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EFFECTS OF MAGNETICALLY TREATED IRRIGATION WATER AND EXPOSURE THE ROOTS TO CONSTANT MAGNETIC FIELD ON NODULES FORMATION IN THE BEAN CROPS

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Abstract

This study was conducted in private farm in Rifai District - Thi-Qar Governorate - Southern of Iraq at winter agriculture season of 2017 to realize the effects of irrigation by magnetically treated water and exposure the roots to constant magnetic field on nodules formation in the root of vicia faba, as an attempt to find renewable sources for nitrogen as environmentally friendly procedure.

Five treatments as showed in the procedure and materials were applied with three replications for each treatment which distributed randomly according to the Completely Random Design.

The results showed that the exposure of roots to the high constant magnetic intensity (T_5) caused high average weight of the roots and high average weight of nodules, followed by the treatment that depended on continuously irrigation with magnetically treated water (T_3), for that the study recommended to utilize the technique which be indicated to, for obtaining additional quantity of nitrogen that is necessary to plant growth and increasing soil nitrogen content through the fixation of atmospheric nitrogen by the root nodules that be formed as a result of application of mentioned technique .

Key words : Magnetically treated water, constant magnetic field, root nodules.

Introduction

The major strategy towards addressing soil fertility depletion is the conservation and sustainable use of rhizobia that are able to fix nitrogen in the soil in association with legumes (Mwenda, *et al*. 2011). Rhizobium that belong to *Rhizobiaceae* family is a group of symbiotic bacteria which fix atmospheric nitrogen throughout nodule formations, can be found in soil or in roots of legumes. The nitrogen fixation is a process which transforms atmospheric nitrogen to ammonia, nitrate and nitrogen dioxide . (Monica, *et al.* 2013), it occurs by the soil bacteria that can engage in a symbiosis with leguminous plants which produce nitrogen-fixing root nodules (Herman, 2000), these organisms are gram-negative capable to colonize the soil immediately surrounding roots under the influence of the plant "rhizosphere" and reduce atmospheric nitrogen into the available form to plants through nitrogen fixation process (Simon, *et al*. 2014), It is estimated that legume N2 fixation accounts for about 40% of global N2 fixation. (Mwenda, *et al*. 2011), therefore (Mohammadi, *et al*. 2012) regarded the biological nitrogen fixation is an efficient source of fixed N2 that plays an important role in land remediation. The amount of nitrogen supplied by fixation depends on the ability of the inoculant rhizobia to fix nitrogen and also on the ability of the plant to provide energy to the rhizobia in the nodules (Shankar, *et al.* 2012).

There are significant differences among legumes in the morphology of the nodules. Red & white clovers have club shaped & lobed structures, the nodules of alfalfa are more branched & longer while those of cow pea, peanut, & lime bean exhibit a spherical shape. Nodule size is a low as several millimeters in diameter to the size of a baseball. Legumes with fibrous roots frequently have a greater abundance of nodules than plants with well farmed tap roots, and plants bearing large nodules often have a few, whereas roots with smaller structures have them in greater numbers. (Shankar, *et al.* 2012).

The environmental factors that affect the efficiency

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of symbiotic nitrogen fixation by Rhizobium in soil included pH, Salinity, Moisture, Temperature, micro organisms, organic matter and soil texture. (Alfalih 2002), so (Mohammadi, *et al.* 2012) saw that from environmental condition which affect on biological nitrogen fixation are fluctuations in pH, nutrient availability, temperature, and water status, When (Hungria and Vargas 2000) regarded that High temperature and moisture deficiency are the major causes of nodulation failure, affecting all stages of the symbiosis and limiting rhizobial growth and survival in soil .while the results of (Shereen, *et al.* 1998) indicated that the salt showed greater inhibitor effect on nodulation with decrease nodule number and weight. So there is a positive correlation was observed between nodules and shot dry weight.

So (Monica, *et al.* 2013) pointed out that the most common factors affecting nitrogen fixation and symbiosis activity are salinity, drought and temperature .

