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# Effect of Humic Substances Extracted from Compost and Different Rates of Mineral Fertilization on Growth and Yield of Potato Plants Grown in Sandy Soil

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**Abstract:** This study was performed to evaluate the application of humic substances with N, P and K fertilizers on growth and quantity and quality yield and nutritional status of potato (*Solanum tuberosum*, L. cv Spunta) grown on sandy soils. So, field experiment was carried out at the experimental farm of the Agricultural Research Station, National research center, El-Nubaria district, Egypt during the two early growing seasons of summer 2020 and 2021. Humic substances were extracted from the compost, which was made from vegetable farm wastes. Extraction and purification of humic substances from compost were based on the traditional extraction method (International humic acid substances society, IHSS- $N_2$ method). The used experimental design was a split-plot design with three replicates. Main plots were assigned to the two rates of humic substances (25 and 50 L $fed^{-1}$). While, sub treatments were presented three minerals fertilization levels (100, 75 and 50 %), 100 % recommended chemical NPK fertilizer dose which is 200 kg N, 45 kg $P_2O_5$ and 85 kg $K_2O$ $fed^{-1}$ as recommended by Ministry of Agriculture. The results showed that increasing the addition doses of humic substances from 25 to 50 L $fed^{-1}$ led to a significant increase in growth and yield parameters with an increase in mineral fertilization rates from 50 to 100%. The use of 100% mineral fertilization gave the best values obtained from the chlorophyll content of the leaves and the starch and protein content of the tubers, but with the increase in the rates of humic substances used from 25 to 50 L $fed^{-1}$. Addition of humic substances (50 L $fed^{-1}$) to 50% and 75 % of mineral fertilization positively increased N, P and K content of potato tubers at two seasons of growth. it can be said that it is possible to reduce the total cost and reduce environmental pollution as a result of excessive mineral fertilization and thus more profitability with the use of humic substances, especially at a rate of 50 liters per feddan with irrigation water.

**Key words:** Potato plants · Growth · Yield · Nutritional state · Humic substances · Mineral fertilization

## INTRODUCTION

Potato (*Solanum tuberosum*, L.) is one of the important vegetables in Egypt for both local consumption and exportation [1]. Potato is a major source of inexpensive energy; it contains high levels of carbohydrates, the predominant form of this carbohydrate is starch and amounts of vitamins B and C [2].

The recycling of waste by composting is a promising solution and has become the aim of waste managers the world over during composting, part of the organic matter is mineralized to yield carbon dioxide, ammonia and water, while the remainder is transformed into humic substances [3]. Interestingly humic acids from mature compost usually have molecular sizes smaller than those extracted from fossil or soil samples. This is because composting does not allow the formation of humic acids of high molecular weight, because the humification time is too short for the synthesis of poly condensed molecules. There are several methods for extraction of humic substances, using different extraction reagents because of the contact air with humic substances material under alkaline condition, a new method like international humic acid substances society (IHSS) was established [4].

Humic substances are organic materials formed and manufactured during the process of physical, chemical and microbiological transformation of various wastes, whether animals or plants. Humic substances consist of

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some elements and are essential in their composition, namely carbon, hydrogen, oxygen, nitrogen and sulfur. Humic substances can be divided into three components: humic acids, fulvic acids and humin. One of the most important parts of humic substances is humic acid. Humic acid and fulvic acid represent alkali-soluble humus fragments, humin represents the insoluble residue [5].

Humic substances played an important role in various agricultural activities, as they have an effective role on the physical and chemical properties of soil and its fertility [6] and [7]. The humic substances affect the growth of plants [8] and [9] and the quality and quantity of productivity of different agricultural crops [10, 11].

The paper aimed to extract humic substances from compost and use it at different rates with different levels of mineral fertilization on the growth, yield and nutritional state of potato plants grown in sandy soil during two successive growing seasons.

## MATERIALS AND METHODS

This study was carried out in the Agricultural Research Station, National Research Centre, El-Nubaria district, Egypt (latitude 30°8/ N and longitude 30°16/ E and mean altitude 21 m above sea level), during the two early growing seasons of summer 2020 and 2021to investigate the response of potato(*Solanum tuberosum,* L. cv Spunta) to different rates of humic substances and various levels of mineral fertilization on growth and yield parameters of potato plants.

Potato pieces were cultivated on 15 February 2020 and 17 February 2021. Spacing between plants in rows was 0.25 m at two growth seasons. Soil samples were taken before planting at two growing seasons. Some physical and chemical properties at two seasons of El-Nubaria soil were illustrated in Table (1) according to Hesse [12].

