STUDYING THE EFFECT OF HUMIC ACID AND MAGNETITE ON GROWTH, YIELD AND OIL QUALITY OF BASIL (*OCIMUM BASILICUM* L.) PLANT GROWN UNDER DIFFERENT LEVELS OF CHEMICAL FERTILIZERS.

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ABSTRACT

Two experiments were carried out at Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Centre, Dokki, Giza governorate, Egypt during two successive seasons of 2012 and 2013, to investigate the influence of humic acid, magnetite and their interactions on growth characters (plant height, number of branches, leaf area and leaves number), yield of fresh and dry herb, oil yield and its components as well as chemical composition of basil plants growing under different levels of chemical fertilizer (0, 50,100% NPK). The obtained results showed that using magnetite and humic acid under fertilization of full dose of NPK increased all growth parameters (plant height, number of branches, leaf area, leaves number, herb fresh and air dry weights) and oil percentage in herb compared to the other treatments. In addition, basil plants treated with this integrated treatment gave the highest number of yield of plants compared to the other treatments. further, using magnetite and humic acid under half dose of NPK conditions significantly increased all data collected over the control treatment (plant received only the full recommended dose of NPK). It could be concluded that using magnetite and humic acid might improve nutritional status of plants, leading to higher plant productivity.

Key words: Basil plant, humic acid, magnetite, chemical fertilization, organic fertilization

INTRODUCTION

Basil is annual and perennial herbs and shrubs, mostly native to the tropical and warm temperate regions. They are members of the Lamiaceae family and are cultivated worldwide under a variety of ecological conditions. Basil has been used as a medicinal and aromatic plant for centuries. Due to their pharmaceutical and medical properties, basil species are used in the treatment of headaches, cough, diarrhoea, anti-helminthic treatments and in kidney dysfunctions. The leaves can be used fresh and dried, as edibles or spices (Labra *et al*., 2004).

Environmental pollution due to excessive application of chemical fertilizers is one of the most important environmental and social concerns throughout the world especially in developing countries (Parr *et al*., 1992).

Nanotechnology has various functions in all stages from production, processing, storage, postharvest and transportation of agricultural products (Scott and Chen, 2003). Nanotechnology introduced a large scope of new application in agriculture. Using Nano fertilzers to plants is one of the critical importance due to its unique properties and activities in size brings about substantial changes in their physical properties with respect to bulk materials in terms of the small size of the particles and increase the surface area consequently for its higher resonance (Xia *et al*., 2009). The nanotechnology increases the application efficiency of fertilizers, reduces soil pollution and environmental risks of chemical fertilizers (Bakhtiari *et al*., 2015). Previous studies showed that nanoparticles can have a beneficial effect on plants growth and development (Zhu *et al.*, 2008; Roghayyeh *et al.*, 2010).Nutrients are very important for plant growth and development; there are many factors that reduce their availability to plants. Thus, it is necessary to reduce nutrient losses to increase crop yields through using new applications such as nanotechnology. Nano fertilzers or nano-encapsulated nutrients might have properties that are effective to crops, released the nutrients on-demand, controlled release of chemicals fertilizers that regulate plant growth and enhanced target activity (DeRosa *et al*., 2010; Nair *et al*., 2010). This effect maybe also due to super para-magnetism behavior of MNPs as describes (Shouhu *et al.* 2007). Magnetic field improved the plant growth characteristics (Abou El-Yazied *et al*., 2012; Esitken and Turan, 2003; Carbonell *et al*., 2011; Radhakrishnan and Kumari, 2012), influenced the chemical composition of plants (Radhakrishnan and Kumari, 2012) and activate plant enzymes such as superoxide dismutase (SOD), catalase (CAT), peroxidase (POX) and ascorbate peroxidase (APX) (Alikamanoglu and Sen, 2011; Shabrangi *et al*., 2011)

Humic acid can be used as a cheap organic fertilizer source to improve plant growth and yield, and enhance stress tolerance, as well as to improve soil physical properties and complex metal ions (Atiyeh *et al*., 2002; Serenella *et al*., 2002; Zandonadi *et al*., 2007). In addition, the presence of humic molecules raises the effect of NPK fertilization on plants (Chen *et al*., 2001). Humic substances in soil increase nutrient absorption by augmenting the availability of nutrients in addition to improvement of the physical structure of soil (Akinremi *et al*., 2000; Chen *et al*., 2001; Cimrin and Yilmaz, 2005). On the other hand, organic matter in soil has been reported to provide the compounds which affect root growth and the distribution of nutrients absorbed by plants (Lobartini *et al*., 1997). The integrated use of organic nutrient sources with inorganic fertilizer has been shown to increase the potential of organic fertilizer (Heluf, 2002; Ahmad *et al*., 2006); improve the efficiency of inorganic fertilizer (Guar and Geeta, 1993) and to improve soil fertility and

productivity of agricultural systems (VanLauwe *et al.,* 2002). This may not only help in recycling of organic waste causing environmental pollution but also conserve a rich pool of nutrient resources, which can reduce the sole dependence on chemical fertilizers (Ghosh and Sharma, 1999). So, their use could be reduced up to a certain level. Such practice may also enable the farmers to reduce the use of expensive inorganic sources of fertilizers up to a certain level and get practically realizable yield potentials in a cost effective and sustainable manner. Prabhu *et al*. 2010 found that spraying basil (*Ocimum sanctum*) leaves with humic acid increased plant height, number of leaves, leaf area and leaf area index at both stages of the plant growth.
The objective of this study was to investigate the influence of humic acid, magnetite and their interactions under different levels of chemical fertilization on growth, essential oil production and chemical composition of basil (*Ocimum basilicum* L.) plants.

