International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 6, No. 12, p. 81-89, 2015

RESEARCH PAPER OPEN ACCESS

Use of coal derived humic acid as soil conditioner for soil physical properties and its impact on wheat crop yield

Ijaz Ahmad[1,2*], Safdar Ali[1], Khalid Saifullah Khan[1], Fayyaz ul Hassan[3], Shahzada Sohail Ijaz[1], Kashif Bashir[1], Zafar Abbas[1], Mushtaq Ahmad[2], Adnan Shakeel[2]

[1]*Department of Soil Science and Soil Water Conservation, PMAS Arid Agriculture University Rawalpindi, Pakistan*

[2]*National Institute of Bioremediation, NARC Islamabad, Pakistan*

[3]*Department of Agronomy, PMAS Arid Agriculture University Rawalpindi, Pakistan*

Key words: Humic acid, Saturated hydraulic conductivity, Soil aggregate stability, Wheat yield.

http://dx.doi.org/10.12692/ijb/6.12.81-89 Article published on June 30, 2015

Abstract

Humic acid has been utilized as a soil conditioner for improving soil physical health and enhancing sequestration of soil carbon in recent years. In this study, a loamy sand soil was amended at various levels (HL_0 control, HL_1 10 Kg H.A ha^{-1}, HL_2 20 Kg H.A ha^{-1}, HL_3 30 Kg H.A ha^{-1}, HL_4 60 Kg H.A ha^{-1}, HL_5 90 Kg H.A ha^{-1}, HL_6 120 Kg H.A ha^{-1} and HL_7 150 Kg H.A ha^{-1}) of both grades (Lab grade and Commercial grade) of humic acid. Soil physical and hydraulic properties were analyzed, including soil aggregate stability, bulk density, saturated hydraulic conductivity, and volumetric water content. The yield performance of wheat crop (*Triticum aestivum*) grown in soil amended with different rates of humic acid was also assessed in a randomized complete block design with three replications. The results showed that significant improvement in physical properties like aggregate stability, bulk density, saturated hydraulic conductivity and soil moisture content with the application of humic acid at 150 kg ha^{-1} level. And this improvement was also reflected in valuable increase in wheat crop yield. These results strongly suggest positive improvement of soil physical and hydraulic properties by the addition of humic acid amendment.

* **Corresponding Author:** Ijaz Ahmad ✉ ijazswc@gmail.com

Introduction

Enhancement in agricultural production is indispensable to cope with the food requirements of escalating world population. Research efforts have been made to minimize reliance on costly chemical fertilizers by using organic and bio-fertilizers (Parr and Homick, 1992). In recent past, there has been increasing interest in amending soils with highly decomposed products as biofertilizer to improve the soil physical conditions (Zheng *et al.*, 2006). Humic acid is one of the most decomposed portions of organic matter and may improve the soil productivity by affecting soil physical properties. Humic acid naturally occurs in lignite and mainly composed of (10 - 80 %) lignite, moisture, ash, sulfur (Cavani *et al.*, 2003).

Many researchers in developed countries extensively studied the importance of humic acid in controlled and pot culture conditions as nutrient solutions in various crops (Norman *et al.,* 2006; Sharif *et al.*, 2002; Bhardwaj. 2008). Humic acid manipulates soil physical properties and enhances absorption of nutrients by improving plant resistance against stressed conditions. As humic acid is majorly carbon in its composition, it can be a better source for the improvement of soil physical properties in low carbon soils. The soil physical conditions generally refer to the bulk density, aggregate stability, water flow and storage in the root zone (Reynolds *et al.,* 2002). In dry land areas, the upper two horizons of agricultural soils are characterized by low organic matter content, massive structure and sandy texture. In most coarse textured soils, the soil organic matter (SOM) content and moisture retention are the two major limiting factors for dry land agriculture. The wetting and drying cycles reduce the stability of soil aggregates. In naturally well structured soils, cyclic wetting and drying of soils may collapse the soil structure and thereby facilitating soil degradation. It has been presented that the application of humic acid to the soil may improve the aggregation of soil and aggregate stability (Barzegar *et al.,* 2002).

The stable carbonaceous compounds present in soil organic matter like humic acid act as binding factors for the primary soil particles, and resultantly improve the structural stability of the soil aggregates (Six *et al.*, 2000). Application of organic substances in to the soil significantly affects the surface soil physical characteristics. These include stable aggregates, less bulk density and the improved hydraulic conductivity under saturated conditions (Barzegar *et al.,* 2002; Zeleke *et al.,* 2004). The grades of humic substances prepared from farmyard manure has shown better and long lasting stability of aggregates as compared to the application of bulky levels of farmyard manure (Piccolo *et al.,* 1997).

