African Journal of Biotechnology Vol. 10(29), pp. 5587-5592, 22 June, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.2199
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

The effect of different replications of humic acid fertilization on yield performances of common vetch (*Vicia sativa* L.)

Veysel Saruhan[1]*, Alpaslan Kusvuran[2] and Kagan Kokten[3]

[1]Field Crops Departments, Faculty of Agriculture, Dicle University, Diyarbakir, Turkey.
[2]Kizilirmak Vocational High School, Cankiri Karatekin University, Kizilirmak, Cankiri, Turkey.
[3]Field Crops Departments, Faculty of Agriculture, Bingol University, Bingol, Turkey.

Accepted 19 May, 2011

This study was conducted in a randomized complete block design with three replications in Diyarbakir, Turkey, in 2003 to 2004 and 2004 to 2005 growing seasons, in order to determine the effects of different humic acid treatments (control, soil 100%, seeds 100%, leaves 100%, soil 50% + seeds 50%, soil 50% + leaves 50%, seeds 50% + leaves 50% and seeds 33% + soil 33% + leaves 33% fertilizations) on herbage and crude protein concentration of common vetch. According to the results of this study, humic acid treatments increased the yields, and this increase was found to be significant as well as statistical. According to the two-year research, the highest value for green herbage yield (15180 kg ha^{-1}), dry herbage yield (3045 kg ha^{-1}) and plant height (61 cm) was obtained from soil 100% fertilizations, while the highest crude protein concentration (13.43%) was obtained from seeds 33% + soil 33% + leaves 33% fertilizations.

Key words: Crude protein, fertilization, fulvic acid, humic acid and vetch.

INTRODUCTION

Crop production is the basis of certain nutrients for human life and it depends on the amount of available nutrient in soil. Organic matter is fundamental in soil, but it is the dynamic component of soils that influences the many chemical, physical and biological properties that regulate soil productivity. The objective of this study, using humic substances in plant, was to balance vegetative and reproductive growth, as well as to improve herbage and protein yield. To improve the organic contents of soils for growing crops, there are some applications, such as planting rotation, various plough techniques, green fertilizer application and animal fertilizer application. In addition to these practices, utilization of organic-mineral fertilizers in agriculture has increased in recent years (Doran et al., 2003).

One of the used organic-mineral fertilizers is the humic acid. Humic acid is one of the major components of humic substances. Humic matter is formed through the chemical and biological humification of plant and animal matter and through the biological activities of microorganisms (Anonymous, 2010). The effects of humic substances on plant growth depend on the source and concentration, as well as on the molecular fraction weight of humus. Lower molecular size fraction easily reaches the plasma lemma of plant cells, determining a positive effect on plant growth, as well as a later effect at the level of plasma membrane, that is, the nutrient uptake, especially nitrate. The effects seen on the intermediary metabolism are less understood, but it seems that humic substances may influence both respiration and photosynthesis (Nardi et al., 2002).

Humic substances have a very strong influence on the growth of plant roots. When humic and fulvic acids are applied on the soil, enhancement of root initiation and increased root growth may be observed (Pettit, 2004). The stimulatory effects of humic substances have been directly correlated with the enhanced uptake of macronutrients, such as nitrogen, phosphorus and sulfur (Chen and Aviad, 1990), and micronutrients, such as Fe, Zn, Cu and Mn (Chen et al., 1999).

*Corresponding author. E-mail: veysel_saruhan@hotmail.com. Tel: + 90 412 248 85 09 / 8538 or + 90 506 628 98 31. Fax: + 90 412 248 81 53.