MATERIALS AND METHODS

This study was carried out at Central Laboratory for Agricultural Climate (CLAC), Agricultural Research Centre, Dokki, Giza governorate, Egypt during two successive seasons of 2012 and 2013. Seeds of (*Ocimum basilicum*) country of origin Italy obtained from national research center were used in this study. Seeds were sown on 15th and 18th of March 2012 and 2013, respectively for seedling preparation. 15 cm Fresh transplants were transplanted. Transplants were placed into pots filled with 9 kg of sand: clay (1:1) 25 cm in diameter. Humic acid from Elahram Company applied as solution 1 liter/fed. at transplanting time then after 15 and 30 days respectively per season, magnetite was done after sowing by applying 0.9 g/ pot as recommended by El Ahram mining company. Treatments were arranged in split design with three replicates in both seasons. The soil chemical properties were determined according to Jackson, (1973). (Table1)

Table (1): some physical and chemical analysis of experimental soil.

Property	value	Cations (me./l)	value	Anion (me./l)	value	PH (soil paste	EC (ds/m)at 25^o c
Sand%	49%	Ca^{++}	8.8	CO_3^{--}	0	8.6	2
Silt%	26%	Mg^{++}	1.08	HCO_3^-	3.6		
Clay %	24.4	Na^+	5.8	Cl^-	4.1		
		K+	2.22	SO_4^{--}	10.2		

The Treatments Were as Follows:

* Control plants fertilized with full recommended dose of NPK(300 kg/fed super calcium phosphate (before sowing), ammonium sulphate 600-900 kg /fed potassium sulphate 100- 150 kg /f.
* Half dose of NPK of recommended dose.
* Without fertilization.
* Humic acid
* Magnetite
* Magnetite + humic acid

* Humic acid with half dose of recommended dose of NPK.
* Magnetite with half dose of recommended dose of NPK.
* Magnetite + humic acid with half dose of recommended dose of NPK.
* Humic acid with the recomended dose of NPK
* Magnetite with the recommended dose of NPK.
* Magnetite + humic acid with the recommended dose of NPK.

Recorded Data:

Vegetative growth parameters:

In both successive seasons, three plants were randomly labeled from each treatment, for growth and chemical analysis. Three cuts were taken from each labeled plant at the early bloom stages (on $20^{th}$and 22^{nd} August, 24^{th} and 21^{st} of October, and 10^{th} and 12^{nd} of December 2012 and 2013 respectively in the two seasons). The following data were recorded and statistically analyzed. At each harvesting time, Plant height (cm), number of leaves/plant, Leaf area cm^2 of the fifth leaf from above, number of branches /plant were recorded.

The yield:

* Yield fresh weight (g/plant) and ton/faddan (total of all fresh weight of the three cuts).
* Yield dry weight. (g/plant) and ton/faddan (total of all dry weight of the three cuts).
* Essential oil productavity L/faddan.

Chemical analysis:

Chemical constituents in herb and root were presented in total carbohydrates content, nutrients contents (N, P, K, Ca, Zn, Mn. Fe), and oil components. Total nitrogen was determined by Kjeldah method described by Bremner and Mulvaney(1982). Phosphorous concentration in acid digested was determined by colorimeter method (ammonium molybdate) using spectrophotometer according to Jackson (1973). Potassium content was determined using Flame photometer as described by Chapman and Pratt (1961) and the results were represented as gm/100 gm D.W. of plant. Calcium content and Micro-nutrients (Mn, Zn, and Fe) elements content were determined using atomic absorption spectro-photometer, D.P.3300 Parkenvelemer. While the content of carbohydrates in dried herb samples were determined using the method described by Dubois *et al*. (1956). Pigments content including Chlorophyll a,b and carotenoids were determined in fresh leaves samples (mg/gm F.W.) according to Lichtenthaler &Wellburn, 1983

Essential-oil extraction and analysis

The aerial parts of *Ocimum basilicum* were processed by hydro-distillation for 2hours in a Clevenger apparatus to obtain the essential oil. Essential oils were dried over anhydrous sodium sulfate, stored in a dark glass vials and kept at 4°C (Omidbaigi *et al*., 2003). Essential oil yield per plant was calculated in proportion to the herb fresh weight and analyzed by gas-chromatography (GC) coupled to mass spectrometry (MS).

Oil yield/plant = plant fresh weight x oil percentage.

Statistical Analyses

The treatment means were compared by least significant difference (L.S.D.) test as given by Snedecor and Cochran (1994) by used Assistat program.

