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Short Communication

# Effect of Water Treatment Sludge (WTS) on Zinc Content in Sorghum (*Sorghum bicolor*)

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Zinc is one of the essential elements in plants [Okuda, 1973]. Its property is different from copper (Cu) or nickel (Ni) because Zn is not a transition metal [Baek and Zeong, 1991]. Trace element determinations differ in precision, accuracy, and reliability and are known to bear both systematic and nonsystematic analytical errors. Therefore, it becomes difficult to determine the extent of concentrations recorded in various soil and plant materials [Kabata-Pendias and Pendias, 1985].

Two experiments were conducted in order to know the effects of alum sludge application on the growth of forage sorghum (*Sorghum bicolor*×*S. bicolor*) [Chang *et al.*, 1993; Kim *et al.*, 1997] and the effects of alum sludge application on root growth of forage sorghum (*Sorghum bicolor*×*S. bicolor*) cultivated in mountainous Kumsan district of Korea [Kim and Chang, 2000].

Analyses of copper (Cu) [Choi *et al.*, 2007], nickel (Ni) [Kim *et al.*, 2007], and cadmium (Cd) contents in Pioneer 931, a sorghum hybrid (*Sorghum bicolor* (L.) Moench), were performed. The Zn content was examined using the method of an atomic absorption analysis [Pinta *et al.*, 1979].

The experiment was conducted in mountainous area, with an altitude of 260 meters, at Joongbu University, Kumsan, ChungcheongNam-do, Korea from May to November of 1993. There were 4 treatments with 3 replications in randomized complete block design (RCBD). The treatments were as follows: Control, Compost, Alum+NPK and Compost+NPK. The alum sludge and fertilizers were applied on June 7 and June 17, respectively. Sorghum hybrid seed of Pioneer 931, was sown in June 23 and forage was harvested in November 4, 1993.

The zinc (Zn) content was measured after 3 hours warming up similar to nickel (Ni) analysis reported by Park *et al.* [2008 a]. The analysis of Zn was carried out at the Department of Companion Animal and Animal Resources Science in Joongbu University from October 2, 2007 to January 16, 2008. Eleven samples were air-dried and milled for Zn analysis using an atomic absorption/flame emission spectrophotometer (AA-680, Shimadzu Co. Ltd., Kyoto, Japan) as described by Pinta *et al.* [1979]. The complete specifications are:

Atomic absorption spectrophotometer AA-680, hollow cathode (HC) lamp 4 mA, slit 0.50 nm, wave length 213.9 nm, mode back ground correction (BGC), flame air-acetylene (acetylene 2.0 L/min, air 8 L/min), respectively. The burner height was set at 3, 6, and 9 mm.

In comparing Zn content of the forage hybrid on the three different burner heights, t-values among Zn contents were calculated and mean differences among treatments were carried out using Duncan's multiple range test [Son and Park, 1999].

Table 1 shows the standard solution and their absorbance for Zn content of the sorghum hybrid at three different burner heights. The two standard solutions were used.

Table 2 shows the directly converted zinc (Zn) content from absorbance values using the samples of the hybrid variety. The Zn values on the three different burner heights were similar. The Zn content ranged from −0.064 ppm at 6 mm burner height to 1.21 ppm at 3 and 9 mm burner heights.

Table 3 shows the real zinc (Zn) content which ranged from 0 to 215 mg/kg DW.

Fig. 1 shows the Zn content on different burner heights with similar zinc values. It was reported that there was a big difference in the absorbance for Cd contents on the different burner heights [Park *et al.*, 2008 b] opposite to the results in this experiment using Pioneer 931.