A little work has been done in dry land regions related to humic acid effect on soil health. A research gap shows that effects of lignite derived humic acid use on soil physical condition and quality of wheat under rainfed agriculture are less well understood. So it is hypothesized that humic acid sources vary in their effectiveness in improving soil physical condition. The response of soil physical properties towards the application of humic acid may vary with different levels and grades of humic acid. Keeping in view the importance of humic acid in different soil processes and being the integral part of soil organic matter it was assumed that humic acid addition in soil may improve soil physical properties and crop production. Therefore, the present study was planned to evaluate the effect of indigenous coal derived humic acid on soil physical properties and wheat crop production. The specific objective was to find out

The effect of lignite derived humic acid on selected soil physical properties and wheat yield

Materials and methods

Humic acid extraction from coal

Humic acid was extracted by Soil and Environmental laboratory, KPK Agricultural University Peshawar, Pakistan following the modified procedure given by Hai and Mir (1998). The contents of humic acid were determined according to Lamar and Talbot (2009), which was more than 70 % pure. The composition of humic acid was conformed according to reported composition given by Hai and Mir (1998).

Field trial

The impact of humic acid application on soil physical properties and wheat yield was studied through a field experiment conducted at Experimental area Koont Research Farm PMAS, Arid Agriculture University, Rawalpindi. The two grades (Lab grade and commercial grade) of humic acid (H.A) were applied each at seven levels i.e. HL_0 (control), HL_1 (10 Kg H.A ha^{-1}), HL_2 (20 Kg H.A ha^{-1}), HL_3 (30 Kg H.A ha^{-1}), HL_4 (60 Kg H.A ha^{-1}), HL_5 (90 Kg H.A ha^{-1}), HL_6 (120 Kg H.A ha^{-1}), and HL_7 (150 Kg H.A ha^{-1}). The treatments were arranged in randomized complete block design (RCBD) with three replications. The fertilizers were applied equally in all the treatment plots (NPK @ 120:90:60 kg ha^{-1}) and wheat crop (CV Chakwal 52) was used as a test crop with the seed rate of 40 kg ha^{-1}.

Analytical methods

Soil samples were taken randomly before and after harvesting for the analyses of physical properties and total organic carbon (TOC) of the soil and crop yield was also recorded. Total organic carbon was measured by oxidizing the soil samples with excess $K_2Cr_2O_7$ through digestion, and the unreacted portion was back titrated (Nelson and Sommers, 1982). Saturated hydraulic conductivity was measured by using Guelph permimeter (at 5 cm and 10 cm heads) and infiltration was fitted in Darcy's law (Youngs, 1991). Aggregate Stability was calculated as dry aggregates (1-2 mm) were sieved against water using Yoder-type sieving machine and stable aggregates were oven dried and weighed (Kemper and Koch, 1966). Bulk density was determined by soil cores (98 cm^3) dried at 105 °C was weighed and calculated (Blake and Hartge, 1982). Total porosity was determined by calculation from bulk density and assumed particle density, Gravimetric moisture content was measured taking the difference in weights of fresh soil sample and oven dried sample (Gardner *et al.*, 1991). Crop grain yield was also recorded from each plot by quadrate.

Statistical analysis

The variance between the means was subjected to analysis of variance (ANOVA) taking humic acid grades and its levels as factors using a statistical software (Statix 8.1), and mean values were compared with LSD test ($P < 0.05$).

Results and discussion

Total organic carbon (TOC)

The results for total organic carbon were statistically different among all the humic acid levels (Figure 1). The soil organic carbon status was significantly improved by the addition of lab grade humic acid at 150 kg ha^{-1}(HL_7) in both experimental years. The application of humic acid improved soil organic carbon status as it is majorly composed of organic carbon. Humic acid increases the soil organic matter as it consists of 50-90 % organic matter (Kulikova *et al* 2005) moreover it prevents loss of carbon due to refractory nature of its chemical structure which makes it resistant against microbial attack. Amendments from organic source increase the total organic carbon in soil (Melero *et al.*, 2007). Bresson *et al.*, (2001) have reported significant increase in organic carbon of the soil due to the application of humic acid.

Table 1. Chemical composition of humic acid grades.