Humic substances have been reported to influence plant growth both directly and indirectly. The indirect effects of humic compounds on soil fertility include: (i) Increase in the soil microbial population including beneficial microorganisms, (ii) Improved soil structure and (iii) Increase in the cation exchange capacity and the pH buffering capacity of the soil. Directly, humic acid compounds may have various biochemical effects either at cell wall, membrane level or in the cytoplasm, including increased photosynthesis and respiration rates in plants, enhanced protein synthesis and plant hormone-like activity (Chen and Aviad, 1990). Humic substances may possibly enhance the uptake of minerals through the stimulation of the microbiological activity (Mayhew, 2004). When adequate humic substances are present within the soil, the requirement for nitrogen, phosphorus and potassium fertilizer applications may be reduced (Pettit, 2004). Humic substances are major components of organic matter, often constituting 60 to 70% of the total organic matter (Schnitzer and Khan, 1972). Increased feed requirements for an expanding Turkish livestock population necessitated the introduction of forage legumes into crop rotations (Firincioglu et al., 2007). The common vetch (*Vicia sativa* L.) is a leguminous, annual, commonly used forage in the Mediterranean basin and Turkey, and is grown over the largest area, in rotation with winter cereal small grains, under rain-fed conditions. However, an attempt should be made to discern which doses and application forms of plant regulators can be used, with accurate application forms and doses, to achieve an increase in efficiency.

In this study, we aimed to determine the most appropriate application of humic acid for common vetch breeding as yield and yield components. In this regard, humic acid fertilizer application in the production of common vetch which is known to be more efficient in terms of production would serve as a resource.

MATERIALS AND METHODS

This study was carried out in Diyarbakir, Turkey (lat 37°54′N, long 40°14′E, and altitude of about 660 m). Generally, the Mediterranean and East Anatolian continental climates are dominant in this region. The average annual temperature is 15.8°C, the total rainfall is 481.6 mm and the average relative humidity is about 53.8%. The average temperature can reach 30°C in July and August, while the lowest average temperature can reach 7°C in December and January. The earliest frost in the region is usually at the end of October, while the last frost is around the end of April. Most rainfalls occur in winter, and there is almost no rainfall from July to September. The highest humidity (70%) occurs in winter, while the lowest (27%) occurs in summer. However, there is no important difference in the average climate data between the years of the experiments and the long-term average. The soils of the experimental area comprise thinly structured alluvial material or limestone; although, the soil is low as regards organic material and phosphorus and it has adequate calcium and high clay content (49 to 67%) in the 0 to 150 cm profile. The treatment material used in this study is liquid humic acid [humic (40%) and fulvic acid (25%)]. Thus, humic acid was applied to eight different treatments (Control, Soil 100%, Seeds 100%, Leaves 100%, Soil 50% + Seeds 50%, Soil 50% + Leaves 50%, Seeds 50% + Leaves 50% and Seeds 33% + Soil 33% + Leaves 33% fertilizations). The experiments were laid out in randomized blocks trial design with three replications in the 2003 to 2004 and 2004 to 2005 growing seasons. In this study, a local variety of common vetch was used as the material. In both years and trials, sowings were made based on the calculation of 120 kg ha^{-1} during the second week of October.

Treatments

Control: Any fertilizer application was made to these plots.
Soil 100%: 450 g of fertilizer were applied to the soil in these plots; and all the fertilizers that were applied to the soil were administered three times at 15 days intervals.
Seeds 100%: 300 g of fertilizer were applied to the seed in these plots; and all the fertilizers to the seed were applied to sowing.
Leaves 100%: 150 g of fertilizer were applied to the leaf in these plots; and all the seed fertilizers were administered three times at 15 days intervals. The first fertilization was performed when plants were 10 cm length.
Seeds 50% + Soil 50%: Firstly, 150 g of the fertilizer were applied to the seeds and then, 225 g of fertilizer were applied to the soil three times at 15 days intervals.
Seeds 50% + Leaves 50%: At first, 150 g of fertilizer were applied to seeds, and then 75 g of fertilizer were applied to the leaf three times at 15 days intervals.
Soil 50% + Leaves 50%: 225 g of fertilizer were applied to soils, and 75 g of fertilizer were applied to leaves, three times at 15 days intervals.
Seeds 33%+Soil 33%+Leaves 33%: At first, 100 g of fertilizer were applied to seed at sowing, and then 150 g were applied to soil and 50 g were applied to the leaf, three times at 15 days intervals.