Table 4 shows the Zn content at 6 mm burner height. It is considered to analyze the Zn content at 6 mm burner height condition. The Zn content in the control (85.16 mg/kg DW) had much higher Zn than those in Compost+NPK (17.80 mg/kg) and those in Alum+NPK (19.90 mg/kg) ($p<0.05$) while the sorghum in Compost (43.03 mg/kg) seemed to be high at not significant level. The mean Zn content of sorghum in replication 3 (17.25

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**Abbreviations:** BGC, back ground correction; Cd, cadmium; Cu, copper; DW, dry weight; HC, hollow cathode; Ni, nickel; NPK, nitrogen, phosphorus, potassium; RCBD, randomized complete block design; WTS, water treatment sludge; Zn, zinc

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**Table 1. Standard solution and their absorbance for Zn content in sorghum hybrid (*Sorghum bicolor* (L.) Moench) at three different burner heights**

| Burner height | Absorbance (X) and Zn content (Y) | |
|---|---|---|
| 3 mm | 0.035 Absorbance | 0.0 ppm |
| | 0.217 Abs | 1.0 ppm |
| | Y1=5.4945 X-0.1923 | |
| 6 mm | 0.046 Absorbance | 0.0 ppm |
| | 0.296 Abs | 1.0 ppm |
| | Y2=4.0000 X-0.1840 | |
| 9 mm | 0.043 Absorbance | 0.0 ppm |
| | 0.282 Abs | 1.0 ppm |
| | Y3=4.1841 X-0.1799 | |

**Table 2. The directly converted zinc (Zn) content from absorbance values with an AA-680 spectrophotometer at three burner heights using sorghum hybrid (*Sorghum bicolor* (L.) Moench)[a]**

| Treatment. | 3 mm burner height Zn1 (ppm)[b] | 6 mm burner height Zn2 (ppm)[b] | 9 mm burner height Zn3 (ppm)[b] |
|---|---|---|---|
| Control 1-1 | 1.075 | 1.047 | 1.075 |
| Control 1-2 | 0.470 | 0.466 | 0.464 |
| Control 2-1[c] | 0.559 | 0.545 | 0.563 |
| Control 2-2[c] | 0.332 | 0.328 | 0.317 |
| Compost 1-1 | 0.139 | 0.137 | 0.133 |
| Compost 1-2 | 0.346 | 0.336 | 0.332 |
| Compost 2-1[c] | 1.214 | 1.199 | 1.215 |
| Compost 2-2[c] | 0.312 | 0.319 | 0.310 |
| Compost 3-1 | 0.062 | 0.060 | 0.055 |
| Compost 3-2 | 0.005 | 0.004 | 0.004 |
| Alum+NPK 1-1[c] | 0.071 | 0.070 | 0.069 |
| Alum+NPK 1-2[c] | 1.115 | 1.097 | 1.116 |
| Alum+NPK 2-1 | (-0.031) | (-0.030) | (-0.034) |
| Alum+NPK 2-2 | (-0.036) | (-0.034) | (-0.038) |
| Alum+NPK 3-1[c] | 0.025 | 0.023 | 0.025 |
| Alum+NPK 3-2[c] | 0.009 | 0.012 | 0.009 |
| Compost+NPK 1-1 | 0.228 | 0.216 | 0.215 |
| Compost+NPK 1-2 | 0.334 | 0.318 | 0.317 |
| Compost+NPK 2-1 | (-0.055) | (-0.058) | (-0.056) |
| Compost+NPK 2-2 | (-0.043) | (-0.052) | (-0.048) |
| Compost+NPK 3-1 | (-0.062) | (-0.064) | (-0.062) |
| Compost+NPK 3-2 | (-0.057) | (-0.064) | (-0.061) |

[a]Zn content directly converted from the absorbance values
[b]These values were obtained at 3, 6, and 9 mm burner heights
[c]Filled up to 50 mL while the others are up to 100 mL.