Results and Discussion

Vegetative growth parameters:

Data presented in (Table 3) showed that, using humic acid + magnetite under full recommended NPK conditions had a significantly promoted effect on all growth parameters (plant height, leaves number/plant, number of branches/plant and leaf area. Focusing on the individual adding, from data it noticed that, magnetite treatments was superior comparing with humic acid treatments. Not only that but from data it is clear that using humic acid and magnetite under half dose of recommended NPK treatment was greater than the control (recommended dose of NPK) treatment. These data are in harmony with those obtained by Mansour, 2007 who reported that, Magnetic iron increased plant growth and leaf mineral content on cauliflower and Yasser *et al*. (2011) on Roselle plants (*Hibiscus Sabdariffal*). These results may be due to the effect of Iron while it is one of the essential elements for plant growth and plays an important role in the photosynthetic reactions. Iron activates several enzymes and contributes in RNA synthesis and improves the performance of photo-systems (Malakouti&Tehrani, 2005).

Moreover, Prabhu *et al*.(2010) found that, spraying basil (*Ocimum sanctum*) leaves with humic acid increased plant height, number of leaves, leaf area and leaf area index at both stages of the plant growth. This is may be due to increasing cell membrane permeability, respiration, photosynthesis, oxygen and phosphorus uptake, and supplying root cell growth (Cacco& Dell Agnolla, 1984; Russo &Berlyn, 1990).

Table (2): effect of magnetite, humic acid and their combinations under different levels of NPK on vegetative growth parameters of basil plant.

Treatments	Cut	Plant hight(cm)		No. of branch/plant		Leaves No.		Leaf area cm^2	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Recommended dose of NPK (control)	1st	30.33	28.83	31.33	34.33	208.33	229.33	22.82	22.37
	2nd	32.27	30.67	36.67	40.67	210.33	231.33	23.05	26.45
	3rd	36.23	34.43	35.33	39	204.33	225	22.36	26.72
mean		32.94f	31.31e	34.44g	38g	207.66g	228.55g	22.74e	25.18c
50% of recommended dose of NPK	1st	19.67	18.7	13.33	14.67	103.67	114	17.36	17.01
	2nd	24.03	22.83	15.33	17	104.67	115	17.53	21.93
	3rd	30.63	29.1	15.33	17	101.67	112	17	22.15
mean		24.78h	23.54g	14.66i	16.22i	103.34h	113.67h	17.30g	20.36 g
Soil without adding NPK	1st	13.83	13.13	6.67	7.67	50.67	55.67	6.21	6.34
	2nd	15.37	14.60	8	9	52.33	57.33	6.275	6.40
	3rd	20.83	19.80	7.67	8.67	50.33	55.33	6.086	6.21
mean		16.68j	15.84i	7.45k	8.45k	51.11k	56.11k	6.19k	6.32k
Humic acid	1st	23.70	22.53	12.67	13.67	69.33	76.33	13.282	13.55
	2nd	23.63	22.43	16	18	70.33	77.33	11.309	13.69
	3rd	25.33	24.10	15.33	17.33	68.33	75.33	13.011	13.28
mean		24.22h	23.02g	14.67i	16.33i	69.33j	76.33j	12.53i	13.51i
magnetite	1st	21.50	20.43	10	11	69.67	76.67	11.816	12.06
	2nd	21.50	20.43	12.67	13.67	70.67	77.67	11.933	12.18
	3rd	23.77	22.57	14.33	15.67	68.67	75.67	11.577	11.81
Mean		22.26i	21.14h	12.33j	13.45j	69.67j	76.67j	11.78j	12.02j
Humic acid+ magnetite	1st	26	24.73	15	16.67	80	88	16.37	16.70
	2nd	27.90	26.03	23.67	23.67	81	89	16.479	16.87
	3rd	32.70	31.07	20	22	78	86	16.145	16.37
Mean		28.87g	27.28f	19.56h	20.78h	79.67i	87.67i	16.33h	16.65h
Humic acid+half dose of NPK	1st	32.90	31.27	32.67	35.67	254.33	279.67	21.54	21.98
	2nd	36.87	35.03	40.33	44.33	257.33	283.33	21.759	22.20
	3rd	42.90	44.83	38.33	42.33	245.67	270.33	21.106	21.54
Mean		37.56e	37.04d	37.11f	40.78f	252.44f	277.78f	21.47f	21.91f
magnetite+half dose of NPK	1st	35.67	33.87	39	43	265.67	292.33	22.08	22.53
	2nd	41.73	39.63	44.67	49	268.67	295.67	22.302	22.76
	3rd	44.60	42.37	42.67	47	260.67	287	21.629	22.07
Mean		40.67d	38.62d	42.11e	46.33e	265e	291.67e	22f	22.45e
Humic acid+magnetite +half dose of NPK	1st	44.10	41.90	48.33	53.33	305	335.67	23.445	23.92
	2nd	48.37	46.17	53	58.33	308	339	23.680	24.16
	3rd	52.63	50	55.33	61	299	329	22.968	23.44
Mean		48.37b	46.02b	52.22	57.55d	304d	334.56d	23.36d	23.84d
Humic acid+full dose of NPK	1st	40.90	38.87	51	56	356	391.67	25.99	26.52
	2nd	46.63	44.30	53	58	360	396	26.254	26.79
	3rd	49.93	47.43	61.33	67.33	349	384	25.467	25.99
Mean		45.82c	43.53c	55.11c	60.44c	355c	390.56c	25.90c	26.43b
magnetite+full dose of NPK	1st	42.23	40.13	54	59.67	363	399.33	26.94	27.49
	2nd	48.13	45.77	57	63	367	404	26.391	27.77
	3rd	52	49.40	61	67	356	391.67	27.211	26.93
Mean		47.45b	45.10b	57.33b	63.22b	362b	398.33b	26.85b	27.40a
magnetite+humic acid +full dose of NPK	1st	46.13	43.83	69	76	452.33	497.33	27.639	28.20
	2nd	57.70	56.87	81.67	92.33	457.33	503.33	27.914	28.48
	3rd	56.77	53.93	78	86	443.33	487.67	27.077	27.63
Mean		53.53a	51.54b	76.22a	84.78a	451a	496.11a	27.54a	28.10a

