisted of a power supply that converts 220 volts into 12 volts and a 6 Amperes and transmits it to the signal generator. The sinusoidal signal is then transmitted to the solenoid with a maximum frequency of 10 kHz. On the solenoid, 250 rounds of copper wire with a diameter of 0.85 mm are wrapped. An aluminum heat sink has been installed to dissipate the heat of the signal generator. Different intensities of the magnetic field (4-12 mT) were applied by a potentiometer and placed the water meter device at the water outlet to determine the amount of used water (Fig 1). Different intensities of the magnetic field induced by device were calibrated by the Teslameter (Model: Leybold didactic, Germany). Some characteristics of irrigated water under influence of magnetic field are shown in Table 3.

Also in this research, different concentrations of methanol were prepared by diluting methanol with distilled water. For each liter of solution, 2 g of glycine amino acid was also added (In order to increase methanol metabolism rate and prevent methanol damage at high concentrations or in low light intensity, recommended by Nonomura and Benson 1992b).

Aqueous solutions of methanol were sprayed on plant foliage in three stages during the growing season (60, 75 and 90 days after planting). Spraying was performed by a 20-liter, manual sprayer in the cool hours of the day and the operation continued until dripping droplets from plant leaves. The total water used during the three foliar spraying (due to the developed the plant canopy in the second and third foliar spraying) was 580 liters per hectare.

The studied traits in this experiment included: photosynthetic pigments *viz* (Chlorophyll a, b, carotenoid), yield attributes (such as: infertile and fertile pod per plant, seed number per pod, 100 seed weight), seed yield, stover, biological yield (Without calculating leaf weight due to falling leaves at ripening stage), seed protein content and soybean economics. Finally, data were analyzed by $SAS_{9.1}$ (SAS Institute Inc) and the means of treatments were compared by Duncan's multiple range tests at the 0.05 probability level.

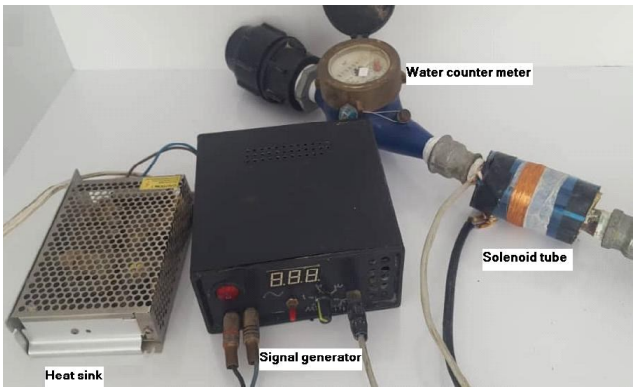


Fig 1: Magnetic field signal generator with different intensities and how it connects to the solenoid and water meter at the magnetic water outlet.

RESULTS AND DISCUSSION

Photosynthetic pigments

Chlorophyll a, b and carotenoids showed a significant difference under the influence of experimental treatments. Based on the results of the mean comparison in Table 4, these pigments increased significantly in the second year of the experiment.

The different intensities of the magnetic water also increased the pigments. So that in 8 mT, the amount of chlorophyll a, b and carotenoids increased as 60.71, 50.16 and 22.22%, respectively, compared to the control.

An increase in photosynthetic pigments in beans has been reported under the influence of magnetic water and this increase has been greater in chlorophyll a (Hozayn *et al.* 2016a).

Table 1: Meteorological parameters in Sanandaj synoptic meteorological site.

Month/ Parameters	Minimum temperature (°C)	Maximum temperature (°C)	Minimum relative humidity (%)	Maximum relative humidity (%)	Rainfall (mm)	Sunshine duration (h)	Evaporation (mm)
2016 growing season							
April	5.2	20.1	15	94	43.35	235.8	134.4
May	10.8	22.3	4	91	22.86	308.7	207.4
June	19	29.9	7	71	0.22	335.4	331.4
July	26.5	32.8	6	50	0	379.1	377.3
Aug	27.1	31.7	3	62	0	365.2	368.2
Sept	17.1	25.3	5	71	0	323.7	283.6
Oct	12	17.9	5	93	4.2	291.3	168.1
Nov	0	14.4	10	95	9.43	242.9	74.8
2017 growing season							
April	6.4	18.9	10	94	56.67	226.8	151.3
May	13	22.6	2	92	24.15	331.4	228.5
June	17.9	30.7	4	65	0	389.4	330.2
July	27	31.6	5	51	0	342.9	392.5
Aug	26.5	32.2	6	49	0.01	357.2	345
Sept	17.8	27.2	4	59	0	307.1	251.1
Oct	11.2	21.2	7	68	0.24	280.1	175.7
Nov	6.9	15	17	94	39.77	166.7	42.2

Table 2: The soil analysis in the site of study during two year study.