Fundamentally, green herbage yields, dry herbage yields, plant height and crude protein concentrations were investigated in this study. Analysis of variance was done by using a MSTAT-C statistic program and the differences were compared by the LSD test (MSTAT-C, 1991).

RESULTS

Green herbage yields (kg ha^{-1})

The differences between treatments with respect to the green herbage yield of common vetch were found to be significant for average years. As such, the data of the first and second growing seasons were found to be non-significant (Table 1).

In the 2003 to 2004 and 2004 to 2005 growing seasons, the highest green herbage yields were obtained from the treatment of Soil 100% (14630 and 15730 kg ha^{-1}), while the lowest green herbage yields were obtained from the control (11730 and 12130 kg ha^{-1}). When the average of over two years was calculated, the treatment of Soil 100% gave a significantly higher green herbage yield (15180 kg ha^{-1}) than the other treatments.

Dry herbage yields (kg ha^{-1})

The differences between treatments with respect to the

Table 1. Green herbage yields (kg ha^{-1}) of common vetch in the 2003 to 2004 and 2004 to 2005 growing seasons.

Treatment	2003-2004	2004-2005	Average
Control	11730	12130	11930^{c}
Seeds 100%	12630	13530	13080^{bc}
Soil 100%	14630	15730	15180^{a}
Leaves 100%	13830	14850	14340^{ab}
Seeds 50% + Soil 50%	12870	13770	13320^{bc}
Seeds 50% + Leaves 50%	13500	13950	13725^{ab}
Soil 50% + Leaves 50%	13200	14970	14085^{ab}
Seeds 33% + Soil 33% + Leaves 33%	13030	14400	13715^{ab}
LSD	N.S.	N.S.	1750*
CV %	8.71	12.35	10.82

*: Means having same letter in the same column are non-significantly different (P<0.05); **: means having same letter in the same column are non-significantly different (P<0.01).

Table 2. Dry herbage yields (kg ha^{-1}) of common vetch in the 2003 to 2004 and 2004 to 2005 growing seasons.

Treatment	2003-2004	2004-2005	Average
Control	2460	2460	2460^{c}
Seeds 100%	2580	2670	$2625b^{c}$
Soil 100%	2890	3200	3045^{a}
Leaves 100%	2770	2900	2835^{ab}
Seeds 50% + Soil 50%	2600	2730	2665^{bc}
Seeds 50% + Leaves 50%	2670	2780	2725^{bc}
Soil 50% + Leaves 50%	2650	2990	2820^{ab}
Seeds 33% + Soil 33% + Leaves 33%	2620	2880	2750^{ac}
LSD	N.S.	N.S.	307.2*
CV %	9.16	9.73	9.47

*: Means having same letter in the same column are non-significantly different (P< 0.05); **: means having same letter in the same column are non-significantly different (P< 0.01).

dry herbage yield of common vetch were found to be significant for average years. As such, the data of the first and second growing seasons were found to be non-significant (Table 2).

In the 2003 to 2004 and 2004 to 2005 growing seasons, the highest dry herbage yields were obtained from the treatment of Soil 100% (2890 and 3200 kg ha^{-1}), while the lowest dry herbage yields were obtained from the control in both years (2460 kg ha^{-1}). When the average of over two years was calculated, the treatment of Soil 100% gave a significantly higher dry herbage yield (3045 kg ha^{-1}) than the other treatments.

Plant height (cm)

The differences between treatments with respect to the plant height value of common vetch were found to be significant for each of the two growing seasons and the average of these years (Table 3).

In the first growing season, the treatment of Leaf 100% gave significantly higher plant height (59 cm) than the control (50 cm). However, in the second growing season and the average of two years, the treatment of Soil 100% gave significantly higher plant height (64 and 61 cm, respectively) than the control (51 and 50.5 cm, respectively).

Crude protein concentration (%)

The differences between treatments, with respect to the crude protein concentration of common vetch, were found to be significant for the first growing season and the average of these years (Table 4).

