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Plant Growth Stimulation By Lignite Humic Acids. *Part-I.* Effect of Ammonium Humate on the Growth of Wheat

Surriaya Mir[a]*, Y Z Abbasi[a] and A Rasheed Khan[b]

[a]*Fuel Research Centre, PCSIR, Off University Road, Karachi-75280, Pakistan*

[b]*PCSIR, Scientific Information Centre, 39 Garden Road, Karachi-74400, Pakistan*

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Humic acids were prepared by nitric acid oxidation of Lakhra coal. The product was alkali soluble polymeric material having an aromatic characteristic. Ammonium salt of the humic substances was prepared to find out its effects in the presence and absence of N-fertilizer on the yield of wheat, biological yield of whole plant and number of tillers associated with the plants. The addition of ammonia salt of humic acids increased the size of grain, plant and leaves. The small dose of 0.5 $kgha^{-1}$ alone and in combination with half dose of N-fertilizer (60 kg ha^{-1}) is the optimum dose of growth stimulation of wheat in Sindh. It suggests that the agricultural soil of experimental site is rich in humous material.

Key words: Oxidation, Humous material, Biological yield, N-fertilizer, Stimulation.

Introduction

Humic acids are chemically active polymeric organic compound found in soil, peat and lignite (Schinitzer and Khan 1972) and is an intimate/vital organic constituent of soil. It enhances soil fertility, root development and plant growth. (Tau and Nopainorbodiq 1979). Experiments have been conducted to produce humic acids from various peat and lignite and added to the soil to overcome humic acids deficiency and to enhance soil fertility/agriculture growth (Lee and Borlett 1976). The fertility of Pakistani soil is poor and cannot sustain high crop yields. On an average, the agriculture soils from wheat growing areas of Punjab contain less than 1% organic matter (Azam 1988). Fertility of soil can be enhanced by the addition of humic acids along with N-fertilizer like urea. The activity of humic acids depend upon the source of coal from which it is extracted. Studies have shown that low rank lignitic coals contain higher amounts of humic acids which gradually disappears with the increasing maturity of coal (Ibarra and Rajuan 1985). The chemical composition and structural configuration like degree of aromaticity, distribution of nitrogen and oxygen functional groups role in metal ion transport role etc. of various humic acids play an important role in plant growth stimulation and soil conditioning. Humic acids possess plant hormonial activity and form complexes with the essential mineral ions present in the soil and subsequently slowly release these ions to the plant as and when required. The complexing capability of humic acids shear a significant role in phosphate fixation show release of nitrogen and micronutrients to plants. Furthermore sulfer present in its structure is also beneficial to plants. Pakistan contains huge deposits of lignitic low rank high sulfur coals from which large quantities of humic acids can be extracted (Ahmed *et al* 1991). Utilization of its under utilized widely available lignitic coal resources in the form of humic acids can have a great economic significance. Since humic acids is insoluble in water it is used in the form of sodium or ammonium salt. For this purpose ammonium humate is prepared. This paper describes the production of ammonium humate and its use in combination with various doses of N-Fertilizer to achieve maximum productivity of wheat grain. All experiments were conducted in the soil of Hyderabad, Sindh.

* Author for correspondence

Experimental

Material. Lakhra coal samples were collected from Habibullah coal mines. Nitric acid (commercial grade) and ammonia (E. Merck) and N-fertilizer in the form of urea (Engro) were used without further purification. Seeds of wheat were of the type TJ-83.

Preparation of ammonium humate. The coal samples were crushed to 60 mesh size. Oxidation of coal was accomplished using HNO_3 in a double jacketed reaction vessel fitted with stirrer and thermometer. Since oxidation of coal with HNO_3 is an exothermic process the temperature of the reactants rises and then stabilizes at 70°C. About 8-9kg of coal was transferred to reaction vessel. The 40 litre of 10% commercial HNO_3 was added to the reaction vessel in eight steps to slow down the exothermic reaction between coal and oxidant. The reaction was completed in three hours. The product was separated, washed with water and dried. The product so obtained was dark brown powdery material soluble in aqueous NaOH and NH_4OH. It begins to degrade at temperature 260°C and becomes dark brown when temperature reaches to 310°C. The decomposed product is insoluble in alkali. For the preparation of ammonium humate, the oxidised coal product was dissolved in 50 litre NH_4OH. The resulting solution was ammonium humate which was dried at 90°C on water bath. The coal and product were estimated for C, H and N using LECO Model CHN-600 Elemental Analyzer. Sulfur was determined on LECO-Sulfur determinator model SC 132 and LECO MAC-400. FT-IR spectrum of the product was recorded on Perkin Elmer FT-IR spectrometer model 1800 using K Br disk. The maximum absorbance were found as 3400(s), 2960(s), 2830(m), 720(w), 1620(w), 1550(w), 1460(w), 1340(w), 1260(m), 1175(w), 1100(w), 1040(m), 920(m), 920(m) and 670(w) cm^{-1} wave number. Here S, m and w, stand for strong, medium and weak absorbance respectively.