Soil depth (cm)	Clay %	Sand %	Silt %	Soil texture	EC (dS/m)	pH	TNV %	OM %	NT %	P (mg/kg)	K (mg/kg)
2016 growing season											
0-30	32.28	33.72	34	Loam	0.489	7.69	4.5	1.13	0.11	14.03	234.4
30-60	32.28	39.72	28	Clay loam	0.535	8.01	7.25	0.83	0.08	10.86	205
2017 growing season											
0-30	21	56	23	Sandy clay loam	0.501	7.99	10	0.83	0.08	9.5	180
30-60	25	46	29	Loam	0.542	8.03	13.75	0.58	0.06	7.3	110

Also, during a separate study, the increase in photosynthetic pigments in canola was 8-19% (Hozayn *et al.* 2016b) and in bean was 3-25% (Hozayn and Abdul Qados 2010).

Enhanced photosynthetic pigments (13-66%) and also increased photosynthetic efficiency (35%) have been proven under the influence of magnetic water in beans (El Sayed 2014).

Due to the chemical structure of chlorophyll molecule- as light receptors in the phenomenon of photosynthesis- which is composed of various elements, especially magnesium and nitrogen, and because magnetic water increases the absorption of various elements, including these, therefore, increasing the synthesis of chlorophyll pigments and thus improving the rate of net photosynthesis and ultimately encourage plant growth and yield is expected (Sadeghipour 2016). Increased absorption of nutrients, especially nitrogen, has been reported by the use of magnetic water in cotton (Gao *et al.* 2017) and soybean (Aliverdi *et al.* 2015). Furthermore, an increase in the number and weight of nitrogen-fixing nodules as 16-73% was reported in 5 soybean cultivars (Aliverdi *et al.* 2015).

In another study, intensification the absorption of nutrients such as magnesium (6.7%), manganese (9.09%), copper (28.57%), potassium (3.33%) and calcium (0.74%) has been proven in canola by magnetic water (Hozayn *et al.* 2016b). Also, magnetic water improved the micro and macro-nutrient such as, N, K, Ca, Mg, S, Zn, Fe and Mn in chickpea and snow pea (Grewal and Maheshwari 2011).

In this experiment, the effect of methanol on increasing photosynthetic pigments was observed and the maximum chlorophyll a, b and carotenoids were obtained in 20% of methanol, which increased as 34.59, 12.64 and 49.29%, respectively, compared to the control (Table 4). Methanol has been shown to increase the activity of the nitrate reductase enzyme by 50% -an enzyme that inhibits the accumulation of nitrate in plant tissues by converting nitrate to ammonium- and significantly increases CO_2 assimilation (Zbieć *et al.* 2003). These researchers also reported an increase in the alkaline phosphatase enzyme - an enzyme that converts organic phosphate to mineral and plants have access to it - under the influence of the methanol foliar application on the plant.

Yield attributes

Soybean yield attributes included as number of fertile pods per plant, seed number per pod and 100 seed weight. The number of fertile pods in the second year of experiment showed a significant increase compared to the first year (Table 4). On the other hand, the number of infertile pods decreased in the second year. The increase in the number of fertile pods and also infertile pod in the second year, seems to be due to the more moderate climate conditions (Table 1).

The number of pods increased in the treatment of 12mT by 36.29% in comparison with the control (Table 4). It seems that magnetized water could enhance the development of flower and pods and also prevent abortion of them along with increased allocation of photosynthetic products towards seeds (Sadeghipour 2016).

In this study, spraying various concentrations of methanol also increased the number of pods. Although 20% methanol treatment was superior to control treatment with a gain of 21.36%. In the same study, application of 30% methanol improved the boll number (39.8), boll dry weight (28.6) and seed cotton weight by 17.8 (Madhaiyan *et al.* 2006).

Based on the results of interaction effects, the maximum number of fertile pods was achieved in the 20% methanol and in the second year (data not shown). According to the meteorological data (Table 1), the average of the minimum monthly temperature and total rainfall in the second year of the experiment was superior which could stimulate growth. Also, the average monthly sunshine and evaporation rates were lower in the second year, this could increase the methanol uptake when spraying due to reduce its evaporation.