Humic substances were extracted from the compost, which was made from vegetable farm wastes. Extraction and purification of humic substances from compost were based on the traditional extraction method (International humic acid substances society, IHSS- $N_2$method), this method was described by Andelkovic *et al*. [13]. Chemical properties of the tested humic substances were measured according to the standard methods described by Cottenie, [14].

The used experimental design was a split-plot design with three replicates. Main plots were assigned to the two rates of humic substances (25 and 50 L $fed^{-1}$). While, sub treatments were presented three minerals fertilization levels (100, 75 and 50 %), 100 % recommended chemical NPK fertilizer dose which is200 kg N, 45 kg $P_2O_5$ and 85 kg $K_2O$ $fed^{-1}$ as recommended by Ministry of Agriculture.

A random sample of four plants was taken from each experimental unit to determine the growth parameters, *i.e.* (plant length "cm" and number of leaves).

At harvesting time (115 days from planting), a representative sample of 10 tubers from each experimental plot was selected from the larger sizes to obtain the quantity and quality of potato yield (number of tubers, tuber weight, length and diameter).

To determine N, P and K concentrations in tuber tissues of potato, samples were taken from each plot, dried at 70° and grounded using stainless steel equipment. From each sample, 0.2 g was digested using 5 cm3 from the mixture of sulfuric ($H_2SO_4$) and perchloric (HClO) acids (1:1) as described by [15]. Total chlorophyll was determined in representative fresh leaves samples according to Moran [16]. Soluble starch content was determined following Malik and Srivastava [17].

The data were subjected to the proper statistical analysis of split-split plot design using(MSTAT-C Software package). Since the data in both seasons took similar trends, Bartlett's test was applied and the combined analysis of the data was done. For means comparison, Least Significant Difference (LSD) at 5% level was applied [18].

Table 1: Some physical and chemical properties of the soil used

| | | Values | |
|---|---|---|---|
| Soil properties | | First season | Second season |
| Particle size distribution (%) | Sand | 92.32 | 93.0 |
| | Silt | 5.68 | 4.56 |
| | Clay | 2.00 | 2.44 |
| | Texture | Sandy soil | Sandy soil |
| $CaCO_3$ (%) | | 2.11 | 2.14 |
| pH (1:2.5 soil suspension) | | 7.80 | 7.70 |
| EC (dS $m^{-1}$) | | 1.60 | 1.92 |
| Soluble caions (mmol $L^{-1}$) | $Ca^{++}$ | 6.02 | 8.96 |
| | $Mg^{++}$ | 3.97 | 3.16 |
| | $Na^{+}$ | 3.64 | 5.20 |
| | $K^{+}$ | 2.37 | 1.88 |
| Soluble anions (mmol $L^{-1}$) | $CO_3^{--}$ | - | - |
| | $HCO_3^{-}$ | 0.64 | 0.64 |
| | $Cl^{-}$ | 4.10 | 7.82 |
| | $SO_4^{--}$ | 6.02 | 10.74 |
| Available nutrients mg $kg^{-1}$ | N | 32.2 | 28.5 |
| | P | 4.05 | 4.00 |
| | K | 88.6 | 58.5 |

Table 2: Chemical properties of humic substances

| Sample | pH | EC $dSm^{-1}$ | Organic matter % | N | P | K | Fe | Zn | Mn |
|---|---|---|---|---|---|---|---|---|---|
| | | | | % | | | mg $kg^{-1}$ | | |
| Humic substances | 7.60 | 1.84 | 65.2 | 2.11 | 1.36 | 4.27 | 522 | 112 | 245 |

## RESULTS AND DISCUSSION

The results in Table (3) indicate that potato growth and yield parameters were affected as a result of using humic substances with different levels of mineral fertilization at two growth seasons. Increasing the additional doses of humic substances from 25 to 50 liters per feddan led to a significant increase in growth and yield coordinates with an increase in mineral fertilization rates from 50 to 100%. The addition of humic substances with irrigation water contributed to reducing the quantities of mineral fertilization, as with the decrease in the amounts of mineral fertilization to 50 and 75%, the growth and total yield of potatoes planted in sandy soil did not significantly decrease, as a result of the addition of humic substances extracted from compost.It was found that the use of 50 L $fed^{-1}$ of humic materials with the use of levels of nitrogen, phosphorus and potassium fertilizers up to 75% of the complete mineral fertilization decreased the yield by a very small amount, up to 12% of the yield obtained as a result of adding the three mineral fertilizers in the quantities recommended by the Ministry of Agriculture. For this, it can be said that it is possible to reduce the total cost and reduce environmental pollution as a result of excessive mineral fertilization and thus more profitability with the use of humicsubstances, especially at a rate of 50 liters per feddan with irrigation water.

