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ORIGINAL ARTICLE

The Effects of Different levels of using Zinc nano chelated fertilizers and humic acid on Growth Parameters and on some quality and quantity Characteristics of Medicinal Plants of Savory

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ABSTRACT
savory, member of Labiatae family, is an annual plant. In order to investigate the effect of zinc nano chelated fertilizers foliar application and humic acid on savory, an experiment was arranged on randomized design in four replications during the 2014-2015 cropping seasons in the research greenhouse of the Institute of, University of zabol, Iran). The treatments were humic acid concentrations in four levels (0, 0.5, 1, and 1.5 on each one 1000 m/liters water) and nano Zn chelated fertilizer in four levels (0, 50, 100, and 200 mg; on each one at 1000 m/liters per water) and second factor included zinc nano chelated foliar application in four levels, Zn1, control, Zn2, 50mg zinc nano chelated fertilizers foliar application per 1000m/ liter water, Zn3; 100mg zinc nano chelated fertilizers foliar application per 1000m/ liter water and Zn4, 200mg zinc nano chelated fertilizers foliar application per 1000 liter water. The results showed that humic acid, nano zn chelated fertilizer and the interaction of humic acid and nano Zn chelated fertilizer had significant in 1 % probability level effects on Stem diameter, Root length, root dry weight, root fresh weight, Phosphorus,Number of leaves per plant, Chlorophyll content t (SPAD value), Essential oil content t and zinc content .Application system Fertilizers effective in improving qualityand quantity characterties and the highest concentration of Stem diameter, Root length, root dry weight, root fresh weight, Phosphorus,Number of leaves per plant, Chlorophyll content t (SPAD value), Essential oil content t and zinc content .were obtained in mixture treatment.
Keywords: nano fertilizer, Zinc, Humic acid, Savory

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INTRODUCTION

Production of medicinal plants is mainly under the circumstances of sustainable agricultural system.In this system, management of environmental parameters is very critical. By using correct nutritional sources through humic acid, nano Zn chelated fertilizers quantitative and qualitative yield of medicinal plants can be maximized.aim of In this study the effect of nano Zn chelated fertilizer and humic acid on growth parameters and Essential oil content t were investigated. Savory (*Satureja hortensis* L.) is an annual plant from family Labiatae (Lamiaceae). It is native to southern Europe and central and south-west of Asia countries such as Iran [1, 2]. Shoot parts of this plant are frequently used as additives for many foods. This plant is also used in the traditional medicine to treat muscle pains, indigestion, potential, and infection diseases [2]. Major oil constituents of this plant are thymol, carvacrol, γ-terpene and borneol [3]. Some biofertilizers are icrobial inoculants contain living cells of micro-organism such as bacteria, algae and fungi which may help plant growth. Biological activities are markedly enhanced by microbial interactions in the rhizosphere of plants [4]. Suitable and useful usage of different kind of fertilizers is the main way for reformation and potential of soil fertility and increasing of crops yield [5]. Each plant needs to certain fertilizers according to its needs and soil analyze results. Also macroelements is the critical elements for plants; however, microelements play the important role in crop productivity where it is used in low rate. Optimum plant nutrition and maximum yield is achieved when nutrient elements are available for plant during the growing season [6]. Mental synthetic chelates are recommending according to their stability in soil, solubility in water, absorption capability by plant root or according to soli pH and plant type [7]. Khazra iron nano chelate Zinc and manganese supplements had the potential role in iron fertilizer [8]. Seven elements of available nutrients in natural environment have low necessity for plant growth. Some of them are absorbed in cation form such as iron, manganese, copper and zinc and some of them are absorbed in one form such as Br, molybdenum and chlorine [9]. The advantage of leaf feeding or foliar nutrients is that when its fast effect is need it is available for branches, leaves or fruit. Some parts of plant such as fruit, needs more food such as the calcium. In early spring when soil temperature is low the roots couldn't absorb nutrients so, elements such as bor and zinc are need for plant. In some cases such as when incompatibly phenomenon by addition of some material occurred in plant root or microorganism's leaf feeding gets more important [10] showed that by using of zinc sulphate, copper sulphate besides the increasing of grain yield, iron, zinc and copper concentration in grain increased and protein rate increased from 6-10% to 14 percentages. Khalily *et al*. [11] indicated that foliar application of micro elements such as iron, zinc, manganese in both shooting and a little before the flowering stages increased the yield and yield components of corn silage. The main difference between nano technology and other technologies is in material and structures which are used in this technology. Nono powders are mixture of particles with dimensions between 1 to 10 nm. One of the most important applications of nanotechnology in agriculture and trends in water and soil science is using nano fertilizers for plant nutrition. Pahlavan and Kolli [12] indicated that microelements such as iron and zinc increased the grain number per spike and 1000 grain weight, in addition this elements concentration were increased in grain. Today due to the low concentration of micronutrients in wheat grain that is the main food of the people of Iran many diseases, such as kidney stones, anemia, fatigue and gastrointestinal disorders are common [6]. Humic compounds have potentials return to increase population of soil potential, especially in the surface layer of root rhizospher that create substances which stimulate plant growth [13]. Humic acid is a product contains many elements which improve the soil fertility and increase the 57potentials of nutrient elements by holding them on mineral surfaces and, consequently, affect Plant growth and yield. Fertility, plant physiology and environmental sciences, as the multiple roles played by these materials can greatly improve plant growth and nutrient uptake [14, 15]. Many investigators reported that, application of humic substances led to a remarkable increment in soil organic matter which improve plant growth and increase crop production [16-18].Thus, the main objective of this study was to investigate the effects of different amounts of humic acid and nano zn chelated fertilizers on the growth morphological and physiological of Satureja hortensis.The aim of the present study was the effects of foliar spraying of HA and nano zn chelated fertilizers either alone or in combination on the growth, quantitative and qualitative characteristics of savory.