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Chemical analysis:

As stated of growth parameters, the results of chemical analysis (macro nutrients) in herb (Table 3), micro nutrients in herb(table 4) and leaf pigments and total carbohydrates(table 5) have the same conclusion where, all parameters significantly increased as a result of humic acid + magnetite under full recommended NPK treatment compared to control plants (plants received the recommended NPK dose). Going along with other treatments it is clear that, humic acid+ magnetite under half dose of NPK treatment was significantly higher than the control (plant received full dose of NPK) treatment. This is may be due to, Improving plant nutrition by humic acid which stimulating the absorption of mineral elements through stimulating root growth and increases the rate of absorption of mineral ions on root surfaces and their penetration into the cells of the plant tissue, so plants show more active metabolism and increase respiratory activity. Sharma *et al*.,(2003);Abada (2009); Mohammed *et al*., (2010); Abd El-Monem *et al.,* (2011) and Aydin *et al*., (2012) indicated that, there are many benefits to crop growth resulted from addition natural mineral product like magnetic iron including improved soil structure, increased soil organic matter, improved water properties and become more energy and vigor and this known as "Magneto biology', improving water holding capacity and cation exchange capacity, Improved crop nutrition from macro and microelements. Moreover, the magnetic process separate all chlorine, toxic and harmful gases from soil, increased salt movement and solubility of nutrients increasing water retention by soil and this help on plant growth, moderation of soil temperature. Magnetic treatment of water may be influencing desorption of P and K from soil adsorbed P on colloidal complex, and thus increasing its availability to plants, and thus resulting in an improved plant growth and productivity.

These results are convenience with those reported by El- Hefny, (2010) on cowpea plants his work revealed that, humic acid application increased N, P, K, K/ Na and Ca/ Na leaf contents .also, carbohydrate content were significantly increased in cowpea seeds by increment the level of humic acid application, and Abd El- Al, (2003) indicated that, application of magnetite for Eggplant at the time of cultivation resulted in the higher values of nitrogen, phosphorus, potassium and iron in plant compared with un-treated plants.

The yield:

Data in table (6) shown that, humic acid + magnetite under full recommended NPK treatment significantly increased herb fresh and dry weight/ fadden and essential oil productivity /fadden in both seasons of basil plants compared to the control treatment (plants received the recommended NPK dose) and other treatments. About the individual treatment, from data it can be concluded that magnetite treatments were significantly higher in yield fresh and dry weight and oil productivity in both seasons. Also we can concluded that humic acid + magnetite under half dose of NPK treatment was greater than plant received recommended dose of NPK only(control). These results may be due to ,the role of magnetite and humic acid addition in enhancing the efficacy of applied chemical fertilizers which resulting in increases in vegetative growth and herb fresh and dry yields, also, better supply of soil nutrients and organic matter contributes to improvement of vegetative growth, leaf quality and yield. These results are in harmony with those obtained by Ahmed, *et al*., (2011) who demonstrated that, magnetic iron plus humic acid application on Roselle plants recorded the highest values of seed yield, number of fruits/ plant compared with other treatments.

Essential oil Composition

The content of essential oil in the fresh herb of all treatments of basil plants was extracted. 9 compounds were determined in the essential oil obtained from all treatments (table 7). From data it noticed that, there was no significant effect of NPK level on essential oil components. The essential oil of basil plants is characterized by high amount of linalool (42.04 -45.15%) The highest amount of linalool was increased (45.15 %) with humic acid + magnetite under full recommended dose of NPK treatment as compared with the control treatment (full recommended dose of NPK) (42.04%). The same trend observed with estragole, 1.8-cineole, Bornyl acetate and Eugenol while α- terpineol, Trans-a'bergamotene, Germacrene-D and Alfa-copaene as recorded the highest amount of it with the control plants and the lowest amount of it noticed with the humic acid+ magnetite treatment. The variations in essential oil content and composition could be due to the effect of different treatments on enzymes activity and metabolism improvements. These finding is in line with Khater 2015 who mentioned that, the foliar treatment of *mentha piperita* L. with magnetite nanoparticles (MNPs) at 5, 10 and 15 ppm increased significantly the principal component of peppermint essential oil as compared with the control ones and EL- Gohary *et al*., 2014 recorded that, the concentration of mono-terpene hydro-carbons as highest in the essential oil of plants grown under 0.2 g L^{-1} of humic acid with 10 g/L of foliar nutrition.

