African Journal of Agricultural Research Vol. 7(15), pp. 2359-2362, 19 April 2011
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.1813
ISSN 1991-637X ©2012 Academic Journals

Full Length Research Paper

Morphological reaction and yield of *Nigella sativa* L. to Fe and Zn

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Accepted 12 March, 2012

This experiment was conducted in Ardestan University in an experiment based on randomized complete block design with four replications. Each replication consisted of 12 treatments in four fertilizer levels including 2.5 per thousand of Fe-sulfate solution, 2.5 per thousand of Zn-sulfate solution in three stages of growth (4, 8 and 12 leaves). During the experiment, the height of plant, number of stem branches, follicle number in plant, seed number in follicle, 1000- grain weight, biologic yield, seed yield/plant and harvest index were assessed. This study showed that using spraying had significant differences in different growth stages except in the factors like plant height, times of flowering and weight of thousands grain. Also, using all microelement treatments had significant effects to the level of 1%. The most grain yield was in eight-leaf-stage with 172.35 kg/ha and after that four-and twelve-leaf-stages were in the second level. In case of using spraying treatments, the best results were related to 2.5 per thousand of Fe-sulfate solution and the least were related to control and 2.5 per thousand of Zn-sulfate solution. In evaluating the interaction between treatments, the best yield was related to 2.5 per thousand of Fe-sulfate solution in eight- leaf- stage and the least related to 2.5 per thousand of Zn-sulfate solution and control. In the end, spraying of 2.5 per thousand of Fe-sulfate solution in eight-leaf- stage without using Zn-sulfate, in many cases dedicated the best results to itself. This formulation can be used for increasing yield, enhancing the products and removing food deficiencies.

Key words: *Nigella sativa* L., Fe-sulfate, Zn sulfate, seed yield and growth stage, spraying.

INTRODUCTION

About 30% of agricultural lands across the world suffer from the severe shortage of micronutrients including iron and zinc because of various reasons such as limy soil, bicarbonate water, drought of farms and low level of organic substances in arable soil. Most of the recommendations about fertilizing the soils in our country do not consider the need of plants and do not care about the proper plant nutrition. Because of failure in optimized usage, the fertilizers do not fulfill their role as the major tool in increasing the yield (Malakooti, 2001). One of major issues in use of micronutrient fertilizers is the comparison of methods and dosage of fertilizers which is important in terms of the increase in yield and economical views. Spraying and foliar fertilization is applied to reduce the amount of needed chemical fertilizers and their environmental risks. The method provides the plants directly and faster with nutrients in order to be used by the foliages and fruits (Nasiri et al., 2010). Foliar fertilization is more important when there are some problems in uptake of substances through the root due to antagonism phenomenon or when the microorganisms are destroyed due to adding some substances to the soil (Malakooti, 2005; Noor, 2001). The micronutrients are used in a slight amount, but they have important consequences. Theses elements, in the case of their shortage, serve as the limiting factors in uptake of other nutritional elements, so it necessitates more attention to applying them (Heidari et al., 2011).

Graham et al. (1992) expressed that the shortage of zinc in limy and alkaline soil prevents the growth of plants and it results in problems in vegetative organs, especially the leaves, formation of photosynthesis substances and

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generative organs is impaired and consequently the formation and seed yield. Malakooti (2001) reported that if the plant can not take up enough iron compounds, the amount of chlorophyll in leaves will reduce and the leave will turn pale. In this case, at first the surface between the veins becomes yellow and then if the shortage of substance continues, all the surface of leaf will become yellow. Zareie (2011) indicated that in dry soil in need of zinc and iron compounds, applying these compounds to the soil had no influence but spraying or foliar fertilization of such compounds at the early vegetative stage of seed plant lead to the increase in seed yield. Salahi and Malakooti (2001) reported of advantages of spraying the fertilizer solution compared to applying it to the soil in terms of increase in seed yield in soybean and sun flower. Vankhadeh (1999) found out in a study that the rate of chlorophyll in the zinc-treated leaves of and the dry weight of safflower increased significantly. Sadri and Malakooti (1999) concluded in their study that in addition to the protein yield, the concentration of iron, zinc, and copper increased significantly in the wheat's seed and straw after applying the ferrous, zinc and copper sulfate. In general, the results from various experiments showed that applying the micronutrients results in the increase of sesame, safflower, rape, and other agricultural and herbal productions (Baidbudi et al., 2002; Yari et al., 2006; Valadabadi and Aliabadi, 2011).