Both in the first and second growing season, the treatment of 100% Seed gave significantly higher crude protein concentration (13.21% and 13.24%) than the other treatments. However, when the average of two years was calculated, the treatment of Seeds 33% + Soil 33% + Leaves 33% gave significantly higher crude

Table 3. Plant height (cm) of common vetch in the 2003 to 2004 and 2004 to 2005 growing seasons.

Treatment	2003-2004	2004-2005	Average
Control	50[b]	51[c]	50.5[c]
Seeds 100%	56[a]	60[ab]	58.0[ab]
Soil 100%	58[a]	64[a]	61.0[a]
Leaves 100%	59[a]	62[ab]	60.5[ab]
Seeds 50% + Soil 50%	55[a]	58[ab]	56.5[ab]
Seeds 50% + Leaves 50%	55[a]	60[ab]	57.5[ab]
Soil 50% + Leaves 50%	56[a]	57[bc]	56.5[b]
Seeds 33% + Soil 33% + Leaves 33%	55[a]	58[ab]	56.5[b]
LSD	4.8*	6.3**	4.3**
CV %	4.95	4.41	4.67

*: Means having same letter in the same column are non-significantly different (P< 0.05); **: means having same letter in the same column are non-significantly different (P < 0.01).

Table 4. Crude protein concentration (%) of common vetch cultivars in the 2003 to 2004 and 2004 to 2005 growing seasons.

Treatment	2003-2004	2004-2005	Average
Control	11.53[c]	11.67[d]	11.60[c]
Seeds 100%	13.21[a]	13.24[ab]	13.23[a]
Soil 100%	12.21[bc]	12.48[bd]	12.35[bc]
Leaves 100%	12.95[ab]	13.30[ab]	13.13[a]
Seeds 50% + Soil 50%	12.81[ab]	12.01[cd]	12.41[b]
Seeds 50% + Leaves 50%	13.02[ab]	12.77[bc]	12.90[ab]
Soil 50% + Leaves 50%	12.96[ab]	12.57[bc]	12.77[ab]
Seeds 33% + Soil 33% + Leaves 33%	13.03[ab]	13.83[a]	13.43[a]
LSD	0.98*	1.07**	0.80**
CV %	4.39	3.44	3.94

*: Means having same letter in the same column are non-significantly different (P < 0.05); **: means having same letter in the same column are non-significantly different (P < 0.01).

protein concentration (13.43%) than the control (11.60%).

DISCUSSION

Improvement of soil conditions and establishing equilibrium among plant nutrients are also important for soil productivity and plant production. Humic substances and organical improvement of soil increased the yields of some field crops in several studies (Ulukan, 2008). Studies on the effects of humic substances on plant growth, showed improved effects on growth, independent of nutrition (Chen and Aviad, 1990; Dursun et al., 1999; Aydin et al., 1999; Dursun et al., 2002). Duplessis and Mackenzie (1983) found that the grain yield of legumes, such as mung bean (mash bean=moong) (*Vigna radiata* L.), soybean (*Glycine max* L.) and pea (*Pisum sativum* L.) (Iswaran et al., 1980), increased by the use of these humic substances. Some researchers found that humic acid increased the yields in some plants. Studies have shown that this substance has caused yield increase of 22 to 23% (Adani et al., 1998) and 36.3% (Togun and Akanbi, 2003) in tomato, 32.5 to 42.5% in maize (Tan and Binger, 1986), 10 to 30% in cotton (Ulukan, 2008) and 15 to 100% in grass (Zhang, 1997). It was reported that the increase in grain yield was believed to be due to phenolic compounds that were toxic to soil bacteria and protozoa that were antagonistic towards *Rhizobium* species (Bhardwaj and Gaur, 1971), but some study results were different from them. According to their results, this application was ineffective in maize and bean yields (Adriano et al., 1978), and in the yield and quality of potatoes (Rowberry and Collin, 1977). These studies have been conducted on the Fe and Al densely soils, so this type of soil inactivates the effect of the humic acid. However, Tan and Nopamornbodi (1979) found that humic acid decreased the P concentration in maize plants. The researcher explained that this situation was due to the reaction of P with the phenolic functional groups on the humic acid ion. Studies have shown that humic acid are capable of forming complexes with P that are unavailable to the plant. Nonetheless, phosphorus is very important in the early seedling development phase of most vegetable and row crops. Moreover, Yan et al. (2009) reported positive correlation between humic acid content and seedling growth. They found that humic acid content had remarkable effect on tobacco seedling growth, while the rate of emergence and quality of tobacco seedling would be reduced when humic acid content was greater than 60%.