Parameters of field for cultivation. Experiments were performed on the soil of Hyderabad, Sindh. The land was thoroughly prepared for the study. The entire field was divided into plots of equal size ($4x2m^2$ each), Proper husbandry practices like hoeing, irrigation etc. were kept in practice. 75 $kgha^{-1}$ of phosphate in the form of DAP and 75 $kgha^{-1}$ of potash in the form of SOP were mixed to the soil as a blanket application. 120 $kgha^{-1}$ urea was used as a full fertilizer dose and 60$kgha^{-1}$ as a half fertilizer dose of N-fertilizer. The effects of concentration of N-fertilizer with a view to compare these concentrations were selected i.e. 0, 60 and 120 $kgha^{-1}$. Besides four concentrations of ammonium humate were selected as 0.05 $kgha^{-1}$ 0.5, 2.5 and 5 $kgha^{-1}$.

Results and Discussion

Data were obtained from the effects of various concentrations of ammonium humate in combination of different doses of N-fertilizer (urea) on the soil fertility, plant growth and grain yield.

The product obtained by oxidation of coal with nitric acid was identified with the help of promixate and ultimate analysis, solubility and IR spectral studies. The estimation of raw coal and the product are shown in Table 1. Data show that Lakhra coal contains carbon 63.3%, hydrogen 5.09% and nitrogen 1.87% whereas the analysis of humic acids estimates carbon 57.3%, hydrogen 4.43% and nitrogen shows 6.86%. Further, the peroxidate analysis shows sulfur contents as 4.7% from coal and 1.24% from humic acids. The percentage contents of carbon and hydrogen reported for humic acids (Ibarra and Juan 1985) are in good agreement with these of C=57%, H=4.2%.

Table 1
Preparation of humic acids by oxidation of Lakhra coal with HNO_3

Amount of coal	Yield of humic acid	Proximate utilization analysis			
kg	%	%C	%H	%N	%S
9.0	60.5	57.3	4.43	6.86	4.84
8.5	60.0	57.3	4.42	6.86	4.86
8.0	59.8	57.2	4.43	6.86	4.84

Lakhra coal C, 63.3%; H, 5.09%; N, 1.87; S, 4.7%; Time, 3h; commercial HNO_3.

Table 2
Effects of different levels of N-fertilizer (Urea) on wheat (TJ-83) crop without ammonium humate

N-fertilizer	Ammonium humate	No. of tillers	Biological yield of whole plant	Yield grain
kg ha^{-1}	kg ha^{-1}	ha^{-1}	kg ha^{-1}	kg ha^{-1}
0	0.00	3107500	1670	750
60	0.00	3695000	4584	2280
120	0.00	3612500	7084	3300

Table 3
Effect of 0.05 kg ha^{-1} ammonium humate on wheat (TJ-83) crop using different levels of N-fertilizer (Urea)

N-fertilizer	Ammonium humate	No of tillers	Biological yield of whole plant	Yield grain
kg ha^{-1}	kg ha^{-1}	ha^{-1}	kg ha^{-1}	kg ha^{-1}
0	0.05	3190000	1670	874
60	0.05	3590000	5000	2435
120	0.05	3397500	7065	3210

The percentage of sulfur is mostly different at different places. Lakhra coal is insoluble in water and as well as in NaOH and NH_4OH while the product is insoluble in water and soluble in NH_4OH and NaOH. The results of elemental analysis verify that the product to be humic acids.

IR spectrum of this product shows maximum absorption band at 1720 cm^{-1} which is due to the carbonyl stretching vibration of the -COOH group being introduced through oxidation of coal (Paul *et al* 1980) whereas the band at 1260 cm^{-1} shows C-O stretching vibration in aryl ether. These bands are absent in the spectrum of coal (Ibarra and Juan 1985).