MATERIALS AND METHODS

The experiment was carried out in the glasshouse of University of zabol, Iran, in 2014year. To investigate the effects of nano zinc and humic acid and on savory a factorial experiment was carried out using a completely randomized design (CRD) with four replications. The first factor included The treatments were humic acid concentrations in four levels (0, 0.5, 1, and 1.5 on each one 1000 m/liters water). And second factor included zinc nano chelated foliar application in four levels, Zn1, control, Zn2, 50mg zinc nano chelated fertilizers foliar application per 1000m/ liter water, Zn3; 100mg zinc nano chelated fertilizers foliar application per 1000m/ liter water and Zn4, 200mg zinc nano chelated fertilizers foliar application per 1000 liter water.

Soil analysis

The seeds of savory were sown in the pots containing 2/5 soil, The pot mixture were tested before applying treatments and the texture was sandy loam with PH=7.20, organic C=2.88%, total (Table1).

Record data growth condition and measure parameters

All of the treatments were sprayed in four stages regularly during growing season with 15 day intervals on the shoot of savory. The first spray applied 28 days after sowing and other applied 43, 58 and 73 days after sowing. Before flowering In order to measure parameters, 4 plants were selected randomly from each pot at before flowering stage. Following parameters were recorded for each sample: Root length, Stem diameter, root fresh weight and root dry weight, zinc content and Content t Essential oil The aerial parts of savory were collected at the Before flowering stage.

Essential analysis

Air-drying of plant material was performed in a shady place at room temperature for 10 days. Dried aerial parts (20gr) were subjected to hydro-distillation of dried sample of shoots, using a Clevenger-type apparatus over 3 hours. The essential oil was dried over anhydrous sodium sulfate and then essential oil content t (v/w) and yield for each plot were determined. The data were subjected to analysis of variance (ANOVA) using SAS computer software and means compared with Duncan's at 1% level of probability.

RESULTS AND DISCUSSION

This study indicated that the foliar spraying of humic acid and nano Zn chelated fertilizer had significant effect on the growth I obtained results from the present research indicated that foliar application of humic acid and nano Zn chelated fertilizer at suitable concentrations had positive effects on the morphological, physiological and agronomical traits of savory. The stimulated values of biochemical constituents strengthened the role of the applied humic acid and nano Zn chelated fertilizer in the metabolism of savory plants. Moreover, and humic acid, Chelated zinc fertilizer and Interactions of humic acid and nano Zn chelated fertilizer treatments resulted in the increase of Stem diameter, Root length, root dry weight, root fresh weight, Phosphorus, Number of leaves per plant, Chlorophyll content t (SPAD value), Essential oil content t and zinc content amounts in comparison with Control.

Root length

Results of variance analysis table (table2) indicate that effect of humic acid and nano Zn chelated fertilizer and the interaction effect of nano Zn chelated fertilizer and on Root length was significant in 1 % probability level. The highest content t of essential oil was observed in the interaction of humic acid and nano zn chelated fertilizer. The lowest content t of Stem diameter, Root length, root dry weight, root fresh weight, Essential oil content t and zinc content were observed in control treatments (Table 3). Results showed that the interaction humic acid and nano Zn chelated fertilizer significantly increased and Stem diameter, Root length, root dry weight, root fresh weight, Essential oil content t and zinc content t, and Also, the maximum Root length(12.6500 cm) was observed at treatment the interaction of humic acid and nano Zn chelated fertilizer, and the minimum Root length (6.5500 cm) and was related to treatment of no humic acid and nano Zn chelated fertilizer, and no nano Zn chelated fertilizer and humic acid, respectively (Table3).The results indicated that the highest (11.6438 cm) Root length was obtained by utilization of humic acid (Table4). The lowest (7.9063 cm) Root length was gained by no application of humic acid (Table4).The maximum Root length was in N4 and minimum Root length was N1 with treatments respectively with 10.6375 cm and 8.2063cm (Table 4). Figure 1 shows the results of the minimum amount of Root length was obtained by control treatment (without humic acid and nano Zn chelated fertilizer application) the highest Root length among interaction effect levels was recorded from H_4N_4 treatment (1.5 cc/l foliar spraying of humic acid and 200 on each one at 1000 m/liters per water nano Zn chelated fertilizer. Humic acids could increase the plant and root growth in proper dilutions[22].Stephan (1994) indicated viscosity of 50 mg/l humic Acid cause increasing length of wheat root from 13.1 cm to 20.2 cm [23]. Other results in examination of humic Acid effect on growth of roof show that most growth beginning is in 54 mg/l viscosity of humic Acid, which increasing root's absorption capacity in the presence of humic Acid, which be the factor of growth increasing [24]. Some reports indicated that by consumption of zinc, log concentration of hemoglobin in the knots, iron and zinc concentration in the root, activity of reductase nitrate in the leaves and the concentration of nitrogen in the roots and aerial parts of the peanut also will increase [26]. Root growth enhancement has been attributed to improved soil structure, stimulation of soil microflora, and auxin-like effects [25].

Number of leaves per plant

Results of variance analysis table (table1) indicate that effect of humic acid and nano Zn chelated fertilizer and the interaction effect of nano Zn chelated fertilizer and on number of leaves per plant was significant in 1 % probability level (Table2). The highest (43 leaves plant-1) and lowest (19 leaves plant-1) of number of leaves per plant was gained by control and and humic acid sole, respectively (Table3).In addition, the greatest Number of leaves per plant was achieved in H4 fertilizer treatment with 38 the lowest Number of leaves per planting H_1 treatment was 26 (Table4). The greatest Number of leaves per plantwas related to N_4 fertilizer treatment with 38 and the lowest Number of leaves per plant was related to N_1 fertilizer treatment with 25(Table5). Figure 2 shows the results of the Minimum Number of leaves per plant of the treatment without fertilizer or control and maximum Number of leaves per plant of treatment were gained in H_4N_4. Abdossalam *et al*., [19] showed that foliar application of Zn had the most effective influence as compare with soil application of Zn on increased of yield. Humates are natural organic substances, high in humic acid and containing most of known trace minerals essential to the growth of plant life [20]. Studies of the positive effects of humic substances on plant growth have demonstrated the importance of optimum mineral supply, independent of nutrition [21].