Table (3): effect of magnetite, humic acid and their combinations under different levels of NPK on macronutrients in dry herb of basil plants g/100g dry herb.

Treatments	Cut	N		P		K		Ca	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Recommended dose of NPK (control)	1st	3.09	3.40	0.38	0.42	0.93	1.02	3.06	3.37
	2nd	3.11	3.42	0.42	0.46	0.94	1.04	3.08	3.39
	3rd	3.06	3.37	0.41	0.45	0.95	1.04	3.03	3.33
mean		3.09h	3.40h	0.40h	0.44i	0.94g	1.03g	3.06h	3.36h
50% of recommended dose of NPK	1st	2.49	2.74	0.30	0.33	0.64	0.70	2.47	2.72
	2nd	2.50	2.76	0.33	0.36	0.47	0.52	2.48	2.73
	3rd	2.47	2.72	0.33	0.36	0.53	0.58	2.45	2.70
mean		2.49k	2.74k	0.32i	0.35j	0.55j	0.60j	2.47k	2.72k
Soil without adding NPK	1st	2.02	2.22	0.22	0.24	0.42	0.46	2	2.20
	2nd	2.03	2.23	0.24	0.27	0.39	0.43	2.01	2.21
	3rd	2.01	2.21	0.23	0.26	0.39	0.44	1.99	2.19
mean		2.02l	2.22l	0.23j	0.26k	0.40k	0.44l	2.00l	2.20l
Humic acid	1st	2.83	3.11	0.45	0.49	0.59	0.65	2.80	3.08
	2nd	2.84	3.12	0.49	0.54	0.56	0.62	2.81	3.09
	3rd	2.80	3.08	0.48	0.53	0.56	0.62	2.78	3.06
mean		2.82i	3.10i	0.47g	0.52h	0.57i	0.63i	2.80i	3.08i
magnetite	1st	2.80	3.08	0.44	0.49	0.47	0.52	2.77	3.05
	2nd	2.81	3.09	0.49	0.53	0.49	0.54	2.78	3.06
	3rd	2.77	3.05	0.48	0.52	0.47	0.52	2.74	3.02
Mean		2.79j	3.07j	0.47g	0.51g	0.48	0.53k	2.76j	3.04j
Humic acid+ magnetite	1st	3.49	3.84	0.57	0.63	0.67	0.73	3.46	3.81
	2nd	3.51	3.86	0.63	0.70	0.64	0.70	3.48	3.83
	3rd	3.45	3.80	0.62	0.68	0.67	0.74	3.42	3.76
Mean		3.48g	3.83g	0.61d	0.67d	0.66h	0.72h	3.45g	3.80g
Humic acid+half dose of NPK	1st	4.18	4.60	0.51	0.56	0.99	1.09	4.14	4.55
	2nd	4.21	4.63	0.56	0.62	0.98	1.08	4.17	4.58
	3rd	4.12	4.54	0.55	0.61	0.99	1.09	4.08	4.49
Mean		4.17f	4.59f	0.54f	0.60f	0.99f	1.09f	4.13f	4.54f
magnetite+half dose of NPK	1st	4.40	4.84	0.56	0.61	1	1.10	4.36	4.80
	2nd	4.43	4.88	0.61	0.67	1.04	1.14	4.39	4.83
	3rd	4.34	4.78	0.60	0.66	1.03	1.13	4.30	4.73
Mean		4.39e	4.83e	0.59e	0.65e	1.02e	1.12e	4.35e	4.79e
Humic acid+magnetite +half dose of NPK	1st	4.65	5.11	0.58	0.63	1.05	1.15	4.61	5.07
	2nd	4.68	5.15	0.63	0.70	1.12	1.24	4.64	5.10
	3rd	4.59	5.05	0.62	0.68	1.07	1.18	4.55	5
Mean		4.64d	5.10d	0.61d	0.67d	1.08d	1.19d	4.60d	5.06d
Humic acid+full dose of NPK	1st	4.79	5.27	0.82	0.90	1.21	1.33	4.75	5.23
	2nd	4.82	5.30	0.90	0.99	1.20	1.32	4.78	5.26
	3rd	4.72	5.19	0.88	0.97	1.21	1.33	4.68	5.15
Mean		4.78c	5.25c	0.87c	0.95c	1.21c	1.33c	4.74c	5.21c
magnetite+full dose of NPK	1st	5.06	5.57	0.86	0.95	1.24	1.36	5.01	5.51
	2nd	5.10	5.61	0.95	1.04	1.37	1.50	5.05	5.56
	3rd	4.99	5.49	0.93	1.02	1.33	1.47	4.94	5.44
Mean		5.05b	5.56b	0.91b	1.00b	1.31b	1.44b	5.00b	5.50b
magnetite+humic acid +full dose of NPK	1st	5.55	6.10	0.94	1.03	1.51	1.66	5.50	6.05
	2nd	5.59	6.15	1.03	1.14	1.50	1.65	5.54	6.09
	3rd	5.47	6.02	1.01	1.11	1.50	1.65	5.42	5.96
Mean		5.54a	6.09a	0.99a	1.09a	1.50a	1.65a	5.49a	6.03a

Mean separation within columns by Duncan’s multiple range test, 5% level. Values that don’t share the same letter are significantly different.