Also, the maximum amount of number of seeds per pod was obtained in treatment of 12mT, which increased by 5.16% in comparison with control. In this experiment, the 100 seed weight in the first year showed a significant increase compared to the second year. Since the number of pods in the second year had a significant increase compared to the first year of the experiment, due to the negative correlation between the yield component of the plant, such as the number of pods per plant and the number of seeds per pod, this seems logical. It may also be due to an increase in the average monthly maximum humidity during the growing season, especially during the seed filling period in the first year. Also, according to Table 4, with increasing magnetic field intensity, the weight of 100 seeds increased and in 12 mT was superior to 15.86%.

Sadeghipour (2016) found that magnetic water increased the number of pods per plant, number of seeds per pod and 100 seed weight as 15, 9 and 10% in the arrangement.

Magnetic water increased pod numbers by 25.3 but decreased 100 seed weight of canola by 5.44% (Hozayn *et al.* 2016b).

Methanol spraying also increased the weight of 100 seeds and its value increased by 11.04% in 20% treatment and subsequently showed a downward trend. Amplification of peanut yield attributes such as 100 seed weight and number of pods formed by 20% methanol approved by Safarzade Vishgahi *et al.* (2005). Moghadas *et al.* (2013) were studied the different concentrations of foliar methanol including (0, 15 and 30%) and found an increasing number of seeds per spike by 15% methanol.

Seed yield

Application of magnetic water treatment resulted in a significant increase in seed yield as 45.56, 70.05 and 72.19% in 4, 8 and 12 mT treatments, respectively.

Due to the increase of photosynthetic pigments and effective traits in seed yield, especially the number of fertile pods in previous section by magnetic water, it is reasonable

Table 3: The some properties of irrigated water as affected by magnetic field.

Treatment	Level	EC (µS/cm)	pH	TDS (mg/l)
Magnetic water (mTesla)	Control (0)	846	7.4	567.45
	4	843	7.56	554.45
	8	853	7.58	549.9
	12	873	7.61	547.95

Table 4: The mean comparison of magnetic water and methanol on soybean traits.

Treatment	Level	Photosynthetic pigments			Yield attributes				Seed yield	Biological yield	Stover yield
		Cha mg/gfw	Chb mg/gfw	Car mg/gfw	Infertile pod	Fertile pod	Seed per pod	100 seed weight (g)	(Kg/ha)	(Kg/ha)	(Kg/ha)
Year	2016	6.47^{b}	3.56^{b}	0.83^{b}	4.07^{a}	34.73^{b}	3.12^{a}	20.45^{a}	3942.1^{a}	11462.1^{a}	7519.9^{a}
	2017	7.45^{a}	4.39^{a}	0.95^{a}	2.68^{b}	37.7^{a}	3.18^{a}	19.66^{b}	3953.7^{a}	11264.3^{a}	7310.6^{a}
Magnetic water (mTesla)	Control (0)	5.04^{c}	3.09^{c}	0.81^{b}	3.2^{a}	29.01^{b}	3.1^{b}	18.22^{c}	2686.5^{c}	8175^{c}	5470.5^{c}
	4	6.15^{b}	3.53^{b}	0.85^{ab}	3.11^{a}	37.34^{a}	3.13^{b}	19.93^{b}	3910.6^{b}	11537.5^{b}	7626.9^{b}
	8	8.1^{a}	4.64^{a}	0.99^{a}	3.45^{a}	38.97^{a}	3.11^{b}	20.95^{a}	4568.6^{a}	13042.6^{a}	8474^{a}
	12	8.18^{a}	4.63^{a}	0.89^{ab}	3.75^{a}	39.54^{a}	3.26^{a}	21.11^{a}	4625.9^{a}	12715.6^{ab}	089.7^{ab}
Methanol spraying (v/v)	Distilled water	6.1^{c}	3.73^{b}	0.71^{c}	3.27^{a}	32.95^{c}	3.13^{a}	19.73^{c}	3661.9^{b}	10846.3^{b}	7184.4^{a}
	10	6.77^{b}	4.09^{a}	0.89^{b}	3.2^{a}	37.76^{ab}	3.09^{a}	20.44^{b}	3858.6^{ab}	11094 a^{b}	7235.4^{a}
	20	8.21^{a}	4.18^{a}	1.06^{a}	3.3^{a}	39.99^{a}	3.22^{a}	21.91^{a}	4358.3^{a}	12336.2^{a}	7977.8^{a}
	30	6.75^{b}	3.89^{a}	0.87^{b}	3.74^{a}	34.17^{bc}	3.16^{a}	18.12^{d}	3912.17^{ab}	11176.2 ^{ab}	7263.5^{a}