Elements name	Lab. grade	Commercial grade
Carbon (% dry wt.)	72	60
Nitrogen (% dry wt.)	5.0	5.0
Sulpher (% dry wt.)	0.8	1.2
Humic acid contents (% dry wt)	77	65
Moisture (% dry wt.)	11	9.5
Ash (% dry wt.)	8.9	8
Color	Blackish grey	Dark grey
Structure	Polymeric, Cluster	-
Functional group	Carboxyl. Phenolic, Alcoholic	-

Table 2. Physico-chemical properties of experimental site.

Characteristics	Koont Site
Texture	Sandy clay loam
EC (dS m^{-1})	0.53
Soil pH	7.87
Bulk Density (Mg m^{-3})	1.56
Soil Moisture (g $100g^{-1}$)	8.19
Total Organic Carbon (g $100g^{-1}$)	0.59

Soil aggregate stability

The interactive effect of humic acid grades and levels on the stability of aggregates (Figure 2) was statistically non significant in both experimental years. But overall the humic acid applied at 120 and 150 kg ha^{-1} showed significantly higher aggregate stability among all other treatments in both years. A significant correlation among soil aggregate stability and organic carbon was observed (r = 0.62). Mbagwu (2003) reported that polyvalent cations complexation within surface of clay and Humic acid-oxygen-containing groups surrounds the hydrophobic constituents all around the soil aggregate. Such type of hydrophobic coating decrease the soil slaking in water, hence help in maintaining the aggregate stability and prevent the soil loss by run-off. Humic acid being the most important fraction of soil organic matter is an important factor for maintenance of soil through which it improves soil aggregation (Carpenter *et al.*, 2000). The addition of a mixture of fulvic and humic acids in soil can significantly increase the soil aggregation (Barzegar *et al.* 2002). Humic acid extracted from different organic sources is mostly utilized in agriculture as a bio-fertilizer and soil conditioner (Nisar and Mir, 1989; Chen *et al.*, 2004; Lee *et al.*, 2004) and thus have positive effect on soil physical properties (Khungar and Manoharan. 2000).

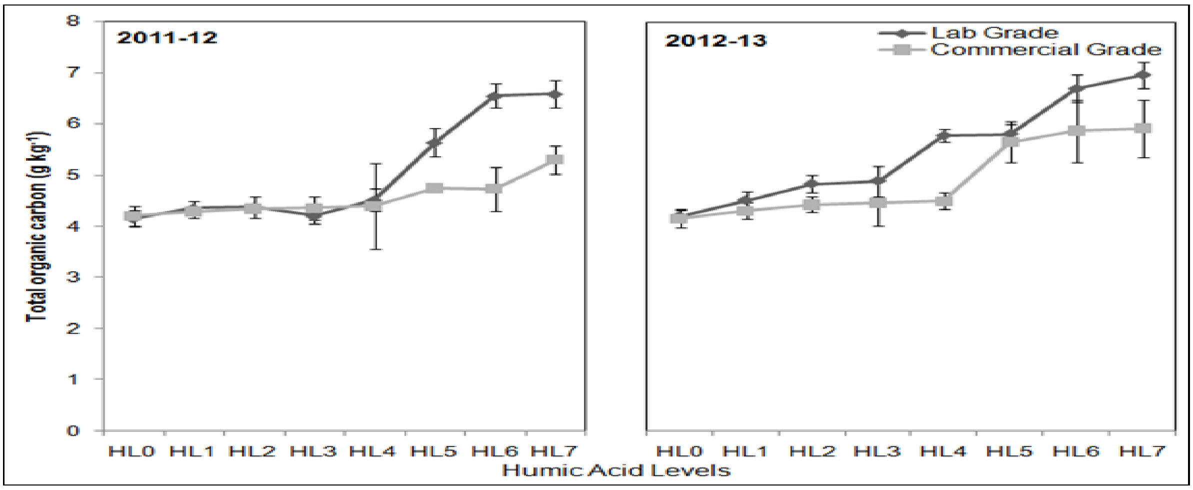

Fig. 1. Total organic carbon of soil as affected by humic acid levels and grades during two years of experimental period (HL0 = 0 Kg H.A ha^{-1}, HL1 = 10 Kg H.A ha^{-1}, HL2 = 20 Kg H.A ha^{-1}, HL3 = 30 Kg H.A ha^{-1}, HL4 = 60 Kg H.A ha^{-1}, HL5 = 90 Kg H.A ha^{-1}, HL6 = 120 Kg H.A ha^{-1}, HL7 = 150 Kg H.A ha^{-1} With a basal recommended dose of N.P.K 120 90 60 kg ha^{-1}).