Root fresh weight and root dry weight

But there was significant humic acid and nano Zn chelated fertilizer treatment and Interactions of humic acid and nano Zn chelated fertilizer treatments respectively with greatest and lowest root fresh weight rate (table2). The highest root fresh weight was achieved in N4H4 by utilization the interaction of humic acid and nano Zn chelated fertilizer treatment as 0.380 gr and the lowest root fresh weight was achieved in N1H1 fertilizer treatment as 0.097gr (Table3). The highest (0.146250 gr) root fresh weight was obtained by humic acid and lowest (0.338125gr) root fresh weight content t was gained by control (without using of humic acid fertilizer) (Table4). According to the results of mean comparison, the highest root fresh weight was achieved in N4 fertilizer treatment with 0.264375 gr and the lowest root fresh weight was achieved in N1 fertilizer treatment with 0.185000 gr and there was significant all the applied fertilizer treatments (Table5).The highest root dry weight was achieved in N4H4 by utilization the interaction of humic acid and nano Zn chelated fertilizer treatment as 0.202 gr and the lowest root dry weight was achieved in N1H1 fertilizer treatment as 0.0375 gr (Table3). The highest root dry weight was achieved in N4 fertilizer treatment as 0.148750 gr and the lowest root dry weight was achieved in N1 fertilizer treatment as 0.080000 gr (Table5).The greatest root dry weight was achieved in humic acid fertilizer treatment with 0.1506 gr and the lowest root dry weight was achieved in indicate that humic acid with 0.077gr (Table 4). Results of showed that (Figure 4,5), maximum root fresh weight and root dry weight content t of treatment were obtained in N_4H_4 and N_3H_4 and Also, the minimum amount root fresh weight and root dry weight was obtained by control treatment (without humic acid and nano Zn chelated fertilizer application). Durnbus *et al* [14] indicated budding and plant dry weight as normal soybean decreased when placed on drought shock during seed filling. Abdossalam *et al*., [19] showed that foliar application of Zn had the most effective influence as compare with soil application of Zn on increased of yield.

Stem diameter

in addition the highest Stem diameter was achieved in N4H4 fertilizer treatment with 0.700 cm and the lowest Stem diameter was achieved in N1H1fertilizer treatment with 0.200 cm (table 3).to study on the effect of humic acid fertilizer in Stem diameter indicated that the highest Stem diameter for H4 treatment was achieved in the highest humic acid level and the lowest 0.350 Stem diameter was gained by no application of humic acid (Table 4).According to the results of mean comparison, the highest Stem diameter was achieved in N4 nano Zn chelated fertilizer treatment with 0.5687cmand the lowest Stem diameter was achieved in N1 nano zn chelated fertilizer treatment with 0.3187 cm (Table5) Results of showed that (Figure 5) the highest Stem diameter content t among interaction effect levels was recorded from H_4N_4 treatment (1.5 cc/l foliar spraying of humic acid and 200 on each one at 1000 m/liters per water nano Zn chelated fertilizer. Also, the minimum amount Stem diameter was obtained by control treatment H_1N_1 (without humic acid and nano Zn chelated fertilizer application). Bahmanyare *et al*., [27] showed that Foliar application of Zn and B had a positive effected on Khazar variety of rice and the yield was increased rapidly and nutrient deficiency was compensated. Mostafavi *et al.*, [28] also reported that simultaneous consumption of Zn and Mn led to the 6.8% increase of wheat plant height compared to control treatment. Other results in examination of humic Acid effect on growth of roof show that most growth beginning is in 54 mg/l viscosity of humic Acid, which increasing root's absorption capacity in the presence of humic Acid, which be the factor of growth increasing [29].

Chlorophyll content t (SPAD value)

The interaction effect of humic acid × nano Zn chelated fertilizer and effect of humic acid and nano Zn chelated fertilizer on chlorophyll content t was significant in 1 % probability level (Table2). The results indicated that the highest (12.05 SPAD value) chlorophyll content t was obtained by utilization the interaction of humic acid and nano Zn chelated fertilizer and the lowest (1.4 SPAD value) chlorophyll content t was gained by no application of humic acid and nano Zn chelated fertilizer (Table3). Maximum Chlorophyll content t was related to the H4 treatment minimum was also related to not-using-fertilizer treatments and reproductive stages (Table4). The greatest Chlorophyll content was related to N4 fertilizer treatment with 9.24 and lowest Chlorophyll content twas related to N1 fertilizer treatment with 5.74 (Table5). Results of showed that (Figure 6) the highest Chlorophyll content t (SPAD value)among interaction effect levels was recorded from H_3N_4 treatment. Also, the minimum amount Stem diameter was obtained by control treatment. Hemantaranjan and Gray [30] indicated that using Zn led to increases in leaf chlorophyll and indol acetic acid, so photosynthesis will be improved and then dry mater will be increased. Humic acid improves the physical, chemical and biological properties of the soil and influences plant growth [31]. Nitrogen and phosphorus are the most limiting nutrients to vegetative production but their sufficient use by majority of the smallholder farmers become limiting due to their high costs. There are several problems which are impeding the balance and efficient use of fertilizers. They may be well addressed by the application of humic acid. It seems that humic substances may influence both respiration and photosynthesis [32].Humic substances are an important soil component because they constitute a stable fraction of carbon and improve water holding capacity, pH buffering and thermal insulation [33].

Content Essential oil

The maximum (0.6250 m/lit) and minimum (2.1775 m/lit) of Content t Essential oil was observed by application 200 on each one at 1000 m/liters per water and1/5 cc on each one 1000 m/liters water) of conc. methanol with nano Zn chelated fertilizer and humic acid to control treatment, respectively (Table3). Which was significantly in 1 % probability level.Qualitative and quantitative analysis of essential oils have been shown in (Table2). The results of mean comparison, the highest Essential oil content t was achieved in H4 fertilizer treatment with 0.264375 m/lit and the lowest Essential oil content t was achieved in H1 with 0.9850 m/lit (Table 4). In addition, the greatest Essential oil content t was related to N4 fertilizer treatment with 1.71063 m/litand the lowest Essential oil content t was related to N1 fertilizer treatment with 0.92500 m/lit(Table5). Figure 7 shows the results of the highest essential oil content of obtained for treatment H_4N_4 compared with plant (control). Bagheri and Mazaherilaghab, [34] reported that the application of low consumption elements Mn and Zn can have positive significant effect on the growth and chemical compositions of *Cuminum cyminum* essence and the use of their mixture showed further effect. Addition of humic and fulvic acids has numerous profit and agriculturists all over the world are accepting humic and fulvic acids as a vital part of their fertilizer program. It can be applied directly to the plant foliage in liquid form or to the soil in the form of granules alone or as fertilizer mix. Humic acid is one of the major components of humus. Humates are natural organic substances, high in humic acid and containing most of known trace minerals essential to the growth of plant life [20]. Foliar spraying is a new method for crop feeding which micro and macro nutrients in form of liquid are used into leaves [35]. Humic acid (HA) is a promising natural resource that can be used as an alternative to synthetic fertilizers to increase crop production. It exerts either a direct effect, such as on enzymatic activities and membrane permeability, or an indirect effect, mainly by changing the soil structure [28].