Mean with the common letters in each column have not significant differences at $p \leq 0.05$ probability level by Duncan's multiple range test.

to make such a conclusion. Similarly, increasing the seed yield and water use efficiency of the cowpea plant by 38% were found by Sadeghipour (2016), who declared that magnetic water could reduce nitrogen fertilizer application by 25%, therefore it reduces the environmental pollution. Increasing seed yield by magnetic water may be due to increase the activity of nitrogen bacteria fixation in the root of the plant, as reported by Aliverdi *et al.* (2015) who found the amazing effect of magnetic water on increasing the nodule numbers per plant as they increased from 16 to 73% in different soybean varieties. They also declared that the magnetic water enhanced the nitrogen fixation and absorption and also phosphorus absorption results to higher dry weight and seed yield of soybean.

El Sayed (2014) concluded that enhanced seed yield up to 63% by magnetic water induced to rapid coverage of the soil by the plant canopy, hence decrease the disturbance of weeds results to increases in nutrient and water use efficiency. El-Yazied *et al.* (2012) were found that magnetic water increased the contents of phosphors in plant and soil, therefore total yield were improved.

Al Janaby (2014) reported an enormous increase in the yield of maize as 85.49% under the influence of magnetic water. Hozayn and Abdul Qados (2010) who announced a 24.56% increase in grain yield, concluded that the grain yield increased by magnetic water as a result of improving of photosynthetic pigments content and indole acetic acid (IAA).

Under limited irrigation, magnetizing the water increased the seed yield of the plant by improving the chlorophyll content and enhancing the macro and micro-nutrients in plants (Zlotopolski 2017). Hasan *et al.* (2018) declared that magnetic water increased antioxidants under the drought stress and ultimately increases the yield of Moringa plant.

In this experiment, the seed yield in 20% methanol increased by 19.01% compared with the control. By comparing the interaction, it was found that in 20% methanol and in the second year, maximum seed yield was obtained (data not shown). Different effects of various methanol concentrations during the first and second years may be due to changes in meteorological parameters that affect the evaporation of methanol during spraying and subsequent reduction of its absorption by foliage plant in the first study year. As the average number of sunny hours and evaporation rates in the first year was higher.

Zbieć *et al.* (2003) declared that the yield of bean, sugar beet, tomato and rape seed could increase by 12 to 30% when treated with 30% methanol. They concluded that increasing the yield of plants affected by methanol will be desirable in the controlled environments, but in the farm conditions where the weather conditions is hot and dry, it will be unfavorable, due to the rapid evaporation of methanol.

In a similar way, increasing growth and yield of cotton and sugarcane by methanol related to cytokinins hormone excitation (a stimulator growth hormone) which induced by pink-pigmented facultative methylotrophic bacteria on the leaves surface (Madhaiyan *et al.* 2006). They found that application of 30% methanol could increase sugarcane and cotton yield by 7.8 and 31.7% in arrangement. Increasing soybean yield by 16-22% by methanol were attributed to increasing the frequency of CO_2 and thereby improving the photosynthetic potential of the plant (Yuncong *et al.* 1995).

Biological and stover yield

This attributes was increased under the influence of various magnetic water intensities and its maximum value was obtained in 8mT treatment, which was superior to control by 59.54 and 54.9%, respectively. Enhancing the biological yield (25.31%) and straw yield (38.31%) faba bean by magnetic water were announced by Hozayn *et al.* (2016a). furthermore, biological and straw yield of wheat improved by 24.56 and 28.24% respectively (Hozayn and Abdul Qados 2010).

In another study, enhancing the growth indices, leaf area, fresh and dry weight of tomato has been reported by magnetic water (El-Yazied *et al.* 2011). Also Abedinpour and Rohani (2017) mentioned that magnetic water decreased soil pH and improved the availability of main necessary macro nutrient such as nitrogen and phosphorus. They found accelerated seed germination, improving the emergence rate index and increasing seedling weight of maize. Gao *et al.* (2017) reported increasing cotton dry weight by 14, 22 and 29% under the treatments of 100, 300 and 500mT magnetic water irrigation, respectively. They concluded that the magnetic water could enhance the nitrogen uptake by plants.