Saturated hydraulic conductivity

The results regarding saturated hydraulic conductivity variation with changing levels of different humic acid grades was statistically significant (Figure 3). The maximum saturated hydraulic conductivity (30.11 mm hr^{-1}) was observed in soil applied with lab grade at 150 kg ha^{-1} level in first experimental year. Similarly, in second year the application of HL_7 (150 kg ha^{-1} lab grade) enhanced the conductivity rates significantly as compared to other treatments.

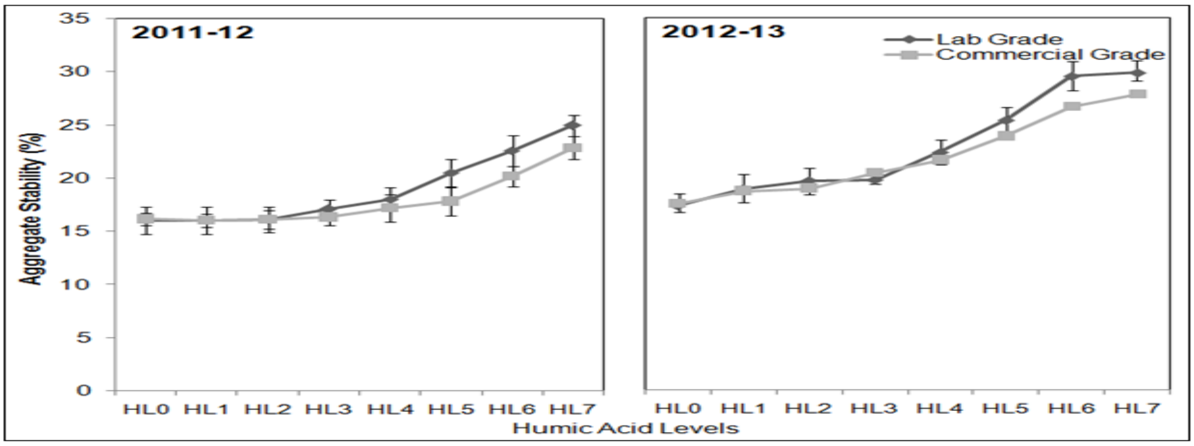

Fig. 2. Soil aggregate stability as affected by humic acid levels and grades during two years of experimental period (HL0 = 0 Kg H.A ha^{-1}, HL1 = 10 Kg H.A ha^{-1}, HL2 = 20 Kg H.A ha^{-1}, HL3 = 30 Kg H.A ha^{-1}, HL4 = 60 Kg H.A ha^{-1}, HL5 = 90 Kg H.A ha^{-1}, HL6 = 120 Kg H.A ha^{-1}, HL7 = 150 Kg H.A ha^{-1} With a basal recommended dose of N.P.K 120 90 60 kg ha^{-1}).

The improvement in total organic carbon of soil and aggregate stability helped in improving the saturated hydraulic conductivity of soil. With the improvement in organic carbon of the soil and the aggregate stability at higher applied levels of humic acid, the higher rate of saturated hydraulic conductivity was also observed. A significant positive correlation was found between aggregate stability of soil and saturated hydraulic conductivity (r = 0.61) which indicate the improvement in saturated hydraulic conductivity is mainly due to enhancement in the proportion of stable aggregates. The presence of stable aggregates improves the porosity which leads to better water flow in the soil.