Humic substances isolated from compost present higher N and H content than the other sources , probably due to the incorporation of N-containing groups and polysaccharides-like structures, which may be decomposed by microbial activities when the process takes more time, or even, the type and/or the characteristics of the processes used to stabilize the organic residues [19]. Rizk *et al*. [20] mentioned that humic substances are recognized as the most chemically active compounds in soils. Bryan and Stark [21] found that humic acid application with phosphorus fertilization rates led to increasing total yield, marketable yield and gross return of potato crop. Shankle *et al*. [22] indicated that the addition of humic materials to soil increased the total marketable yield of sweet potato than the standard fertility program.

The data in Table (4) showed the role of adding humic substances extracted from compost on improving the total chlorophyll content of leaves and the starch and protein content of potato tubers grown in sandy soil during the two successive growing seasons. The use of 100% mineral fertilization gave the best values obtained from the chlorophyll content of the leaves and the starch and protein content of the tubers, but with the increase in the rates of humic substances used from 25 to 50 liters per feddan, there was no significant decrease in the quality of the potato yield with the decrease in the quantities of mineral fertilization, especially when 75% of mineral fertilization are used.

Humic substances have been shown to stimulate plant growth and consequently yield by acting on mechanisms involved in: cell respiration, photosynthesis, protein synthesis and enzyme activities [23]. Improving potato yield could be related to the increase of soil aggregates due to the high content of organic matter in humic substances application. The formation of these aggregates could protect potato tubers to be covered under soil at all growth stages and this could improve tubers quality [24].

As shown in Table (5), the differences in means of N, P and K concentration in potato tuber with the addition of humic substances fertigation were significant. Addition of NPK fertilizer at the maximum dose (100 %) produced the maximum concentration of nutrients in tubers. Concerning the effect of the addition of humic substances to low rates of mineral fertilization, the same Table showed that the addition of humic substances to 50 % and 75 % of mineral fertilization positivelyincreased nutrients concentration in potato tubers. The highest values of these nutrients were occurred with 100% mineral fertilization plus humic substances followed by 75 % mineral fertilization plus humic substances and finally 50 % mineral fertilization plus humic substances, respectively, at two successive growing seasons.

Humic substances reduce other fertilizer requirements, increase yield in crops, improve drainage and increase nutrient content of most crops [25].

The role of humic substances application is mainly related to the enrichment of nutrients uptake where these humic substances increase soil cation exchange capacity and can also form aqueous complexes with micronutrient effects were associated with increasing nutrient concentration in potato tubers [26].

Table 3: Effect of humic substances and different rates of mineral fertilization on potato growth and yield parameters at two seasons

| Humic substances L fed$^{-1}$ | Mineral fertilization levels % | Plant length cm | No. leaves | No. Tubers | Tubers weight kg | Tuber length cm | Tuber diameter cm | Total yield ton fed $^{1}$ |
|---|---|---|---|---|---|---|---|---|
| | | | | | First season | | | |
| 25 | 50 | 40.8 | 59.2 | 9.51 | 0.77 | 6.99 | 4.99 | 9.66 |
| | 75 | 48.6 | 62.2 | 11.3 | 0.93 | 7.11 | 5.23 | 13.7 |
| | 100 | 52.5 | 63.4 | 12.7 | 1.02 | 8.12 | 5.89 | 16.2 |
| 50 | 50 | 47.5 | 65.1 | 12.9 | 1.22 | 7.92 | 5.33 | 10.5 |
| | 75 | 50.2 | 69.5 | 14.1 | 1.40 | 8.62 | 6.35 | 15.2 |
| | 100 | 54.1 | 70.4 | 15.0 | 1.48 | 8.91 | 6.84 | 17.3 |
| L.S.D$_{0.05}$ | | 3.61 | 4.02 | 1.20 | 0.16 | 0.50 | 0.61 | 3.22 |
| | | | | | Second season | | | |
| 25 | 50 | 41.2 | 55.2 | 8.36 | 0.69 | 5.81 | 4.82 | 9.72 |
| | 75 | 48.3 | 63.0 | 10.8 | 0.89 | 6.91 | 5.02 | 14.5 |
| | 100 | 52.0 | 65.4 | 12.0 | 1.00 | 8.00 | 5.67 | 16.8 |
| 50 | 50 | 45.5 | 64.3 | 12.6 | 1.14 | 7.90 | 5.24 | 10.6 |
| | 75 | 51.4 | 70.2 | 14.3 | 1.38 | 8.63 | 5.98 | 15.7 |
| | 100 | 55.1 | 71.8 | 14.9 | 1.42 | 8.96 | 6.34 | 17.8 |
| L.S.D$_{0.05}$ | | 3.60 | 4.11 | 1.19 | 0.15 | 4.99 | 0.59 | 3.20 |