Yaofu (2005) found that the application of humic acid increased the content of N, P, K and Fe in tobacco plant. Furthermore, with the increase of humic acid, the yield, high quality leaf ratio and the content of nicotine in the cured leaves increased, and the content of reducing sugar decreased, but the difference in the content of total nitrogen was not significant. Paksoy et al. (2010) have found out that humic substances played a major role in plant nutrient uptake and growth parameters in plant seedlings. The results of this study showed that K and humic acid have a great potential to increase the performance, growth and mineral contents of okra plant.

Albayrak and Camas (2005) obtained the highest root and leaf dry matter yields from the 1200 ml ha^{-1} humic acid level and after two months of sowing date application onto leaves in forage turnip (*Brassica rapa* L.) crop. Foliar spray with humic acid also increased root length (Malik and Azam, 1985) and leaf area index (Figliolia et al., 1994). Van Dyke et al. (2009) reported that the addition of humic acid did not result in an increased tissue concentration of nutrients in the creeping bentgrass, top growth or dry shoot mass when compared with the other treatments. However, creeping bentgrass root length was greater in the greens treated with humic acid when compared with the untreated control.

Kolsarici et al. (2005) discovered that 60 g of humic acid per 100 seeds were the highest values for all criteria and they recommended that this ratio could be used for all cultivated sunflower (*Helianthus annus* L.) varieties.

Erdal et al. (2000) reported that the dry weight, plant P concentration, P uptake and residual available P amount increased with humic acid applications, and that the effect of humic acid on these parameters when combined with P fertilization was higher than that of humic acid alone. Oren and Basal (2006) reported that the application method of humic acid had no significant effect on the investigated characters; however, application dose had significant and positive effect on earliness, one hundred seed weight, boll weight and yield and the best result was obtained by underground application via a dose of 2000 g ha^{-1} in cotton (*Gossypium hirsutum* L.). Kaya et al. (2005) reported that a combination of zinc and foliar humic acid or zinc and separate applications increased the grain yield of bread wheat as compared to the control; whereas Siviero et al. (1996) determined that when humic acid was applied to the soil, it led to increase in the plant growth. Saruhan et al. (2011) obtained that the highest plant heights (73 cm), bunch lengths (25.05 cm), grain yields (46.11 kg ha^{-1}), 1000 grain-weights (5.58 g), crude protein concentrations (9.95%) and grain number per bunch (904 item) were from leaves 100% humic acid fertilization in common millet. However, they reported that humic acid treatments increased the yield and yield components.

Conclusion

When looking into the two years average values, different humic acids applications significantly and statistically affected the investigated characters, which caused an increase in the plots when compared to the control plots.

It was determined that the Soil 100% humic acid applications when compared to the control increased the herbage yield (27.2%), dry herbage yield (23.7%), plant height (20.8%) and crude protein concentration (10.65%), respectively. In this study, application of humic acid increased the concentration of the crude protein level from 10.65 to 11.58%. The highest growth rate of 11.58% in Seeds 33%+Soil 33%+Leaves 33% applications has been obtained, and the applications of Seed 100% (11.41%) and Leaf 100% (11.32%) followed these applications.

According to the results of this study, humic acid treatments increased the yields, and this increase was found to be significant as well as statistical. The highest value for green, dry herbage yields and plant heights were obtained from 100% soil fertilizations and the highest crude protein concentration was obtained from Seeds 33%+Soil 33%+Leaves 33% fertilizations.