The purpose of this present study is to determine the best fertilization level of micronutrients of iron and zinc compounds and also the best time for applying the method of spraying the ferrous and zinc sulfate in plant growth time of black cumin in Ardestan region.

MATERIALS AND METHODS

This experiment was conducted in agricultural year of 2011 to 2012 in Islamic Azad University, Ardestan Branch located in east north of Isfahan (Ardestan is located in 33° 33' N latitude and 52° 49' E longitude with altitude of 1209 m above sea level). According to Kopen classification, it has very dry climate with very hot and dry summer. The average rainfall and annual temperature are 140 mm and 14°C, respectively (Karimi, 1988). To determine the physical and chemical status of the studied soil, a sample was prepared from the depth of 0 to 30 cm before the test. The results from sampling are shown in Table 1. The experiment was conducted as a design of completely randomized blocks with 4 replications and 4 level of sparing solution including F = control (without sparing fertilizer solution), F1 = ferrous sulfate, F2 = zinc sulfate, and F3 = zinc sulfate + ferrous sulfate in three stages of the growth of black cumin: G1 = four-leaf growth, G2 = eight- leaf growth, twelve-leaf growth. The concentration of all fertilizers was 2.5/1000. Spraying time was early in the morning and before sunrise in order to avoid the undesired effect of sunshine on the sprayed materials. Having sprayed, the irrigation was done by the distilled water in order to increase the circulation of water in the plant's internal system and hence the uptake of the sprayed compounds. The land was weeded manually several times. The plots were 3 × 3 m. The distance between the rows and between two bushes was 30 and 10 cm, respectively. Sowing the seeds was done manually and in each row at 3rd January, 2001. The nitrogen and phosphate fertilizers needed based on the soil test was provided as 150 and 100 $kg.ha^{-1}$, respectively. All triple super phosphate was consumed before and at the time of planting, but the nitrogen phosphate was consumed in three stages (1/3 in planting, 1/3 in pawing and the rest 1/3 in flowering).

The harvest was performed when the bushes became yellow but with no crack in the follicles. Before harvesting, five bushes were selected randomly in each plot in order of their morphological properties and function to be measured. After removing the borders, the rest of cultivated surface was harvested and dried in open air, and then the seeds were separated from the straws. The weight of seeds was measured by scales with the accuracy of 0.01 g. Using SPSS software, the statistical calculations were performed on the resulted data including variance analysis of data relevant to the various properties and the comparison between the means. To compare the means of various properties, Duncan test was applied.

RESULTS AND DISCUSSION

The shortage of iron influenced most of the measured properties, and the factors with significant changes determined through spraying ferrous and zinc plus ferrous by 2.5/1000 and 5/1000, respectively (Table 2). Providing the iron compound resulted in the increase in the properties such as height of plant, number of follicles in plant, number of seeds in follicles, weight of 1000 seeds, seed yield, and harvest index, and reduced positively the time needed for plant to flower and pass the phenological stage. Abuzid and Obukhov (1998) believed that the lack of iron impairs the chlorophyll production process, because it is obvious that the amount of chlorophyll depends on the access to the iron. The amount of iron is as important as or even more than the amount of other elements in the tissue of plants. Salahi and Malakooti (2001) believed that the iron in the cytochrome oxidase enzyme is the very hematin and protein compound which is very necessary for breathing and oxide and reduction processes. Also, in the process of chlorophyll production, at first the compounds are produced whose molecule is very similar to the chlorophyll molecule but it has in the central nucleus the iron instead of magnesium, enzyme substitution process of such two elements produces the chlorophyll and the shortage of iron results in the early ageing and yellowness. Spraying the 2.5/1000 zinc solution did not lead to the increase in the measured properties and mostly it acted as the control (Table 3), it had the most number of days to reach the flowering stage which is incompatible with the results from Sommer (1995), El-Hag (1996) and Heidari et al. (2011). Spraying in different stages, which was performed in four-leaf, eight-leaf, and twelve-leaf stages caused extensive changes in measured properties and parameters (Tables 2). In the eight-leaf stage, it was achieved the highest harvest, seed yield, and number of seed in the follicle and had no effect on the properties such as height of plant, flowering time and the 1000 seed weight.

Studying the various stages of black cumin's growth showed that the most effect on the number of follicles in plant, number of seeds in the follicle, and seed yield was

Table 1. Physical and chemical properties of the soil of experimental location.