Table 4: Effect of humic substances and different rates of mineral fertilization on potato yield quality at two seasons

| Humic substances L fed$^{-1}$ | Mineral fertilization levels % | Total chlorophyll (100 mg g$^{-1}$) | Starch (%) | Protein (%) |
|---|---|---|---|---|
| | | First season | | |
| 25 | 50 | 47.5 | 12.8 | 9.40 |
| | 75 | 52.6 | 13.1 | 9.50 |
| | 100 | 62.4 | 13.7 | 10.2 |
| 50 | 50 | 53.4 | 13.0 | 9.62 |
| | 75 | 60.0 | 13.8 | 9.75 |
| | 100 | 66.2 | 14.1 | 10.8 |
| L.S.D$_{0.05}$ | | 8.40 | 0.30 | 0.73 |
| | | Second season | | |
| 25 | 50 | 45.7 | 12.9 | 9.33 |
| | 75 | 54.2 | 13.4 | 9.52 |
| | 100 | 64.2 | 14.1 | 10.5 |
| 50 | 50 | 52.1 | 13.3 | 9.66 |
| | 75 | 61.5 | 14.4 | 10.0 |
| | 100 | 68.2 | 15.3 | 11.1 |
| L.S.D$_{0.05}$ | | 9.20 | 0.34 | 0.80 |

Table 5: Effect of humic substances and different rates of mineral fertilization on N, P and K content of potato's tubers at two seasons

| | | N | P | K |
|---|---|---|---|---|
| Humic substances L fed$^{-1}$ | Mineral fertilization levels % | ---------- % ---------- | | |
| | | | First season | |
| 25 | 50 | 1.09 | 0.28 | 2.40 |
| | 75 | 1.39 | 0.30 | 2.51 |
| | 100 | 1.44 | 0.37 | 2.52 |
| 50 | 50 | 1.12 | 0.31 | 2.51 |
| | 75 | 1.46 | 0.32 | 2.58 |
| | 100 | 1.58 | 0.40 | 2.60 |
| L.S.D$_{0.05}$ | | 0.10 | 0.02 | 0.11 |
| | | | Second season | |
| 25 | 50 | 1.10 | 0.26 | 2.39 |
| | 75 | 1.44 | 0.31 | 2.50 |
| | 100 | 1.49 | 0.39 | 2.54 |
| 50 | 50 | 1.11 | 0.30 | 2.61 |
| | 75 | 1.54 | 0.35 | 2.65 |
| | 100 | 1.61 | 0.42 | 2.71 |
| L.S.D$_{0.05}$ | | 0.11 | 0.02 | 0.12 |