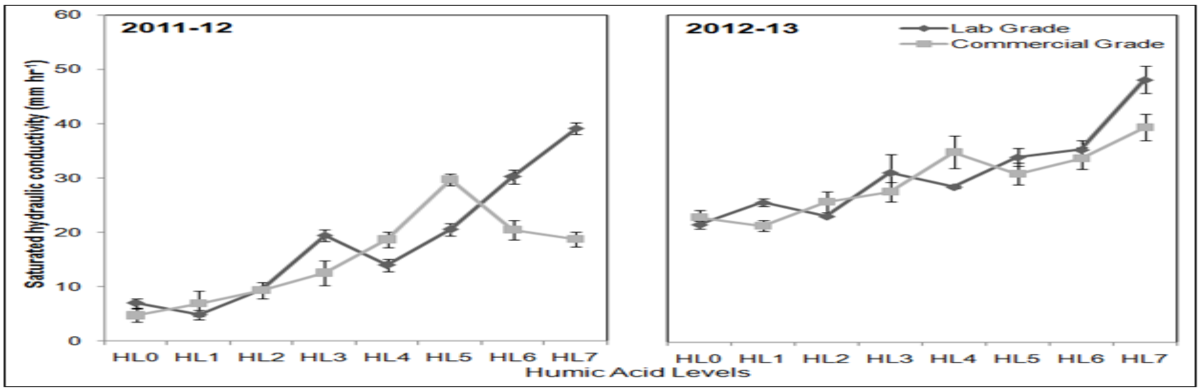

Fig. 3. Saturated hydraulic conductivity as affected by humic acid levels and grades during two years of experimental period (HL0 = 0 Kg H.A ha^{-1}, HL1 = 10 Kg H.A ha^{-1}, HL2 = 20 Kg H.A ha^{-1}, HL3 = 30 Kg H.A ha^{-1}, HL4 = 60 Kg H.A ha^{-1}, HL5 = 90 Kg H.A ha^{-1}, HL6 = 120 Kg H.A ha^{-1}, HL7 = 150 Kg H.A ha^{-1} With a basal recommended dose of N.P.K 120 90 60 kg ha^{-1}).

Soil moisture content

The field experiment data about the effect of humic acid on gravimetric water contents revealed maximum gravimetric water contents (5.17 g kg^{-1}) observed in HL_7, in first year (Figure 4). In second experimental year, the application level HL_7 (150 kg ha^{-1}) significantly enhanced the soil moisture as compared to all other levels, and lab grade was statistically better as compared to commercial grade. Humic acid mainly composed of carbon, when carbon is added up in soil it improves the soil aggregate stability by binding the aggregates resulting in improvement of micro and macro pore of the soil. Macro pore of soil enhances the aeration as well as increase root penetration into the soil, while micro pores enhances the water holding capacity and increase the water contents of soil, In our study humic acid significantly improved the aggregate stability of soil which cleared the role of humic acid for the improvement of water content and bulk density of soil. Various researchers reported that the humic acid application improved the water holding capacity of soil (Mylonas & McCants, 1980; Majathoud, 2004).

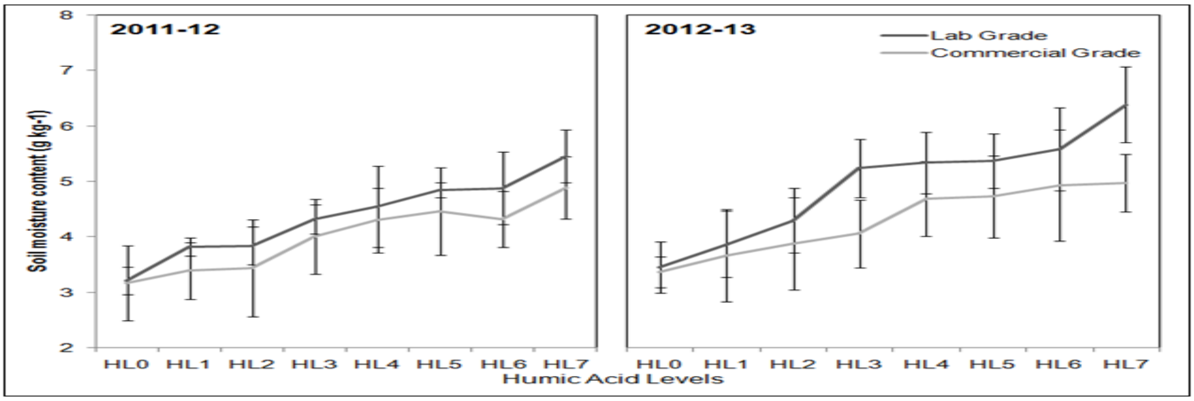

Fig. 4. Soil moisture content as affected by humic acid levels and grades during two years of experimental period (HL0 = 0 Kg H.A ha^{-1}, HL1 = 10 Kg H.A ha^{-1}, HL2 = 20 Kg H.A ha^{-1}, HL3 = 30 Kg H.A ha^{-1}, HL4 = 60 Kg H.A ha^{-1}, HL5 = 90 Kg H.A ha^{-1}, HL6 = 120 Kg H.A ha^{-1}, HL7 = 150 Kg H.A ha^{-1} With a basal recommended dose of N.P.K 120 90 60 kg ha^{-1}).