Phosphorus content

Results of variance analysis table (table2)the interaction effect of humic acid× nano Zn chelated fertilizer had significant (P<0.01) effect Phosphorus and indicate that effect of humic acid and nano Zn chelated fertilizer on Phosphorus content t was significant in 1 % probability level. Also, the maximum Phosphorus(0.1500mg.g-1) was observed at treatment the interaction of humic acid and nano Zn chelated fertilizer, and the minimum Phosphorus (0.1175mg.g-1) and dry weight (0.16 mg.g-1) was related to treatment of no humic acid and nano Zn chelated fertilizer, and no nano Zn chelated fertilizer and humic acid, respectively (Table3).that the greatest Phosphorus content t was achieved in H4 fertilizer treatment with 0.146 mg.g-1 and the lowest Phosphorus content t was related to N4 fertilizer treatment, with 0.133 mg.g-1(Table4).Additionally the greatest Phosphorus content t was related to N3, N4 fertilizer treatment, respectively with (0.1468 mg.g-1) **(**0.1462 mg.g-1)and the lowest Phosphorus content t was related to N_1 fertilizer treatment with 0.131 mg.g-1 (Table5). Figure 8 shows the results of the Minimum Phosphorus content t of the treatment without fertilizer or control and maximum of Phosphorus content t treatments were gained in H_4N_4, H_4N_3, H_3N_3 H_3N_4, H_2N_4, H_2N_3. HA is a suspension, based on potassium-humates, which can be applied successfully in many areas of plant production as a plant growth stimulant or soil conditioner for enhancing natural resistance against plant diseases and pests [36, 37], stimulation plant growth through increased cell division, as well as optimized uptake of nutrients and water, moreover, HA stimulated the soil microorganisms [38, 39]. When adequate humic substances are present within the soil, the requirement for nitrogen, phosphorus and potassium fertilizer applications may be reduced [39]. Humic acid (HA) and phosphorus applications increased the growth and growth parameter of pepper seedling. The combined effects of HA and P application was more effective on growth and growth parameter than each separate effect. Humic acid application significantly increased N, P, K, Ca, Mg, S, Mn and Cu contents of shoot of pepper seedling [40].The stimulatory effects of humic substances have been directly correlated with enhanced uptake of macronutrients, such as nitrogen, phosphorus; sulfur [42], and micronutrients, that is, Fe, Zn, Cu and Mn [41].

Zinc content

The results indicated that the highest (0.2150 ppm) zinc content was obtained by utilization the interaction of humic acid and nano Zn chelated fertilizer (Table 3). The lowest (0.9500 ppm)zinc content was gained by no application of humic acid and nano Zn chelated fertilizer (Table 3). And greatest zinc content mean was achieved in H4 fertilizer treatment with 0.8112 ppm humic acid and lowest zinc content content was achieved in H1 with 0.5687 ppm(Table4).Mean comparison indicated that the greatest zinc content plant was related to N4 fertilizer treatment with 0.8962 ppm a and lowest zinc content plant was related to N1 fertilizer treatment with 0.3450 ppm (Table 5). The maximum and minimum of zinc content t was observed by H4N4 treatment fertilizer or application 200 on each one at 1000 m/liters per water and 1/5cc on each one 1000 m/liters water) of conc. methanol with nano Zn chelated fertilizer and humic acid to control treatment H1N1 (Figure 9). Several factors affect on the absorbable amount of zinc in the peanut cultivation soils. These factors are including paucity of zinc containing minerals in the soils, presence of alkaline pH, and high amount of calcium carbonate and light weight of the soil texture in the peanut fields (Pilevary *et al.,* 2008).Beyond the issue of HA application rate, other important factors may limit agronomic benefit from HA application to agricultural soils. In nutrient solution studies, plant growth response to HS tended to peak at less than 100 mg_L–1 [41].Native soil dissolved organic matter (DOM),which can perform some of the same functions as applied HA [42], maybe present at sufficient concentration to minimize or negate any benefit of applied HA.

Table-1.The physical and chemical properties of farm soil in depth 0-10cm

Depth	0-10 cm	Soil texture	Sand –Loam
Clay (%)	8	Nitrogen (%)	0.288
Silt (%)	48	P(ppm)	26.74
Sand (%)	53	cu(pmm)	1.34
pH	7.20	K (ppm)	150
E.C. (ds/m)	3.40	Fe(pmm)	9.86
organic C	%2.88	zn(pmm)	1.78

N=0.288%, available P=26.74mg/kg, available K=150 mg/kg and EC=3.40 dS/m.