In this experiment application of methanol at 20% concentration increased biological and stover yield by 13.73 and 11.04%, respectively, however stover yield was not significant. Nadali *et al.* (2010) declared that the maximum root, leaf fresh weights and also sugar yield of sugar beets were achieved by 21% methanol. Madhaiyan *et al.* (2006) reported an increased the plant's height by 8.1%, increasing leaf area by 20.9% and eventually increasing the plant dry matter as 28% by 30% methanol. Also, the results of the interaction indicated the maximum amount of biological yield produced in 20% methanol in the second year (data not shown).

Seed protein content and soybean economics

The seed protein content under the influence of magnetic water showed a significant increase, so that the maximum protein was obtained in 8 mT (Table 5).

It seems that the increase in seed protein is due to the increase in the absorption of nutrients such as nitrogen and phosphorus under the influence of magnetic water (Abedinpour and Rohani 2017; Gao *et al.* 2017; Grewal and Maheshwari 2011). Also, in this experiment, magnetic water affected the economic indicators of soybean production, so that in the treatment of 8 and 12 mTesla, the maximum values of net return and B:C ratio was obtained, which showed an increase of 122-126% compared to the control (Table 5). Therefore, it can be concluded that the application of this treatment can significantly increase farmers' incomes.

Foliar application of different concentrations of methanol also increased the protein content and the maximum protein

Table 5: The seed protein content and economics of soybean as affected by magnetic water and methanol.

Treatment	Level	Seed protein (%)	Cost of cultivation (US$/ha)	Gross return (US$/ha)	Net return (US$/ha)	B:C ratio
Year	2016	37.256^{b}	806.7^{a}	2736.6^{a}	1929.9^{a}	2.391^{a}
	2017	39.131^{a}	785.5^{b}	2736.7^{a}	1951.2^{a}	2.482^{a}
Magnetic water (mTesla)	Control (0)	32.729^{c}	796.1^{a}	1862.4^{c}	1066.2^{c}	1.338^{c}
	4	38.291^{b}	796.1^{a}	2710.9^{b}	1914.7^{b}	2.405^{b}
	8	42.8^{a}	796.1^{a}	3167.1^{a}	2371^{a}	2.973^{a}
	12	38.954^{b}	796.1^{a}	3206.3^{a}	2410.2^{a}	3.303^{a}
Methanol spraying (v/v)	Distilled water	35.908^{d}	783^{d}	2538.8^{b}	1755.8^{b}	2.237^{b}
	10	38.916^{b}	791.8^{c}	2674.7^{ab}	1883^{ab}	2.379^{ab}
	20	41.154^{a}	800.5^{b}	3020.3^{a}	2219.8^{a}	2.783^{a}
	30	36.795^{c}	809.2^{a}	2712.8^{ab}	1903.6^{ab}	2.347^{a}

Mean with the common letters in each column have not significant differences at $p \leq 0.05$ probability level by Duncan's multiple range test.

was obtained at a concentration of 20% methanol, which showed an increase of 5.24% compared to the control.

The increased activity of the nitrate reductase enzyme which convert nitrate to ammonium (Zbieć *et al.* 2003) and an increase in the amount of amino acids that are major components of proteins (Nonomura and Benson 1992a, 1992b), may increase the seed protein content.

Economic indicators such as net return and B:C ratio increased under the influence of different concentrations of methanol and the maximum amount was achieved by 20% methanol. So that in this treatment, the amount of net return and B:C ratio increased by 26.42 and 24.4%, respectively in comparison with the control.

CONCLUSION

Based on the findings, application of magnetic water improved the studied traits in soybean. So that the magnetic water at 8 and 12 mT intensity caused a significant increase in photosynthetic pigments, yield attributes, seed yield, biological yield, stover yield, seed protein and soybean economics such as net return and B:C ratio. It was concluded that increasing the photosynthetic pigments (chlorophyll a, b, carotenoid), yield attributes (number of pods, number of seeds per pod, 100 seed weight) enhanced the soybean seed yield by 72.19%. In addition to the biological yield, stover yield and seed protein increased by 8mTesla magnetic irrigation, by 59.54, 54.9 and 10.08% compared to control. Also, the favorable effects of methanol foliar application were observed on the traits, especially in the concentration of 20%. So that the seed yield, biological yield, seed protein, net return and B:C ratio increased by 19.01, 13.73, 5.24, 26.42 and 24.4%, respectively. In this study, however, the desired effects of methanol were less than that of magnetic water.

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