Soil bulk density

The results for bulk density remained non significant in first experimental year, but significant differences were observed in level means at the end of the second year (Figure 5). The application of humic acid at 150 kg ha^{-1} (HL_7) significantly reduced the bulk density. Bulk density explains the solid and pore spaces proportion in soil, follows that better the pores spaces in proportion, the lesser is the bulk density of a solid. Lower bulk density of soil indicates more pore spaces which augment the prospective for soil aeration and improve water content in soil, consequently a good sign of soil quality. The use of humic acid in soil as an organic source improved the physical condition of soil by improving the aggregate stability of soil and reducing the compactness of soil which result in decrease in bulk density and increase in porosity of soil and finally improved the water infiltration (Barzegar *et al.*, 2002; Zeleke *et al.*, 2004). YE *et al.* (2010) reported that while evaluating the effect of humic acid on the soil physical properties, increase in the ability of soil to store more water was observed.

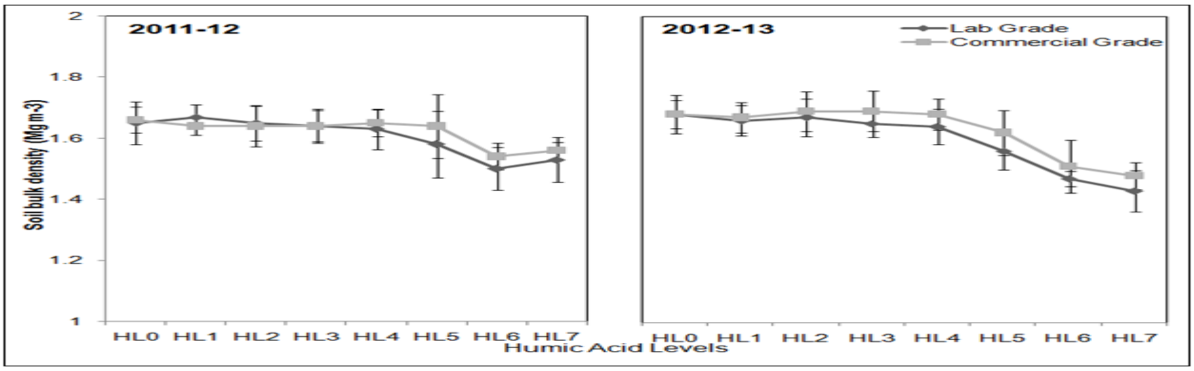

Fig. 5. Soil bulk density as affected by humic acid levels and grades during two years of experimental period (HL0 = 0 Kg H.A ha^{-1}, HL1 = 10 Kg H.A ha^{-1}, HL2 = 20 Kg H.A ha^{-1}, HL3 = 30 Kg H.A ha^{-1}, HL4 = 60 Kg H.A ha^{-1}, HL5 = 90 Kg H.A ha^{-1}, HL6 = 120 Kg H.A ha^{-1}, HL7 = 150 Kg H.A ha^{-1} With a basal recommended dose of N.P.K 120 90 60 kg ha^{-1}).

Wheat grain yield

The humic acid levels and grades showed 10.23%, 7.34 % and 6.47% increase in grain yield by HL_5, HL_6 and HL_7, respectively in contrast to control in lab grade (Figure 6) during 2011-12. Similarly, in second experimental year, increase in grain yield up to 10.75%, 11.83 % and 10.39% by the application of HL_5, HL_6 and HL_7, respectively through lab grade. Humic acid extracted from different organic sources is mostly utilized in agriculture as a bio-fertilizer, plant growth promoter, nutrient carrier, and soil conditioner; it increases the plant membranes permeability and root respiration rate by higher metabolic activity due to increased nutrient availability and enzymatic activity resulting in higher yield. (Nisar and Mir, 1989; Chen *et al.*, 2004; Lee *et al.*, 2004). Our findings are in line with Carpenter *et al.*, (2000) who reported that humic acid is the main constituent of organic fertilizers, through which it supplies nutrients, improve soil aggregation, and stimulate microbial diversity and activity and thus increases the yield.