Table2- Result of analysis variance on studied characteristics in savory Mean square

Treatments	df	root fresh weight(gr)	root dry weight(gr)	Root length(cm)	Stem diameter	Essential oil content t(m/lit)	Zinc content t (ppm)
Humic acid(A)	3	0.111**	0.021**	49.79**	0.098**	1.77**	0.180**
nanozechelated fertilizer(B)	3	0.023**	0.019**	20.50**	0.182**	1.94**	0.947**
A*B	9	0.0029**	0.0033**	1.51**	0.012**	0.055**	0.020**
Error	48	0.00001927	0.00009063	0.2385417	0.00427083	0.0066635	0.00016458
Cv(%)		1.936256	8.167049	4.945896	14.52258	6.012590	1.926458
R-Square		0.997867	0.972336	0.951475	0.823276	0.975008	0.997794

ns= Non significant, ** = p < 0.01, and * = p < 0.05

Table 3. Means comparison of the main effects humic acid of and nano zn chelated fertilizer treatments on morphophysiological and agronomical traits of savory (*Satureja hortensis* L.).

humic acid	nano Zn chelated fertilizer	root fresh weight gr	root dry weight gr	Root length cm	Number of leaves per plant	Stem diameter Cm	Chlorophyll content t (SPAD value	Content t Essential oil m/lit	phosphorous (mg.g-1)	zinc conte
0 (without using humic acid)	0 (without using nano Zn chelated fertilize)	0.097500 l	0.037500 c	6.5500 g	19.00 h	0.20000 h	1.40750 l	0.62500 h	0.117500 d	0.2150 m
	50mg on each one at 1000 m/liters water	0.155000 k	0.087500 b	7.5750 f	24.00 g	0.30000 g	4.3600 j	0.85000 g	0.135000 c	0.5800 h
	100mg on each one at 1000 m/liters water	0.162500 j	0.090000 b	8.7750 de	30.00 e	0.40000 defg	8.45500 e	1.12500 f	0.140000 bc	0.690000 f
	200mg on each one at 1000 m/liters water	0.170000 i	0.095000 b	8.7250 de	33.00 d	0.50000 bcd	8.75250 d	1.34000 e	0.140000 bc	0.790000 e
0/5cc on each one 1000 m/liters water)	0 (without using nano Zn chelated fertilize).	0.177500 h	0.087500 b	8.2750 e	23.00g	0.32500 fg	3.95000 j	0.75000g	0.135000 c	0.300000 l
	50mg on each one at 1000m/liters water	0.165000 ij	0.090000 b	9.1500 d	35.00cd	0.45000 bcde	6.31750 h	1.29000 e	0.140000 bc	0.430000 j
	100mg on eachone at 1000 m/liters water	0.192500 fg	0.095000 b	8.9500 de	35.50cd	0.45000 bcde	8.83750d	1.39000 de	0.147500 a	0.800000 e
	200 on each one at 1000 m/liters water	0.197500 f	0.100000 b	9.2250 d	26.50f	0.52500 bc	7.33750 f	1.52500 c	0.147500 a	0.905000 c
1cc on each one 1000 m/liters water	0 (without using nano Zn chelated fertilize)	0.170000 i	0.092500 b	8.7750 de	33.50d	0.37500 efg	5.65750 i	1.02500 f	0.135000 c	0.330000 k
	50 on each one at 1000 m/liters per water	0.190000 g	0.097500 b	11.6000 c	39.00b	0.50000 bcd	6.72000 g	1.35000 e	0.145000 ab	0.630000 g
	100 on each one at 1000 m/liters per water	0.287500 e	0.192500 a	. 11.8750 bc	40.50b	0.47500 bcde	8.73750 d	1.55000 c	0.150000 a	0.800000 e
	200 on each one at 1000 m/liters per water	0.310000 c	0.197500 a	11.9500 abc	33.00b	0.55000 b	14.06250 a	1.80000 b	0.147000 a	0.940000 ab

1/5 cc on each one 1000 m/liters water)	0 (without using nano Zn chelated fertilize)	0.295000 d	0.102500 b	9.2250 d	33.00d	0.37500 efg	5.73250 i	1.3000 e	0.140000 bc	0.535000 i
	50 on each one at 1000 m/liters per water	0.305000 c	0.100000 b	12.2500 abc	36.50c	0.42500 cdef	8.86750 d	1.47500 cd	0.145000 ab	0.830000 d
	100 on each one at 1000 m/liters per water	0.372500 b	0.197500 a	12.4500 ab	40.00b	0.65000 a	10.30000 c	2.15000 a	0.150000 a	0.930000 b
	200 on each one at 1000 m/liters per water	0.380000 a	0.202500 a	12.6500 a	43.50 a	0.70000 a	12.05250 b	2.17750 a	0.150000 a	0.950000 a

Mean with the same letters in each column does have significant difference at the 1% level of probability. Duncan t test.

Table4. Means comparison of the main effects humic acid of treatments on morphophysiological and agronomical traits of savory (*Satureja hortensis* L.)

Treatment	root fresh weight gr	Root dry weight gr	Root length Cm	Number of leaves per plant	Stem diameter	Chlorophyll content t (SPAD value)	Essential oil content t m/lit	phosphorous (mg.g-1)	zinc content ppm
H_1	0.146250 d	0.077500 c	7.9063 a	26.5000 d	0.35000 c	5.74375 d	0.98500 d	0.133125 c	**0.568750 d**
H_2	0.183125 c	0.093125 b	8.9000 b	32.2500 c	0.43750 b	6.61063 c	1.23875 c	0.142500 b	**0.608750 c**
H_3	0.239375 b	0.145000 a	11.0500 c	34.8750 b	0.47500 b	8.79438 b	1.43125 b	0.14437 ab	**0.675000 b**
H_4	0.338125 a	0.150625 a	11.6438 d	38.250 a	0.53750 a	9.24063 a	1.77563 a	0.146250 a	**0.811250 a**

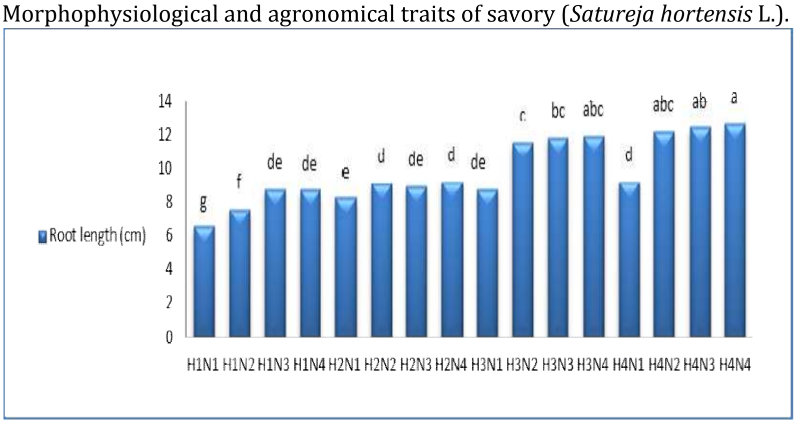
H1: Control (0without using nano Zn chelated fertilize) humic acid
H2: treatment (humic acid (./5cc on each one 1000 m/liters water) humic acid
H3: treatment (humic acid(1cc on each one 1000 m/liters water) humic acid
H4:treatment(humic acid(1.5cc on each one 1000 m/liters water) humic acid
*was not significant.