The study of (Salvagiotti, *et al.* 2008) showed reverse relationship between nitrogen that fixed by soybeans and N applied as fertilizer, and a negative exponential relationship was observed between N fertilizer rate and N2 fixation when N was applied on the surface or incorporated in the topmost soil layers.

In addition to above factors, a modern study that be conducted to determine the effect of magnetically treated irrigation water on the nodule abundance found that all tested varieties, of soybean the lowest nodulation (nodule number and weight) per plant was found in untreated water. The nodule number per plant increased after they were irrigated with magnetically treated water. (Aliverdi, *et al.* 2015) .

Atmospheric nitrogen fixed symbiotically by the association between *Rhizobium* species and legumes represents a renewable source of nitrogen for agriculture (Shankar, *et al.* 2012), therefore and for obtaining renewable source of nitrogen and to reduce the utilizing of mineral fertilizers, and for reduction the cost of crops production this study was conducted for looking for environmentally friendly procedure to achieve the above aims of this research when the study finds that the studied technique provides the soil an excess quantity of nitrogen through out of increasing root nodules formation in vicia faba by depending on using magnetically treated water in irrigation or using of constant magnetic field in stead of utilizing the mineral fertilizers which be harmful to the environment.

Materials & Procedure

Five treatments that applied in this study, these were:

1- Treatment irrigated by natural water (T_1).

2- Treatment with alternately irrigation by magnetically treated water followed by irrigation by natural water (T_2).

3- Treatment with continuously irrigation by magnetically treated water (T_3).

The magnetically treated water can be got by passing the water through pipe which contain 30 pieces of magnet (magnetic intensity between 72 – 80 mT.) were placed in series into the pipe that conveys the water to the plants.

4- Treatment with constant magnetic field (its intensity 144 – 160 mT) by putting two pieces of magnet (intensity for each one 72 – 80 mT) in the root zone and irrigated continuously by natural water (T_4).

5- Treatment with constant magnetic field (its intensity 288 – 320 mT) by putting four pieces of magnet (intensity for each one 72 – 80 mT) in the root zone and irrigated continuously by natural water (T_5).

The treatments distributed according to completely randomized design (CRD) with three replications for each treatment .

At 3/11/2017 ten seeds of legume crop (Vicia faba) were planted in each tub of concrete tubs that be filled by loam soil, the dimensions of each tub were (60 × 60 × 60) cm., with retention five best plants in each tub after seedlings appearance.

All replications were irrigated according to the treatments of study. At 8/4/2018 whole plants in replications were extracted and washed then the roots be separated and weighed, after that the nodules be separated too and weighed, then the percentage of nodules weight to the weight of root be calculated (tables 1, 2 and 3).

Result & Discussion

It appears from the results which were showed in the tables 1, 2, and 3 that there were differences in the average of roots weight, in the average of nodules weight and in the percentage mean of nodules weight to the

Table 1: Average weight of roots.plant^{-1}

Treatments	Average weight of roots for one plant g / plant		
	Replication 1	Replication 2	Replication 3
T_1	8.39	7.16	9.14
T_2	8.89	10.43	11.31
T_3	12.05	13.15	12.61
T_4	11.17	7.91	9.83
T_5	14.22	16.13	12.96

weight of the roots. So the tables showed that the (T_5) gave high values for the mentioned studied properties, while the lowest values for same studied properties were in (T_1), and the another treatments differed in their results between the values of the treatments (T_1) and (T_5).

Table 2: Average weight of nodules.plant^{-1}

Treatments	Average weight of nodules for one plant g/plant		
	Replication 1	Replication 2	Replication 3
T_1	0.56	0.42	0.71
T_2	1.66	1.59	2.43
T_3	2.01	2.61	1.93
T_4	1.43	0.79	1.21
T_5	3.68	4.08	3.12

For realize the effect of treatments, the results were statistically analyzed as following :

1- The average weight of root for each plant :

Table 3: Percentage of nodules weight/weight of roots.plant^{-1}

Treatments	(weight of nodules / weight of roots) %		
	Replication 1	Replication 2	Replication 3
T_1	6.67	5.86	7.76
T_2	18.67	15.24	21.48
T_3	16.68	19.84	15.30
T_4	12.71	10.01	12.31
T_5	25.87	25.21	24.07

This property was studied as a result of its importance for the bean plants because the roots of leguminous plant be regarded the medium that has infected by the nitrogen fixation bacteria to form the root nodules that bacteria present in it and live with the legume plant by symbiosis relation, and for that (Herman 2000) referred to the rhizobia that they are soil bacteria which can engage in a symbiosis with leguminous plants that produces nitrogen-fixing root nodules.