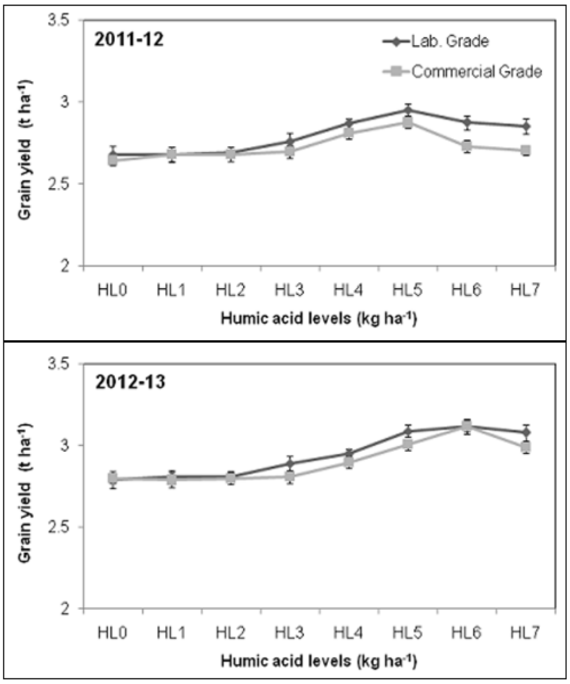

Fig. 6. Grain yield as affected by humic acid levels and grades during two years of experimental period (HL0 = 0 Kg H.A ha^{-1}, HL1 = 10 Kg H.A ha^{-1}, HL2 = 20 Kg H.A ha^{-1}, HL3 = 30 Kg H.A ha^{-1}, HL4 = 60 Kg H.A ha^{-1}, HL5 = 90 Kg H.A ha^{-1}, HL6 = 120 Kg H.A ha^{-1}, HL7 = 150 Kg H.A ha^{-1} With a basal recommended dose of N.P.K 120 90 60 kg ha^{-1}).

Conclusions

Our study strongly suggests the use of coal derived humic acid in physically poor soils may be encouraged for the improvement in soil physical properties. Such improvement not only helped in reclaiming the general soil physical status but also improved the crop growth. So humic acid can be a good carbon source for low carbon soils to improve soil structural stability, hydraulic conductivity and eventually crop yield in dry land agriculture.

References

Barzegar AR, Yousefi A, Daryashenas A. 2002. The effect of addition of different amounts and types of organic materials on soil physical properties and yield of wheat. Public Library Science **247,** 295-301. http://dx.doi.org/10.5897/AJB2013.13352

Blake GR, Hartge KH. 1986. Bulk Density. Methods of Soil Analysis, Part I. Soil Science Society of America 363-376, Madison, WI, USA. http://dx.doi.org/10.1016/j.still.2014.03.002

Bresson LM, Koch C, Bissonnais YL, Barriuso E, Lecomte V. 2001. Soil surface structure stabilization by municipal waste compost application. Soil Science Society of America Journal **65,** 1804-1811. http://dx.doi.org/10.2136/sssaj2001.1804

Carpenter BL, Kennedy AC, Reganold JP. 2000. Organic and biodynamic management: Effects on soil biology. Soil Science Society of America Journal **54,** 1651–1659. http://dx.doi.org/10.2136/sssaj2000.6451651x

Cavani L, Ciavatta C, Gessa C. 2003. Identification of organic matter from peat, leonardite and lignite fertilisers using humification parameters and electrofocussing. Bioresource Technology **86,** 45–52. http://dx.doi.org/10.1016/S0960-8524(02)00107-4

Chen Y, De Nobili M, Aviad T. 2004. Stimulatory effects of humic substanceson plant growth. In:

Magdoff F. Weil RR. (eds.). Soil organic matter in sustainable agriculture. CRC Press, London.

Eynard ATE, Schumacher MJ, Lindstrom, Malo DD, Kohl RA. 2004. Wettability of soil aggregates from cultivate and uncultivated Ustolls and Usterts. Australian Journal of Soil Research **42,** 163-173.
http://dx.doi.org/10.1071/SR03029

Gardner CMK, Bell JP, Cooper JD, Dean TJ, Gardner N, Hodnett MG. 1991. Soil water content. In: Smith KA. Mullins CE. (Eds.). Soil analysis: Physical methods. 1-74. Marcel Dekker, Inc. 270 Madison Avenue, Newyork.

Kemper WD, Koch EJ. 1966. Aggregate stability of soils from the Western United States and Canada. US Department of Agriculture Technology. Bulletin. No. **1335.**

Khungar SC, Manoharan V. 2000. Humic acid an innovative product rich in organic nutrient. Fertilizers News India **45(8),** 23-25.