REFERENCES

Adani F, Genevini P, Zaccheo P, Zocchi G (1998). The effect of commercial humic on tomato plant growth and mineral nutrition. J. Plant Nut. 21: 561-575.

Adriano DC, Woodford TA, Ciravolo TG (1978). Growth and elemental composition of corn and bean seedlings as influenced by soil application of coal ash. J. Environ. Quality, 7: 416-421.

Albayrak S, Camas N (2005). Effects of different levels and application times of humic acid on root and leaf yield and yield components of forage turnip (*Brassica rapa* L.). J. Agron. 4(2): 130-133.

Anonymous (2010). Humic and fulvic acids: The black gold of agriculture? http://www.humintech.com/pdf/humicfulvicacids.pdf (Access date: 10.08.2010)

Aydin A, Turan M, Sezen Y (1999). Effect of fulvic-humic acid application on yield and nutrient uptake in sunflower and corn. Improved Crop Quality by Nutrient Management. Kluwer Acedemic Publishers Dordrecht. Boston. London. pp. 249-252.

Bhardwaj KK, Gaur AC (1971). Studies on the growth stimulating action of humic acid on bacteria. bakteriol parasitenkd. Infektionskr. Hyg. Abt. 2. 126(7): 694-699.

Chen Y, Aviad T (1990). Effects of humic substance on plant growth. In MacCarthy, CE Clapp, RL Malcolm, PR Bloom (eds.). Humic substances in soil and crop sciences: Selected readings. Soil Sci. Society of America. Madison. Wisconsin. pp. 161-186.

Chen Y, Clapp CE, Magen H, Cline VW (1999). Stimulation of plant growth by humic substances: Effects on iron availability. In:

Ghabbour EA, Davies G (eds.). Understanding humic substances: Advanced methods, properties and applications. R. Soc. Chem. Cambridge. UK, pp. 255-263.
Doran I, Akinci C, Yildirim M (2003). Effects of delta humate applied with different doses and methods on yield and yield components of Diyarbakir-81 wheat cultivar. 5th Field Crops Congress. Diyarbakir. Turkey, 2: 530-534 (in Turkish with English abstracts).
Duplessis GL, Mackenzie AF (1983). Effect of leonardite applications on phosphorus availability and corn growth. Can. J. Soil Sci. 63: 749-751.
Dursun A, Guvenc I, Turan M (1999). Macro and micro nutrient contents of tomato and eggplant seedlings and their effects on seedling growth in relation to humic acid application. Improved Crop Quality by Nutrient Management. Kluwer Acedemic Publishers Ordrecht. Boston. London.
Dursun A, Güvenç I, Turan M (2002). Effects of different levels of humic acid on seedling growth and macro and micronutrient contents of tomato and eggplant. Acta Agrobotanica, 56(2): 81-88.
Erdal I, Bozkurt MA, Cimrin KM, Karaca S, Saglam M (2000). Effects of humic acid and phosphorus applications on growth and phosphorus uptake of corn plant (*Zea mays* L.) grown in a calcareous soil. Turkish J. Agric. For. 24: 663-668 (in Turkish with English abstracts).
Firincioglu HK, Tate M, Unal S, Dogruyol L, Ozcan I (2007). A selection strategy for low toxin vetches, Turk. J. Agric. For. 31: 303-311.
Figliolia A, Benedetti A, Izza C, Indiati R, Rea E, Alianiello F, Canali S, Biondi FA, Pierandrei F, Moretti R (1994). Effects of fertilization with humic acid on soils and plant metabolism: A multidisciplinary approach. Note I: Crop production. Humic substances in the global environment and implications on human health, proc. 6th Int. Meet. of the Int. Humic Subst. Soc., Elsevier Publ. Amsterdam. The Netherlands, pp. 579-584.
Iswaran V, Jauhri KS, Sen A (1980). Effect of charcoal, coal, and peat on the yield of moong, soybean, and pea. Soil Biol. Ciochem. 12: 191-192.
Kaya M, Atak M, Ciftci CY, Unver S (2005). Effects of zinc and humic acid applications on yield and some yield components of bread wheat (*Triticum aestivum* L.). Süleyman Demirel University J. Graduate School Natural Appl. Sci., 9(3), (in Turkish with English abstracts).
Kolsarici O, Kaya MD, Day S, Ipek A, Uranbey S (2005). Effects of humic acid doses on emergence and seedling growth of sunflower (*Helianthus annuus* L.). Akdeniz University J. Agric. Faculty, Antalya. Turkey. 18(2): 151-155.
Malik KA, Azam F (1985). Effect of humic acid on wheat (*Triticum aestivum* L.) Seedling Growth. Environ. Exp. Bot. 25: 245-252.
Mayhew L (2004). Humic substances in biological agriculture [Online]. Available at www.acresusa.com/toolbox/reprints/Jan04_Humic%20Substances.pdf(2004).
Mstat-C (1991). A microcomputer program for design management and analysis of agronomic research experiments. Michigan State Univ., East Lansing, MI, USA.
Nardi S, Pizzeghello D, Muscolo A, Vianello A (2002). Physiological effects of humic substances in plant growth. Soil Biol. Biochem. 34(11): 1527-1536.
Oren Y, Basal H (2006). The effect of humic acid and zinc (Zn) application on yield, yield components and fiber quality parameters in cotton (*Gossypium hirsutum* L.). Adnan Menderes University J. Agric. Faculty, 3(2): 77-83.
Paksoy M, Turkmen O, Dursun A (2010). Effects of potassium and humic acid on emergence, growth and nutrient contents of okra (*Abelmoschus esculentus* L.) seedling under saline soil conditions. Afr. J. Biotechnol. 9(33): 5343-5346.
Pettit RE (2004). Organic matter, humus, humate, humic acid, fulvic acid and humin: Their importance in soil fertility and plant health [Online]. Available at www.humate.info/mainpage.htm.
Rowberry RG, Collin GH (1977). The effects of humic acid derivates on the yield and quality of kennebec and sebago potatoes. Am. Potato J. 54: 607-609.
Schnitzer M, Khan SU (1972). Humic substances in the environment. Dekker Publ. New York, NY.
Saruhan V, Kusvuran A, Babat S (2011). The effect of different humic acid fertilization on yield and yield components performances of common millet (*Panicum miliaceum* L.). Sci. Res. Essays, 6(3): 663-669.
Siviero P, Sandei L, Colombi A (1996). Results of applying leonardite and humic acid to processing tomatoes, Informarore Agrario, 52: 57-60.
Tan KH, Nopamornbodi V (1979). Effect of different levels of humic acids on nutrient content and growth of corn (*Zea mays* L.). Plant Soil. 51: 238-287.
Tan KH, Binger A (1986). Effect of humic acid on aluminium toxicity in corn plants. Soil Sci. 141: 20-25.
Togun AO, Akanbi WB (2003). Comparative effectiveness of organic-based fertilizer to chemical fertilizer on tomato growth and fruit yield. Compost Sci. Utilization, 11(4): 337-342.
Ulukan H (2008). Humic acid application into field crops cultivation. Kahraman Maras Sutcu Imam University J. Sci. Eng. 11(2): 119-128.
Van Dyke A, Johnson PG, Grossl PR (2009). Influence of humic acid on water retention and nutrient acquisition in simulated golf putting greens. Soil Use Manage. 25(3): 255-261.
Yan J, YuPing W, YuQi D, YuHong Y, Jia P (2009). Effect of humic acid of media on tobacco seedling-growing in float tray system. Southwest China J. Agric. Sci. 22(1): 122-125.
Yaofu W (2005). Effect of irrigation and rate of humic acid on concentration of nutrients and yield and quality of flue-cured tobacco. J. Anhui Agrıc. Sci. 33(1): 96-97.
Zhang X (1997). Influences of plant growth regulators on turfgrass growth, antioxidanth status, and drought tolerance. PhD. Diss. Virginia Polytechnic Ins. and State State Univ. Blacksburry, USA.