Table (4): effect of magnetite, humic acid and their combinations under different levels of NPK on micronutrients in dry herb of basil plants ppm dry herb.

Treatments	Cut	Fe		Mn		Zn	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Recommended dose of NPK (control)	1st	935.65	1029.22	129.08	141.99	58.96	64.86
	2nd	943.90	1038.29	130.37	143.40	59.55	65.50
	3rd	926.97	1019.66	126.47	139.11	57.76	63.54
mean		935.51g	1029.06h	128.64g	141.50h	58.76e	64.63g
50% of recommended dose of NPK	1st	900.93	991.03	110.19	121.20	51.09	56.20
	2nd	908.83	999.72	111.29	122.42	51.60	56.76
	3rd	823.50	905.85	107.95	118.75	50.05	55.06
mean		877.75h	965.53i	109.81h	120.79j	50.91h	56.01i
Soil without adding NPK	1st	779.57	857.52	105.37	115.90	49.71	54.68
	2nd	786.27	864.89	106.42	117.06	50.21	55.23
	3rd	711	782.10	103.22	113.55	48.70	53.57
mean		758.95k	834.84l	105.00i	115.50k	49.54i	54.49j
Humic acid	1st	883.03	971.34	128.59	141.45	51.40	56.54
	2nd	890.77	979.84	129.87	142.86	51.91	57.10
	3rd	807.33	888.07	125.98	138.58	50.35	55.39
mean		860.38i	946.42k	128.15g	140.96i	51.22g	56.34i
magnetite	1st	867.17	953.88	128.87	141.76	50.63	55.69
	2nd	874.73	962.21	130.16	143.17	51.14	56.25
	3rd	793.07	872.37	126.26	138.89	49.60	54.56
mean		844.99j	929.49j	128.43g	141.27g	50.46h	55.50j
Humic acid+ magnetite	1st	965.27	1061.79	136.82	150.50	53.08	58.39
	2nd	973.83	1071.22	138.18	152.00	53.61	58.97
	3rd	876.70	964.37	134.04	147.44	52.00	57.20
Mean		938.60g	1032.46g	136.35f	149.98f	52.90f	58.19h
Humic acid+half dose of NPK	1st	1015.63	1117.20	140.37	154.41	60.05	66.06
	2nd	1024.70	1127.17	141.77	155.95	60.65	66.72
	3rd	926.97	1019.66	137.52	151.28	58.84	64.72
Mean		989.10f	1088.01f	139.89e	153.88e	59.85e	65.83f
magnetite+half dose of NPK	1st	1032.23	1135.46	145.75	160.33	60.26	66.29
	2nd	1041.47	1145.61	147.21	161.93	60.87	66.95
	3rd	941.97	1036.16	142.79	157.07	59.04	64.94
Mean		1005.22e	1105.74e	145.25d	159.78d	60.06e	66.06e
Humic acid+magnetite +half dose of NPK	1st	1094.28	1203.70	150.58	165.64	62.29	68.52
	2nd	1104.10	1214.51	152.09	167.30	62.92	69.21
	3rd	997.90	1097.69	147.53	162.28	61.03	67.13
Mean		1065.43d	1171.97d	150.07c	165.07c	62.08d	68.29d
Humic acid+full dose of NPK	1st	1109.60	1220.56	145.86	160.44	65.86	72.44
	2nd	1119.60	1231.56	147.32	162.05	66.51	73.17
	3rd	1011.73	1112.91	142.90	157.19	64.52	70.97
Mean		1080.31c	1188.34c	145.36d	159.89d	65.63c	72.19c
magnetite+full dose of NPK	1st	1259.80	1385.78	151.83	167.01	67.71	74.48
	2nd	1271.30	1398.43	153.35	168.68	68.39	75.23
	3rd	1147.23	1261.96	148.74	163.61	66.33	72.97
Mean		1226.11b	1348.72b	151.31b	166.43b	67.48b	74.23b
magnetite+humic acid +full dose of NPK	1st	1337.80	1471.58	155.36	170.90	80.45	88.49
	2nd	1350.10	1485.11	156.92	172.62	81.26	89.38
	3rd	1217.60	1339.36	152.21	167.44	78.82	86.70
Mean		1301.83a	1432.02a	154.83a	170.32a	80.18a	88.19a

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table (5): effect of magnetite, humic acid and their combinations under different levels of NPK on leaf pigments mg/g of fresh weight and % of total carbohydrates on dry herb of basil plant.