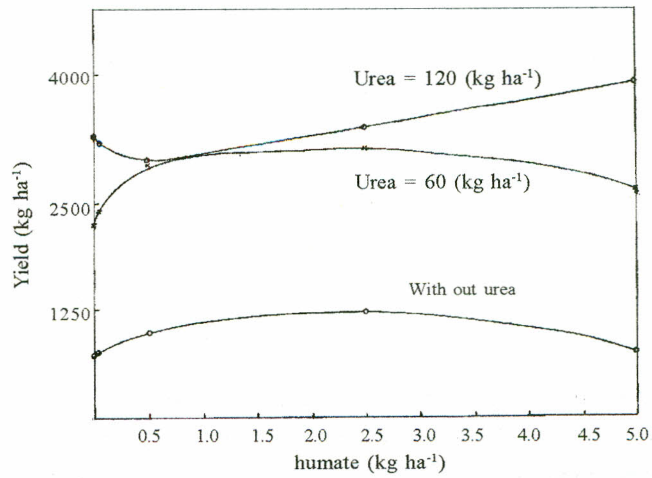
The maximum absorption at 1550 cm^{-1} and 2960, 2830, 1460cm^{-1} are attributed to amide bending and aliphatic C-H and C-H_2 bendings respectively. The bending at 1040cm^{-1}, 1100cm^{-1}, 1620cm^{-1}, 920cm^{-1} and 3400cm^{-1} respectively are due to secondary alcohol or ethers (Bellamy 1954; Cresswell *et al* 1975) aromatic ring and H-bonded hydroxyl groups. The absorption at 1340 and 670cm^{-1} may be due to C-H deformation and C-stretching monosubstituted benzene ring respectively. These observations suggests that the product obtained by the oxidation of coal with nitric acid was definitely humic acids. It is an alkali soluble polymeric material having an aromatic structure substituted by carboxylic, phenolic, hydroxyl and alkyl group ring linked together through either linkages.

Table 2 includes the data for the effect of different levels of N-fertilizer (urea) on the wheat grain yield, biological yield of whole plant and number of tillers associated with the plants without using ammonium humate. It shows that number of tillers, biological yield of whole plant and grain yield increased as the dose of N-fertilizer was increased without using ammonium humate. The increase in number of tillers was 16-19% whereas the biological yield of whole plant increased upto 175-325% by weight and the grain yield increased 20-30% over control. It concludes that N-fertilizer enhances the productivity of the plant.

Table 3 illustrates the results obtained from the effect of 0.05 kgha^{-1} ammonium humate on the biological yield of the plant, number of tillers and grain yield of wheat when three levels of N-fertilizer 0, 60, 120 kgha^{-1} were used. Ammonium humate may be mixed in the soil along with N-fertilizer instead of spraying on the soil. The addition of ammonium humate in the soil increased number of tillers from 319 x 10^4 to 359 x 10^4 at 0 to 60 level of N-fertilizer but dropped to 339.7 x 10^4 at 120 kg ha^{-1} N-fertilizer. The biological yield of the plant was also enhanced from 1667kg ha^{-1} to 7085kg ha^{-1} for three levels of N-fertilizer. The spray of ammonium humate 0.05kg ha^{-1} increased the grain yield from 784 to 3210 (120kg ha^{-1}). On comparing the increase in grain yield with the results of number of tillers, the decrease in number of tillers at the level of 120kg ha^{-1} N-fertilizer is due to the thickness of the grain. The tillers obtained are more thick for this level.

Table 4 summerizes the results obtained for the dose of ammonium humate as 0.5kgha^{-1} in combination with three levels of N-fertilizer i.e. 0, 60 and 120kgha^{-1}. It indicates that with 0.5kg ha^{-1} dose of ammonium humate grain yield, biological yield of plant and number of tillers increased progressively as the levels of N-fertilizer were increased. Grain yield increased from 965 to 3000kg ha^{-1} for o to 120kg ha^{-1} N-fertilizer respetively. The biological yield of plant and number of tillers increased from 2085 to 6670kg ha^{-1} and from 320.2 x 10^4 to 499.2 x 10^4 espectively.

Similarly Table 5 illustrates the data obtained due to the addition of 2.5kg ha^{-1} ammonium humate in combination with three levels of N-fertilizer (0.60, 120kg ha^{-1}). The addition of ammonium humate increased the number of tillers (from 328.8 x 10^4 to 402 x 10^4), biological yield of whole plant (from 2160 to 7580kg ha^{-1}) and the grain yield (from 1200 to 3380kg ha^{-1}).