Table 5. Means comparison of effects nano Zn chelated fertilizer treatments on morphophysiological and agronomical traits of savory (*Satureja hortensis* L.).

treatment	Root fresh weight gr	Root dry weight gr	Root length cm	Number of leaves per plan	Stem diameter	Chlorophyll content t (SPAD value)	Essential oil content m/lit	phosphorous (mg.g-1)	Zinc content ppm
N_1	0.185000 d	0.080000 c	8.2063 c	25.375 d	0.31875 d	4.18938 d	0.92500 d	0.131875 c	0.345000 d
N_2	0.203750 c	0.093750 b	10.1438 b	32.250 c	0.41875 c	6.56625 c	1.24125 c	0.141250 b	0.617500 c
N_3	0.253750 b	0.143750 a	10.5125 a	36.125 b	0.49375 b	9.08250 b	1.55375 b	0.146875 a	0.805000 b
N_4	0.264375 a	0.148750 a	10.6375 a	38.125 a	0.56875 a	10.55125 a	1.71063 a	0.14625 a	0.896250 a

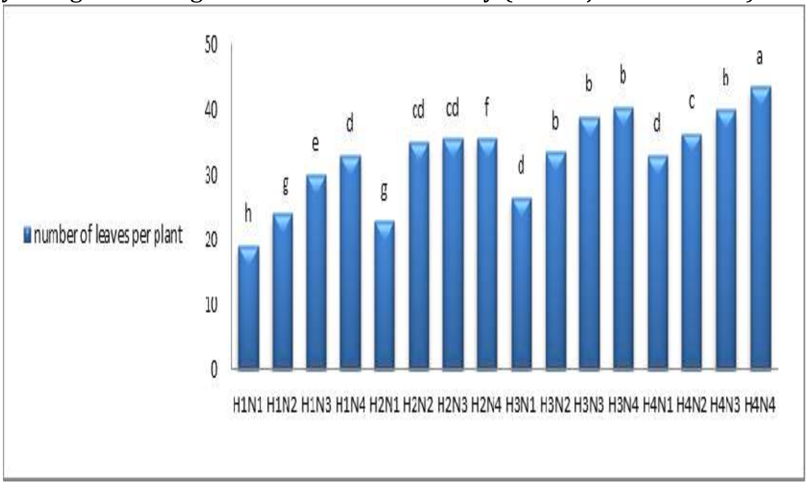
N1:control(0without using nano Zn chelated fertilize)
N2:treatment 50mg on each one at 1000 m/liters water nano Zn chelated fertilizer
N3:treatment100mg on each one at 1000 m/liters water.nano Zn chelated fertilizer
N4:treatment 200mg on each one at 1000 m/liters water nano Zn chelated fertilizer.
*was not significant.

Figure 1 -Average the interaction of humic acid and nano Zn chelated fertilizer root length savory Morphophysiological and agronomical traits of savory (*Satureja hortensis* L.).



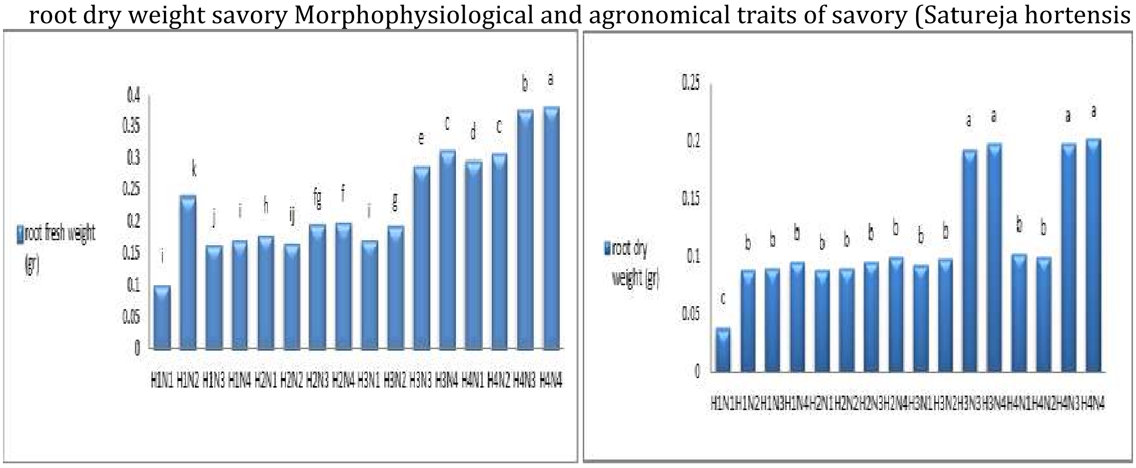
H1:Contro(0without using nano Zn chelated fertilize) humic acid, H2:treatment(humic acid (./5cc on each one 1000 m/liters water) humic acid,H3:treatment (humic acid(1cc on each one 1000 m/liters water) humic acid, H4:treatment(humic acid(1.5cc on each one 1000 m/liters water) humic acid.N1:control(0without using nano Zn chelated fertilize), N2:treatment 50mg on each one at 1000 m/liters water nano Zn chelated fertilizer ،N3:treatment100mg on each one at 1000 m/liters water.nano Zn chelated fertilizer, N4:treatment 200mg on each one at 1000 m/liters water nano Zn chelated fertilizer.

Figure 2-Average the interaction of humic acid and nano Zn chelated fertilizer number of leaves per plant savory Morphophysiological and agronomical traits of savory (Satureja hortensis L.).