Treatments	Cut	chla		chlb		carotinoids		carbohydrates	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Recommended dose of NPK (control)	1st	1.65	1.63	0.31	0.35	0.147	0.16	4.46	5.35
	2nd	1.68	1.65	0.32	0.348	0.148	0.163	4.37	5.24
	3rd	1.6	1.58	0.3	0.334	0.142	0.157	4.17	4.98
mean		1.64d	1.62d	0.31d	0.34d	0.15c	0.16b	4.33c	5.19c
50% of recommended dose of NPK	1st	1.25	1.24	0.26	0.282	0.111	0.121	3.18	3.81
	2nd	1.38	1.35	0.26	0.28	0.119	0.134	3.13	3.74
	3rd	1.31	1.3	0.25	0.271	0.117	0.128	2.93	3.55
mean		1.31h	1.30h	0.26g	0.28h	0.12f	0.13e	3.08d	3.70d
Soil without adding NPK	1st	1.09	1.08	0.21	0.227	0.098	0.112	1.78	2.14
	2nd	1.11	1.09	0.21	0.257	0.101	0.108	1.77	2.09
	3rd	1.06	1.05	0.20	0.220	0.095	0.104	1.67	1.99
mean		1.09l	1.07l	0.21j	0.23j	0.10h	0.11g	1.74e	2.07e
Humic acid	1st	1.14	1.12	0.21	0.238	0.100	0.116	4.62	5.54
	2nd	1.18	1.13	0.22	0.238	0.104	0.111	4.53	5.43
	3rd	1.10	1.08	0.22	0.227	0.097	0.107	4.30	5.16
mean		1.14k	1.11k	0.22i	0.23	0.10h	0.11g	4.48b	5.38b
magnetite	1st	1.23	1.21	0.23	0.257	0.109	0.126	4.93	5.91
	2nd	1.26	1.21	0.24	0.260	0.111	0.120	4.80	5.79
	3rd	1.20	1.18	0.23	0.249	0.106	0.116	4.60	5.50
Mean		1.23j	1.20j	0.23h	0.26i	0.11g	0.12f	4.78b	5.73b
Humic acid+ magnetite	1st	1.29	1.21	0.23	0.260	0.112	0.129	5.01	6.01
	2nd	1.34	1.26	0.24	0.264	0.117	0.125	4.90	5.89
	3rd	1.25	1.25	0.24	0.253	0.109	0.120	4.67	5.59
Mean		1.29i	1.24i	0.24g	0.26i	0.11g	0.12	4.86b	5.83b
Humic acid+half dose of NPK	1st	1.41	1.39	0.26	0.290	0.124	0.135	5.23	6.28
	2nd	1.45	1.34	0.27	0.293	0.123	0.138	5.13	6.15
	3rd	1.37	1.38	0.26	0.282	0.120	0.132	4.87	5.84
Mean		1.41g	1.37g	0.26f	0.29g	0.12f	0.14d	5.08ab	6.09ab
magnetite+half dose of NPK	1st	1.53	1.50	0.28	0.315	0.135	0.147	5.32	6.39
	2nd	1.57	1.51	0.29	0.319	0.134	0.150	5.23	6.26
	3rd	1.48	1.45	0.29	0.304	0.131	0.144	4.97	5.94
Mean		1.53f	1.49f	0.29e	0.31f	0.13e	0.15c	5.17a	6.20a
Humic acid+magnetite +half dose of NPK	1st	1.69	1.49	0.29	0.323	0.138	0.151	5.33	6.39
	2nd	1.64	1.55	0.30	0.326	0.137	0.154	5.20	6.26
	3rd	1.53	1.54	0.29	0.315	0.134	0.148	4.97	5.96
Mean		1.62e	1.53e	0.29e	0.32e	0.14d	0.15c	5.17a	6.20a
Humic acid+full dose of NPK	1st	1.71	1.68	0.32	0.348	0.151	0.165	5.41	6.49
	2nd	1.77	1.70	0.33	0.359	0.152	0.168	5.30	6.36
	3rd	1.66	1.63	0.31	0.341	0.147	0.161	5.03	6.05
Mean		1.71c	1.67c	0.32c	0.35c	0.15c	0.16b	5.25a	6.30a
magnetite+full dose of NPK	1st	1.81	1.83	0.35	0.381	0.164	0.179	5.49	6.59
	2nd	1.92	1.85	0.35	0.389	0.166	0.183	5.37	6.45
	3rd	1.87	1.77	0.34	0.370	0.159	0.175	5.13	6.14
Mean		1.87b	1.82b	0.35b	0.38b	0.16b	0.18a	5.33a	6.39a
magnetite+humic acid +full dose of NPK	1st	1.94	1.82	0.35	0.392	0.169	0.184	5.55	6.66
	2nd	2.02	1.90	0.36	0.396	0.170	0.187	5.43	6.52
	3rd	1.87	1.88	0.36	0.381	0.164	0.180	5.20	6.19
Mean		1.94a	1.87a	0.36a	0.39a	0.17a	0.18a	5.39a	6.46a

Mean separation within columns by Duncan’s multiple range test, 5% level. Values that don’t share the same letter are significantly different.

Table (6): effect of magnetite, humic acid and their combinations under different levels of NPK on yeild of herb fresh weight g/plant and ton/feddan ,herb dry weight g/plant and ton/feddanand essential oil(E.O) yield l/feddan