## REFERENCES


1. Al-Moshileh, A.M. and M.A. Errebi, 2004. Effect of various potassium sulfate rates on growth, yield and quality of potato grown under sandy soil and arid conditions. IPI regional workshop on Potassium andFertigation development in West Asia and NorthAfrica, Rabat, Morocco 24-28 November.
2. Youssef M.E.A., I.A.S. Al-Easily and Dalia A.S. Nawar, 2017. Impact of Biochar Addition on Productivity and Tubers Quality of Some Potato Cultivars Under Sandy Soil Conditions. Egypt. J. Hort., 44(2): 199-217.
3. Jovièić, N., M. Jacimović, D. Petrović, G. Jovièić, 2009. A feasibility study of plant for composting organic waste in the city of Kargujevac. International Journal for Quality Research, 3: 378-385.
4. Abd El-Rheem Kh. M., Ahmed A. Afifi and R.A. Youssef, 2012. Effect of Humic Acid Isolated by IHSS-N2/Mn Method and P Fertilization on Yield of Pepper Plants. Life Sci. J., 9: 356-362.
5. Osman, H.A.M., T.B. Ibrahim, A.T. Ali and H.I.M. Derwa, 2009. Field application of humic acid against the effect of cadmium pollution on cultured tilapia Oreochromisniloticus. World Applied Science Journal, 6: 1569-1575.
6. Varanini, Z. and R. Pinton, 2001. Direct versus indirect effects of soil humic substances on plant growth and nutrition. In: The rhizosphere: biochemistry and organic substances at the soil-plant interface (Pinton R., Varanini Z., Nannipieri P., eds). Marcel Dekker Inc, NY, USA, pp: 141-157.
7. Chen Y., M. De Nobili and T. Aviad, 2004. Stimulatory effects of humic substances on plant growth. In: Soil organic matter in sustainable agriculture (Magdoff F., Weil R.R., eds). CRC Press, NY, USA, pp: 103-129.
8. Palazzo, A.J., C.E. Clapp, N. Senesi, M.H.B. Hayes, T.J. Cary, J.D. Mao and T.L. Bashore, 2008. Isolation and characterization of humic acids in Idaho Slickspot soils. Soil Sci., 173: 375-386.
9. Loffredo, E., A.J. Palazzo, N. Senesi, C.E. Clapp and T.L. Bashore, 2010. Germination and early growth of slickspot peppergrass (*Lepidium papilliferum*) as affected by desert soil humic acids. Soil Sci., 175: 186-193.
10. Zimmer, G., 2004. Humates & humic substances: Bio-correct inputs for the eco-farmer (vol. 34). ACRES, USA.
11. Brunetti, G., C. Plaza, C.E. Clapp and N. Senesi, 2007. Compositional and functional features of humic acids from organic amendments and amended soils in Minnesota, USA. Soil Biol. Biochem., 39: 1355-1365.
12. Hesse, P.R., 1971. A Text Book of Soil ChemicalAnalysis. John Murry (Publishers) Ltd., 50 Albermarle Street, London.
13. Andelkovic, T., D. Andelković, J. Perović, M. Purenović and P. Polić, 2001. Decrease of oxygen interference on humic acid structure alteration during isolation. Facta Universitatis, Series: Physices, Chemistry and Technology, 2: 163-171.
14. Cotteine, A., 1980. Soil Management for Conservation and Production. New York, pp: 245-250.
15. Moran, R., 1982. Formulae for determination of chlorophyllous pigments extracted with N, N-dimethyl formamide. Plant Physiol., 69: 1376-1381.
16. Malik, C.P. and A.K. Srivastava, 1979. Text book of plant physiology. New Delhi, India: Kalyani Publishers.
17. (A.O.A.C.), 1990. Official Methods of Analysis, Association of Officinal Analytical Chemists. 16th Ed., Washington. D.C., U.S.A.
18. MSTAT-C, 1988. MSTAT-C, a microcomputer program for the design, arrangement and analysis of agronomic research. Michigan State University East Lansing https://www.canr.msu.edu/afre/projects/microcomputer_statistical_package_mstat._1983_1985.
19. Lguirati, A., G. Ait Baddi, A. El-Mousadik, V. Gilard, J.C. Revel and M. Hafidi, 2005. Analysis of humic acids from aerated and non-aerated urban landfillcompost. Int. Biodeterior. Biodegrad, 56: 8-16.
20. Rizk A.H., A.M.A. Mashhour, E.S.E. Abd-Elhadyand and K.M.A. EI-Ashri, 2010. The rote of some humic acid products in reducing of use mineralfertlizer and improving soil properties and nutrient uptake. J. Soil Sci. and Agri. Engineering, Mansoura Univ., 1(8): 765-774.
21. Bryan, H. and J. Stark, 2003. Humic acid effects on potato responseto phosphorus. Presented at the Idaho Potato Conference January 22-23, 2003, College of Agriculture and Life Sciences, University of Idaho, U.S. Department of Agriculture Cooperating) after reference Brown JD, O Lilleland (1946).
22. Shankle, M.W., T.F. Garrett and J.L. Main, 2004. Humic acid nutrient trial. Mississippi Agriculture and Forestry Experiment Station Information Bulletin, 405: 218-219.

23. Ulukan, H., 2008. Humic acid application into field crops cultivation. Kahraman Maras Sutcu Imam University J. Sci. Eng., 11: 119-128.
24. Fortun, A., J. Benayas and C. Fortun, 2006. The effects of fulvic and humic substances on soil aggregation: a micro morphological study. European Journal of Soil Sci., 41(4): 563-572.
25. Salman, S.R., S.D. Abou-hussein, A.M.R. Abdel-Mawgoud and M.A. El-Nemr, 2005. Fruit yield and quality of watermelon as affected by hybrids and humic acid application. Journal of Applied Sciences Research, 1: 51-58.
26. Selim, E.M., A.A. Mosa and A.M. El-Ghamry, 2009. Evaluation of humic substances fertigation throughsurface and subsurface drip irrigation systems onpotato grown under Egyptian sandy soil conditions. Agricultural Water Management, 96: 1218-1222.