Ammonium humate (kg ha^{-1})

Fig 1. Effect of ammonium humate on yield of green wheat (J-83) for different level of N-fertilizer

Table 6 shows the results obtained due to the addition of 5kg ha^{-1} ammonium humate in combination with three doses of N-fertilizer (0, 60, 20kg ha^{-1}). The spray of ammonium humate solution on the soil after germination increased the yield of grain (710-3880kg ha^{-1}) biological yield of whole plant (1670 to 7920kg ha^{-1}) and number of tillers (from 317.8 x 10^4 - 376.8 x 10^4) for the three levels of N-fertilizer.

The plots shown in Fig 1 compares the grain yield of wheat obtained due to the addition of different doses of ammonium humate in combination of various doses of N-fertilizer.

Grain yield increased with the increasing dose of ammonium humate (upto 2.5kg ha^{-1}) in the absence of N-fertilizer. But at the dose of ammonium humate i.e. 5.0kg ha^{-1}, decrease in the grain yield were observed. The same thing happens higher upto 60kg ha^{-1} level of N-fertilizer, where as for the level of 20kgha^{-1} N-fertilizer, the yield got decreased at concentrated dose of ammonium humate (5kg ha^{-1}). The increase in grain yield of wheat may be related to the more efficient uptake of nutrients by plants due to added ammonium humate. The effect of ammonium humate in small concentrations on grain yield is due to increase in the permeability of the plant cell and promotion of an active uptake of water and nutrients (Lee and Borlett 1976; Zhukova 1987). From these observations, it is obvious that the grain yield of wheat is highly influenced by all the applications of ammonium humate as such and in combination with N-fertilizer doses. The combination dose of 0.5kg ha^{-1} ammonium humate + 60 kg ha^{-1} N-fertilizer has shown the maximum effect (see Table). The increased grain yield may also be attributed due to the

Table 4

Effect of 0.05 kg ha^{-1} ammonium humate on wheat (TJ-83) crop using different levels of N-fertilizer (Urea)

N-fertilizer kg ha^{-1}	Ammonium humate kg ha^{-1}	No of tillers ha^{-1}	Biological yield of whole plant kg ha^{-1}	Yield grain kg ha^{-1}
0	0.50	3202500	2085	965
60	0.50	3257500	5835	2950
120	0.50	4092500	6670	3000

stimulating plant hormone like effec of ammonium humate in activating plant metabolism and in root respiration.

The ammonium humate also plays an important role in the critical growth of the plant and in increasing size of grain, plant and leaves.

Similar results were also obtained by other researchers (Kausar and Azam 1985). The results of the humic acids (in the form of salt) studies on wheat crop in Sindh indicated that the smaller dose of 0.5 kg ha^{-1} alone and in combination with N-fertilizer 60kg ha^{-1} was the optimum dose for growth stimulation of wheat although doses also produced beneficial effects. It may be assumed at this stage that the experimental agriculture soil of Sindh contain more humous material.

On the basis of the above results it may be concluded that a combination of 60kg ha^{-1} dose of ammonium humate spray would greatly enhance the efficiency of N-fertilizer for wheat crop production. Higher doses of ammonium humate have usually shown a decline effect in crop yield. This may be due to the plant hormone like effect of humic acids where a specific dose of humic acids is required for a specific plant for optimum growth. (O Donnel 1973).

Table 5

Effects of 2.5 kg ha^{-1} ammonium humate on wheat (TJ-83) crop using different levels of N-fertilizer (Urea)

N-fertilizer kg ha^{-1}	Ammonium humate kg ha^{-1}	No of tillers ha^{-1}	Biological yield of whole plant kg ha^{-1}	Yield grain kg ha^{-1}
0	2.5	3288200	2160	1200
60	2.5	3290200	5950	3125
120	2.5	4020080	7580	3380

Table 6

Effects of 5.0 kg ha^{-1} ammonium humate on wheat (TJ-83) crop using different levels of N-fertilizer (Urea)

N-fertilizer kg ha^{-1}	Ammonium humate kg ha^{-1}	No of tillers ha^{-1}	Biological yield of whole plant kg ha^{-1}	Yield grain kg ha^{-1}
0	5.0	317750	1670	710
60	5.0	3445000	5420	2660
120	120	3767500	7920	3880

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