The statistical analysis indicated to existence of significant statistical differences between the some or whole treatments because the value of calculated f (9.3140) was larger than its table value (5.9943), table 4.

Table 4: Variance analysis for the roots.

Sources	df	SS	MS	Cal. F
Treatments	4	74.1699	18.5424	$F_{0.01}$ = 9.3140
Error	10	19.9089	1.9908	
Total	14	94.0788		

Therefore and to realize which treatment that statistically excelled, the ascending order for the averages of roots weight in the treatments, and comparing those averages with less significant difference (3.1842) be achieved, table 5.

Table 5: Ascending order of averages root weight.

T_1	T_4	T_2	T_3	T_5
8.23	9.57	10.21	12.60	14.44

It appeared from table 5 that there were statistically significant differences between T_5 and the treatments (T_1, T_2 & T_4) as a result of the effect of high intensity and constant magnetic field that existed in the root zone on the roots of plants, when no significant differences between T_5 and T_3 in spite of existence of differences between these two treatments, with high average of roots weight in the treatment T_5, but it did not get up to be significant. The rapprochement in the results of the treatment T_3 and T_5 was caused by the continuous irrigation by magnetically treated water for each irrigation, this case means that there is an approaching of magnetic effect for two treatments.

So there was difference between T_3 and T_2 but this difference did not get up to be statistical significant because of similarity of magnetic effect in the treatments, and a same relation was found between T_3 and T_4 in spite of the mean weight of roots in T_3 was larger than in the T_4 as a result of high intensity of magnetic effect in the T_3, so this reason caused significant differences between the third treatment with the first treatment that the plants in it did not expose to any magnetic effect. The results showed too that there was not significant differences between the T_4, T_2 and T_1 as a result of similarity magnetic effect for these treatments.

The above relations between treatment were at a probability level 1%, when the relations between the treatments at a probability level 5% were similar except T_3 which excelled on T_4 whereas the differences between the means of root weight for these treatment was larger than less significant difference at a level 5% (2.5667).

Finally the bottom line indicates that the irrigation by magnetically treated water or exposure the plant roots to a constant magnetic field increase the roots weight of vicia faba, this result is similar to what (Aliverdi, *et al.* 2015) found when soy bean crops had irrigated by magnetically treated water, the roots weight of this crop had increased.

2- Weight average of root nodules per plant :

The root nodules be studied because of having a large importance in leguminous crops due to their relation with nitrogen fixation that occurs through nodules formation by symbiotic bacteria (Monica, *et al.* 2013). By fixation process, the atmospheric nitrogen be reduced into the form available to plants (Simon, *et al.* 2014) by the rhizobia which presented in the nodules (Shankar, *et al.*

2012).

From the table of variance analysis, table 6, it appears that the value of calculated f (28.44) is larger than its table value (5.99), this refers to that significant differences are present between some or whole treatments.

Table 6: Variance analysis for the nodules weight

Sources	df	SS	MS	Cal. F
Treatments	4	16.2587	4.0646	$F_{0.01}$= 28.44
Error	10	1.4294	0.1429	
Total	14	17.6881		

So when the less significant difference (0.8529) is depended, the significant differences appear between T_5 and other treatments, table 7.

Table 7: Ascending order of averages nodules weight.