Treatments	Herb fresh weight g/plant		Herb dry weight g/plant		Yeild fresh weight Ton/fad.		Yeild dry weight Ton/fad.		E.O yield	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Recommended dose of NPK (control)	129.6f	127.63f	27.23f	26.7f	3.564d	3.493d	0.75e	0.734d	7.69e	7.77e
50% of recommended dose of NPK	100.7h	98.7h	21.17h	20.73h	2.769f	2.714f	0.58f	0.57f	2.31g	2.22g
Soil without adding NPK	45.77l	44.83l	9.63l	9.43l	1.258i	1.23i	0.26h	0.26i	1.25h	1.26h
Humic acid	67.87k	66.50k	13.73k	13.43k	1.865h	1.83h	0.38fg	0.37h	2.24g	2.22g
magnetite	66.47j	65.10j	15.97j	15.60j	1.827h	1.79h	0.44f	0.43g	2.56g	2.64g
Humic acid+ magnetite	78.13i	76.60i	18.80i	18.40i	2.15g	2.11g	0.52f	0.51f	4.38f	4.37f
Humic acid+half dose of NPK	108.3g	119.17g	24.60g	24.10g	2.98e	2.98e	0.68e	0.66e	7.44e	7.37e
magnetite+half dose of NPK	135.3e	132.63e	32.50e	31.83e	3.72d	3.72d	0.89d	0.87d	8.36d	8.61d
Humic acid+magnetite +half dose of NPK	165.1d	161.80d	39.67d	38.87d	4.54c	4.54c	1.1c	1.2b	12.06c	12.04c
Humic acid+full dose of NPK	200.2b	196.23c	40.47c	39.63c	5.51a	5.51a	1.11c	1.09c	16.70b	16.53b
magnetite+full dose of NPK	190.7c	186.87b	45.77b	44.87b	5.24b	5.24b	1.29b	1.23b	16.20b	16.69b
magnetite+humic acid +full dose of NPK	200a	221.07a	54.10a	53.07a	5.5a	5.5a	1.49a	1.46a	20.25a	20.21a

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different

Table (7): effect of magnetite, humic acid and their combinations under different levels of NPK on essential oil(E.O) components of basil plants.

treatment	1.8-cineole	linalool	α- terpineol	Bornyl acetate	estragole	Trans- a bergamotene	Germacrene-D	Alfa-copaene	Eugenol
Control	12.6	43	1.57	1.03	16.4	5.19	2.2	5.3	7.57
50%	12.31	42.5	1.54	0.98	16.21	5.14	2.17	5.09	7.4
0 NPK	11.9	42.04	1.52	0.97	16.04	5.1	2.03	5	7.2
Humic acid	13.16	44.18	1.17	2.13	17.94	4.69	1.5	3.2	8
Magnetite	13.74	44.93	1.13	2.15	18.21	4.61	1.46	2.94	8.3
Humic +magnetite	13.79	45.15	1.03	2.36	18.3	4.5	1.37	2.74	8.4
Humic acid+50%	13.1	43.29	1.15	2.31	17.83	4.8	1.5	2.64	7.69
Magnetite +50%	13.67	44.81	1.18	2.34	18.07	4.68	1.49	3	8.12
Humic +magnetite +50%	13.81	44.96	1.12	2.30	18.24	4.63	1.47	2.71	8.22
Humic Acid +100%	13	43	1.06	2.07	17.54	4.9	1.36	2.47	7.48
Magnetite +100%	13.5	44.67	1.34	2	18.2	4.1	1.13	2.05	8.1
Humic acid +magnetite +100 NPK	13.6	44.9	1.04	2.1	18	4.15	1.06	2	8.19

4. Conclusion:

In conclusion, magnetite and humic acid had significant effects on vegetative growth, herb fresh and dry weight and essential oil of basil plants. The results of this work showed that, using humic acid with magnetite under half dose (50%) of recommended NPK conditions improved the yield and other vegetative growth parameters and yield component compared with the plants fertilized with full recommended dose of NPK only. Also using magnetite with half dose of NPK was significantly higher in all parameters compering with humic acid under the same conditions. Therefore it could be concluded that, the chemical fertilizers of NPK could be reduced by using humic acid and magnetite mixture for improving the quality of the produced herb and decreased the environmental pollution.

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دراسة تأثير كل من حامض الهيوميك والماجنيتيت على النمو والمحصول وجودة الزيت لنباتات الريحان النامية تحت مستويات مختلفة من التسميد الكيماوى.

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** المعمل المركزى للمناخ الزراعى- مركز البحوث الزراعية بالجيزة

أجريت تجربتان فى المعمل المركزى للمناخ الزراعى . مركز البحوث الزراعية بالدقى محافظة الجيزة. مصر خلال موسمين متتاليين ٢٠١٢و٢٠١٣ لدراسة تأثير كل من حامض الهيوميك وخام الماجنيتيت على نمو وإنتاجية والتركيب الكيماوى لنبات الريحان تحت مستويات مختلفة من التسميد الكيماوى (بدون تسميد و نصف جرعة التسميد الموصى بها و الجرعة الموصى بها من التسميد الكيماوى). وأظهرت النتائج المتحصل عليها أن إستخدام الماجنيتيت والهيوميك أسيد معا تحت ظروف التسميد الكيماوى الكامل كان ذو تأثير إيجابى على كل الصفات الخضرية والمحصول والتركيب الكيماوى لنبات الريحان ونسبة الزيت فى العشب الطازج مقارنة بالمعاملات الأخرى. وأظهرت النتائج أن إستخدام حامض الهيوميك مع الماجنيتيت إضافة الى نصف التسميد الكيماوى الموصى به أعطت نتائج أفضل من النباتات المسمدة بالجرعة الموصى بها من التسميد الكيماوى فقط.