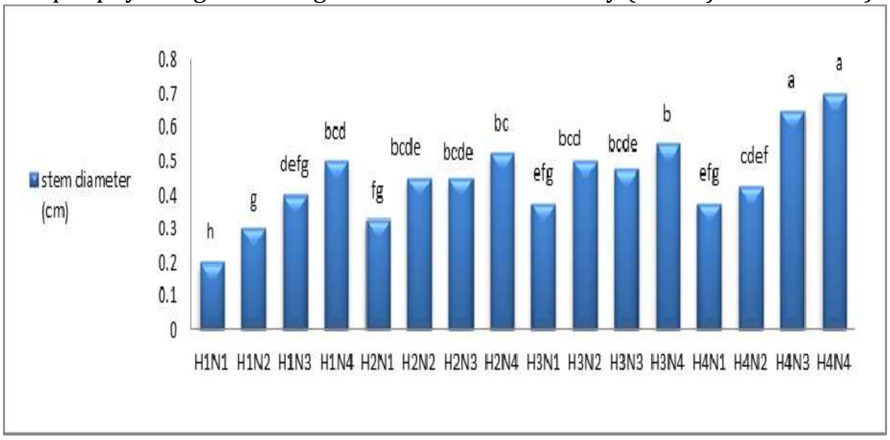
H1:Contro(0without using nano Zn chelated fertilize) humic acid,H2:treatment(humic acid (./5cc on each one 1000 m/liters water) humic acid,H3:treatment (humic acid(1cc on each one 1000 m/liters water) humic acid,H4:treatment(humic acid(1.5cc on each one 1000 m/liters water) humic acid.N1:control(0without using nano Zn chelated fertilize), N2:treatment 50mg on each one at 1000 m/liters water nano Zn chelated fertilizer ،N3:treatment100mg on each one at 1000 m/liters water.nano Zn chelated fertilizer, N4:treatment 200mg on each one at 1000 m/liters water nano Zn chelated fertilizer.

Figure 3,4- Average the interaction of humic acid and nano Zn chelated fertilizer root fresh weight and root dry weight savory Morphophysiological and agronomical traits of savory (Satureja hortensis L.).



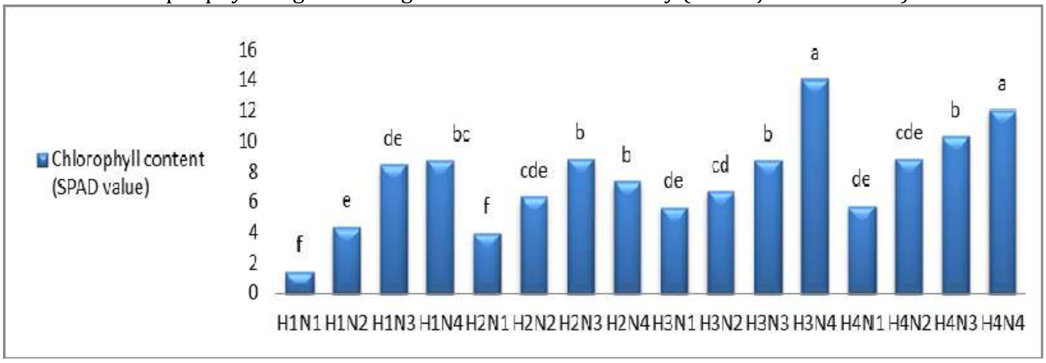
H1:Contro(0without using nano Zn chelated fertilize) humic acid,H2:treatment(humic acid (./5cc on each one 1000 m/liters water) humic acid,H3:treatment (humic acid(1cc on each one 1000 m/liters water) humic acid,H4:treatment(humic acid(1.5cc on each one 1000 m/liters water) humic acid,N1:control(0without using nano Zn chelated fertilize), N2:treatment 50mg on each one at 1000 m/liters water nano Zn chelated fertilizer ،N3:treatment100mg on each one at 1000 m/liters water.nano Zn chelated fertilizer, N4:treatment 200mg on each one at 1000 m/liters water nano Zn chelated fertilizer.

Figure 5-Average the interaction of humic acid and nano Zn chelated fertilizer stem diameter savory Morphophysiological and agronomical traits of savory (*Satureja hortensis* L.).



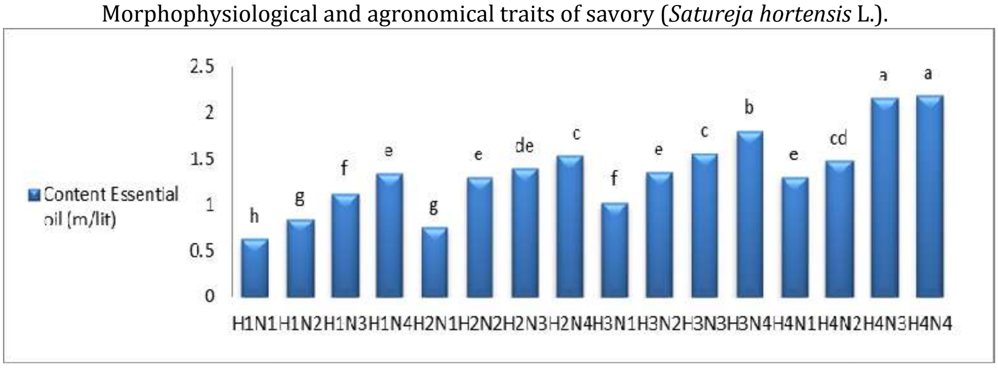
H1:Contro(0without using nano Zn chelated fertilize) humic acid,H2:treatment(humic acid (./5cc on each one 1000 m/liters water) humic acid,H3:treatment (humic acid(1cc on each one 1000 m/liters water) humic acid,H4:treatment(humic acid(1.5cc on each one 1000 m/liters water) humic acid,N1:control (0without using nano Zn chelated fertilize), N2:treatment 50mg on each one at 1000 m/liters water nano Zn chelated fertilizer ‹N3:treatment100mg on each one at 1000 m/liters water. nano Zn chelated fertilizer, N4:treatment 200mg on each one at 1000 m/liters water nano Zn chelated fertilizer.

Figure 6- Average the interaction of humic acid and nano Zn chelated fertilizer chlorophyll content t savory Morphophysiological and agronomical traits of savory (Satureja hortensis L.).