T_1	T_4	T_2	T_3	T_5
0.56	1.14	1.89	2.18	3.62

The weight average of root nodules in it (T_5) took the high value while the weight average of root nodules in T_1 was in lowest value, and the means value of root nodules for another treatments ranged between the high and less value for T_5 and T_1 in series, this state indicates to the effect of magnetically treated irrigation water or constant magnetic field on formation of root nodules and on the weight of them. So the difference between the weight average of root nodules for the treatments T_3 and T_4 that larger than less significant difference refers to presence of significant differences between these treatments, with high value for the mean of T_3, as that the treatments T_3 and T_2 excelled on T_1 that in which the plants did not expose to the magnetic effect, while the treatment T_4 did not show significant differences with T_1 because of low magnetic field intensity that the plants in T_4 were exposed to it. As well there is no significant differences between T_3 and T_2 and between T_2 and T_4 as due to the similar magnetic effect. All above explained data were at 0.01 probability level, while at the level 0.05, in which the value o LSD equals to 0.6875, the treatments had same relation as they were at the level 0.01 except low difference had occurred between T_2 and T_4 with high weight average of root nodules in T_2 as a result of high intensity of magnetic effect that the irrigation water was exposed to it while the magnetic field in T_4 was with low intensity. It is explained from above data that the irrigation of leguminous crops by magnetically treated water or exposure the plants to constant magnetic field with previously mentioned intensity will increase nodules formation and their weight, this result was confirmed by (Aliverdi *et al.* 2015) who found that the irrigation by magnetically treated water increased weight and number of nodules on the roots of soybean.

3- Percentage of average nodules weight to average of root weight:

The table of variance analysis, table no. 8 indicates that the value of calculated f (38.0975) is larger than its table value (5.99), this mean a presence of significant differences among the treatments.

Table 8: Variance analysis for the nodules / roots percentage

Sources	df	SS	MS	Cal. F
Treatments	4	580.4385	145.1096	$F_{0.01}$=38.0975
Error	10	38.0899	3.8089	
Total	14			

So when the average of treatments be compared, it appears that there statistical significant difference between T_5 and all treatments as a result of the differences between the percentage of nodules weight to root weight of T_5 is larger than less significant difference (4.4044) in comparing with same percentage of the another treatments at a level of probability 0.01.

Table 9: Ascending order of averages nodules / percentage root.

T_1	T_4	T_2	T_3	T_5
6.76	11.67	17.27	18.46	25.05

As well, the T_2 and T_3 singly excelled on the T_4 and T_1, so the T_4 achieved significant difference in comparing with T_1 that was characterized it had a low value for studied property, this decline is a result of absence of magnetic effect that its ability was very clear for increasing the weight of root nodules.

It appears too from the order table of ascending averages, table 9 that there was not any significant difference between the treatments T_2 & T_3 because of the difference between their averages is less than LSD. All above relation was at probability level 0.01, and when the level 0.05 is depended (in which LSD = 3.5503) the above relation did not change.

From above information it appears that for the magnetization technique of irrigation water or exposure of bean plants to constant magnetic field many benefits, as increasing of roots weight that the absorption of water and nutrients will be with high efficiency, in addition to the nitrogen fixing bacteria have wide opportunity to infect the roots and form the root nodules with increasing their number and through them the atmospheric nitrogen be fixed, It is estimated that legume N2 fixation accounts for about 40% of global N2 fixation (Mwenda, *et al.* 2011).

As a result of nitrogen fixation, there is no need to utilizing or adding the nitrogen fertilizers to the soil, or reducing the quantity of these manufactured fertilizers which causes many harms to the environment, in addition to the utilization of these fertilizers will amplify the production costs and reduce the profit for area unit, as well as the plants obtain their requirements of nitrogen from renewable source as (Shankar, *et al*. 2012) described it that the association between *Rhizobium* species and legumes represents a renewable source of nitrogen for agriculture, so (Mohammadi, *et al.* 2018) illustrated that the biological nitrogen fixation (BNF) is an efficient source of fixed N2 that plays an important role in land remediation.

For the mentioned benefits, the magnetically treated water or exposure the bean plants to constant magnetic field be regarded considerable environmentally friendly procedure to achieve sustainable agriculture. Finally it must be noted that researches which related to this study are very rare and this requires continuous studies to understand this relations in detailed manner.

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