Depth (cm)	Soil tissue	PH	Organic material (%)	Nitrogen (%)	Absorbable phosphorus (ppm)	Absorbable potassium (ppm)	Iron (ppm)	Zinc (ppm)
0-30	Clay	7.7	1.6	0.09	15	425	1.9	0.95

Table 2. The results of variance analysis and the square means of measured properties.

Changes resource	Degree freedom df	Plant height	Flowering time	Number of follicle	Seeds number follicle	1000 seeds weight	Biological function	Seed yield	Harvest index
Replication	3	116.52	0.01	102.47	0.06	1.04	0.17	1.05	0.09
Spraying	3	421.27**	0.35**	87.54**	15.92**	216.77**	2.91**	9.99**	14.61**
Growth stages	2	238.15^{ns}	0.02^{ns}	88.25**	0.72**	1^{ns}	0.17**	0.16**	0.61**
Reciprocal function	6	204.36^{ns}	0.03**	102.51**	0.03**	6.77**	0.12**	0.02	0.17**
Error	33	182.36	0.01	110.22	0.02	0.87	0.02	0.01	0.04

** and ns are significant at 1% level and non-significant, respectively.

Table 3. Comparing the means of effect of various types of spraying and growth stages on the measured properties in black cumin.

Treatment	Plant height	Flowering time	Follicle number	Seeds number/follicle	1000 seeds weight	Biological function	Seed yield	Harvest index
Spraying								
Control	25.02^{bc}	8.25^{b}	5.05^{c}	41.26^{b}	1.21^{bc}	178.38^{c}	110.08^{b}	20.34^{b}
Ferrous sulfate	29.44^{a}	5.51^{c}	6.82^{a}	48.74^{a}	1.65^{a}	189.91^{a}	141.25^{a}	23.71^{a}
Zinc sulfate	25.27^{bc}	8.69^{a}	5.75^{bc}	40.92^{b}	1.05^{bc}	180.14^{b}	105.64^{b}	19.34^{b}
Ferrous sulfate plus zinc sulfate	27.21^{b}	6.03^{b}	6.54^{b}	43.54^{ab}	1.24^{b}	182.62^{b}	139.25^{ab}	21.25^{ab}
Growth stages								
Four-leaf	26.76^{a}	7.69^{a}	4.7^{b}	48.26^{c}	1.54^{a}	145.52^{c}	130.05^{b}	20.91^{b}
Eight-leaf	26.91^{a}	7.52^{a}	5.4^{a}	69.12^{a}	1.44^{a}	106.03^{b}	173.35^{a}	29.14^{a}
Twelve-leaf	26.72^{a}	7.02^{a}	5.1^{ab}	61.52^{b}	1.47^{a}	169.19^{a}	169.12^{ab}	25.02^{b}

In each column and based on Duncan multi-range test, there is no meaningful difference between the means having at least one similar letter.

related to the eight-leaf and twelve-leaf stages, respectively. However, the reciprocal effect of spraying and various stage of growth had no effect on the height of black cumin plant (Table 3). It may conclude that spraying the micronutrients in the eight-leaf stage and then in the twelve-leaf stage can provide the best results in the increase of the performance and the performance elements. Also, considering the results, the most performance and the performance elements were achieved by spraying the 2.5/1000 iron solution, and it was followed by the 5/1000 zinc and iron treatment. It seems that the increase in the measured properties is resulted from the iron element and the zinc in the treatment has no effect on the increase in the measured properties. The least effect of spraying is related to spraying the 2.5/1000 zinc solution, and the treatment which had the most increase in the most measured properties was the treatment of F1G2 (spraying the 2.5/1000 iron solution in the eight-leaf stage). This formulation can be used for increasing yield, enhancing the products and removing food deficiencies.

So, it appears that considering the climatological conditions of Ardestan region and the type of soil in this region, applying the micronutrient of iron shows the significant effect on the growth and yield of black cumin, but the zinc in the local soil is enough and there is no need to use the zinc in the program of black cumin cultivation.

ACKNOWLEDGMENT

The researchers would like to appreciate the research vice-presidency in Young Researchers Club, Ardestan Branch, Islamic Azad University, Ardetan, Iran, for their support and coordination to fulfill the research plan of “Study of microelement effects on seed, biologic yield and agronomic traits on *Nigella sativa* L.” and the present study.

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