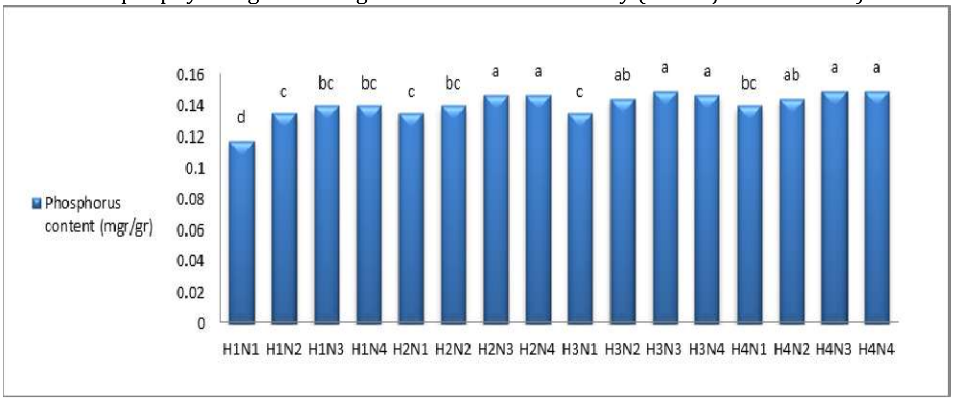
H1:Contro(0without using nano Zn chelated fertilize) humic acid,H2:treatment(humic acid (0/5cc on each one 1000 m/liters water) humic acid,H3:treatment (humic acid(1cc on each one 1000 m/liters water) humic acid,H4:treatment(humic acid(1.5cc on each one 1000 m/liters water) humic acid. N1:control(0without using nano Zn chelated fertilize), N2:treatment 50mg on each one at 1000 m/liters water nano Zn chelated fertilizer ‹N3:treatment100mg on each one at 1000 m/liters water.nano Zn chelated fertilizer, N4:treatment 200mg on each one at 1000 m/liters water nano Zn chelated fertilizer.

Figure 7- Average the interaction of humic acid and nano Zn chelated fertilizer content t essential oil savory Morphophysiological and agronomical traits of savory (*Satureja hortensis* L.).



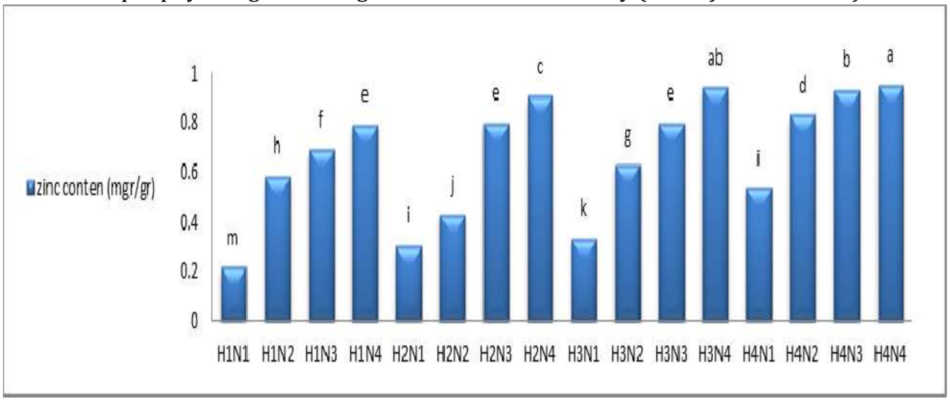
H1:Contro(0without using nano Zn chelated fertilize) humic acid,H2:treatment(humic acid (./5cc on each one 1000 m/liters water) humic acid,H3:treatment (humic acid(1cc on each one 1000 m/liters water) humic acid,H4:treatment (humic acid(1.5cc on each one 1000 m/liters water) humic acid. N1:control(0without using nano Zn chelated fertilize), N2:treatment 50mg on each one at 1000 m/liters water nano Zn chelated fertilizer ‹N3:treatment100mg on each one at 1000 m/liters water.nano Zn chelated fertilizer, N4:treatment 200mg on each one at 1000 m/liters water nano Zn chelated fertilizer.

Figure 8- Average the interaction of humic acid and nano Zn chelated fertilizer phosphorus content t savory Morphophysiological and agronomical traits of savory (Satureja hortensis L.).



H1:Contro(0without using nano Zn chelated fertilize) humic acid,H2:treatment(humic acid (./5cc on each one 1000 m/liters water) humic acid,H3:treatment (humic acid(1cc on each one 1000 m/liters water) humic cid,H4:treatment(humic acid(1.5cc on each one 1000 m/liters water) humic acid. N1:control(0without using nano Zn chelated fertilize), N2:treatment 50mg on each one at 1000 m/liters water nano Zn chelated fertilizer ‹N3:treatment100mg on each one at 1000 m/liters water. Nano Zn chelated fertilizer, N4:treatment 200mg on each one at 1000 m/liters water nano Zn chelated fertilizer.

Figure 9-Average the interaction of humic acid and nano Zn chelated fertilizer zinc content savory Morphophysiological and agronomical traits of savory (*Satureja hortensis* L.).



H1:Contro(0without using nano Zn chelated fertilize) humic acid,H2:treatment(humic acid (./5cc on each one 1000 m/liters water) humic acid,H3:treatment (humic acid(1cc on each one 1000 m/liters water) humic cid,H4:treatment(humic acid(1.5cc on each one 1000 m/liters water) humic acid. N1: control (0without using nano Zn chelated fertilize), N2:treatment 50mg on each one at 1000 m/liters water nano Zn chelated fertilizer ‹N3:treatment100mg on each one at 1000 m/liters water. nano Zn chelated fertilizer, N4:treatment 200mg on each one at 1000 m/liters water nano Zn chelated fertilizer.

RECOMMENDATIONS

1. It is recommended that other humic acid and nano Zn chelated fertilizer are examined and tests are reported in the places and years.
2. According to the trace elements shortage rate in the cultivating soils and humans need to these elements it is suggested that necessary micronutrients be provide for the plant in adequate amounts.
3. Since zinc nano Zn chelated fertilizer will increase the humic acid adoption and thus increases the yield elements, it is recommended that two fertilizer treatment to humic acid and nano Zn chelated fertilizer being utilized with suitable rates alongside each other due to their positive effects.

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