Kulikova NA, Stepanova EV, Koroleva OV. 2005. Mitigating activity of humic substances: Direct influence on biota. In: Perminova K. Hartfield K. Hertkorn N. (eds). Use of humic substances to remediate polluted environments: from theory to practice. Springer, NL

Lamar RT, Talbot KH. 2009. Critical comparison of humic acid testing methods. Commun. Soil Science and Plant Analysis **40,** 2309-2322.
http://dx.doi.org/10.1080/00103620903111251

Lee JJ, Park RD, Kim YW, Shim JH, Chae DH, Rim YS, Sohn BK, Kim TH, Kim KY. 2004. Effect of food waste compost on microbial population, soil enzyme activity and lettuce growth. Bioresource Technology **93,** 21–28.
http://dx.doi.org/10.1016/j.biortech.2003.10.009

Melero S, Madejón E, Ruiz JC, Herencia JF. 2007. Chemical and biochemical properties of clay soil under dry land agriculture system as affected by organic fertilization. European Journal of Agronomy **26,** 327-334.
http://dx.doi.org/10.1016/j.eja.2006.11.004

Mylonas VA, McCants CB. 1980. Effect of humic and fulvic acid on growth of tobacco. Plant and Soil **54,** 485-490.
http://dx.doi.org/10.1007/BF02181841

Nelson DW, Sommers LE. 1982. Total carbon, organic carbon and Organic Matter. In spark DL. (ed). Anaysis of soil and plants chemical methods. SSA Book Series: Soil Science Society of America 5 book series In. American Society Agroecosystem Incorporation Wisconsin. USA.

Nisar A, Mir S. 1989. Lignitic coal utilization in the form of HA as fertilizer and soil conditioner. Science Technology Development **8(1),** 23-26.

Parr IF, Homick SB. 1992. Utilization of municipal wastes. In Soil Microbial Ecology: Application in Agriculture, Forestry, and Environmental Management (B. Metting). Marcel Dekker, New York.

Sharif M. 1985. Improvement of fertilizer efficiency. International Seminar on Fertilizer use efficiency, Lahore Pakistan.

Six J, Elliott ET, Paustian K. 2000. Soil structure and soil organic matter: II. A normalized stability index and the effect of mineralogy. Soil Science Society of American Journal **64,** 1042-1049.

Vallini G, Pera A, Avio L, Valdrighi M, Giovannetti M. 1993. Influence of humic acids on laurel growth, associated rhizospheric microorganisms,and mycorrhizal fungi Biology and Fertility of Soils **16,** 1-4.

Youngs EG. 1991.Hydraulic conductivity of saturated soils. In (eds.) Smith KA and Mullins CE. Soil analysis: Physical methods. 161-208. Marcel

Dekker, Incorporation **270** Madison Avenue, New York.

Zeleke TB, Grevers MCJ, Si BC, Mermut AR, Beyene S. 2004. Effect of residue incorporation on physical properties of the surface soil in the South Central Rift Valley of Ethiopia. Soil and Tillage Research **77,** 35-46.
http://dx.doi.org/10.1016/j.still.2003.10.005

Norman Q, Clive AA, Edward S, Lee M, Byrne R. 2006. Effects of humic acids from vermicomposts on plant growth. European Journal of Soil Biology **42,** 565–569.
http://dx.doi.org/10.1016/j.ejsobi.2006.06.004

Sharif M, Khattak RA, Sarir MS. 2002. Effect of different levels of lignitic coal derived humic acid on growth of maize. Journal of Soil Science and Plant Analysis **33,** 19-20.
http://dx.doi.org/10.1081/CSS-120015906

Bhardwaj KKR, Gaur AC. 2008. Recycling of Organic Wastes. 54-58, Publications of Indian Council of Agricultural Research, New Delhi, India.

Reynolds WD, Bowman BT, Drury CF, Tan CS, Lu X. 2002. Indicators of good soil physical quality: density and storage parameters. GEDMAB. **110,** 131-146.

Piccolo A, Pietramellara G, Mbagwu JSC. 1997. Use of humic substances as soil conditioners to increase aggregate stability. GEDMAB. **75,** 267- 277.

Hai SM, Mir S. 1998. The Lignitic Coal Derived HA and The Prospective Utilization in Pakistn's Agriculture and Industry. Science Technology Division. **17,** 32-40.

Mylonas VA, McCants CB. 1980. Effect of humic acid on growth of tobacco. Plant and Soil **54,** 485-490.
http://dx.doi.org/10.1007/BF02181841