**Table 3. The real zinc (Zn) content at three burner heights using sorghum hybrid (*Sorghum bicolor* (L.) Moench)**

| Treatment | 3 mm burner height[a] real Zn1 (mg/kg DW)[d] | 6 mm burner height[a] real Zn2 (mg/kg DW)[d] | 9 mm burner height[a] real Zn3 (mg/kg DW)[d] |
|---|---|---|---|
| Control 1-1 | 215 | 209 | 215 |
| Control 1-2 | 94.0 | 93.2 | 92.8 |
| Control 2-1[b] | 55.9 | 54.5 | 56.3 |
| Control 2-2[b] | 33.2 | 32.8 | 31.7 |
| Compost 1-1 | 27.8 | 27.4 | 26.6 |
| Compost 1-2 | 69.2 | 67.2 | 66.4 |
| Compost 2-1[b] | 121 | 119 | 121 |
| Compost 2-2[b] | 31.2 | 31.9 | 31.0 |
| Compost 3-1 | 12.4 | 12.0 | 11.0 |
| Compost 3-2 | 1.0 | 0.8 | 0.8 |
| Alum+NPK 1-1[b] | 7.1 | 7.0 | 6.9 |
| Alum+NPK 1-2[b] | 111 | 109 | 111 |
| Alum+NPK 2-1 | 0[c] | 0[c] | 0[c] |
| Alum+NPK 2-2 | 0[c] | 0[c] | 0[c] |
| Alum+NPK 3-1[b] | 2.5 | 2.3 | 2.5 |
| Alum+NPK 3-2[b] | 0.9 | 1.2 | 0.9 |
| Compost+NPK 1-1 | 45.6 | 43.2 | 43.0 |
| Compost+NPK 1-2 | 66.8 | 63.6 | 63.4 |
| Compost+NPK 2-1 | 0[c] | 0[c] | 0[c] |
| Compost+NPK 2-2 | 0[c] | 0[c] | 0[c] |
| Compost+NPK 3-1 | 0[c] | 0[c] | 0[c] |
| Compost+NPK 3-2 | 0[c] | 0[c] | 0[c] |

[a]These values were obtained at 3, 6, and 9 mm burner heights
[b]Filled up to 50 mL while the others are up to 100 mL
[c]Not detected and was estimated as zero
[d]Calculated from (Zn concentration from observed absorbance)/10× 2,000 (filling up to 100 mL) or calculated from (Zn concentration)/20× 2,000 (filling up to 50 mL) on a dry matter (DW) basis

**Table 4. The zinc (Zn) content (mg Zn/kg DM) using sorghum hybrid (*Sorghum bicolor* (L.) Moench) at 6 mm burner height**

| Treatment | Rep 1 | Rep 2 | Rep 3 | Treatment means[†] |
|---|---|---|---|---|
| Control | 151 | 43.6 | 60.9[‡] | 85.16b |
| Compost | 47.3 | 75.4 | 6.4 | 43.03ab |
| Alum+NPK | 58.0 | 0.0* | 1.7 | 19.90a |
| Compost+NPK | 53.4 | 0.0* | 0.0* | 17.80a |
| Replication means[†] | 77.42a | 29.75ab | 17.25 b | |

[†]Values with different letters are significantly different at 5 % level
[‡]An estimated value
*Not detected and was estimated as zero

mg/kg) was lower than the content in replication 1 (77.42 mg/kg) ($p<0.05$) and the Zn content in replication 2 (29.75 mg/kg) seemed to be low at not significant level. In this experiment, the site of replications 2 and 3 were lowly situated and had earlier cultivation than replication 1[Kim *et al.*, 1997]. This means that replications 2 and 3 could be a better choice of more cultivation and that replication 1 is appropriate at higher position and later cultivation.

Fig. 2 shows the time duration after cultivation and Zn content of sorghum hybrid observed at 6 mm burner height.

There was a wide range of the mean Zn content than the general value of 20-100 ppm in plants [Lee and Lee, 1995]. The Zn contents on higher elevation and newly cultivated plots were higher than the lower and early cultivated plots. The phosphorus (P) content increased with longer periods of human activities [Foth, 1978] and with the intensification of agricultural production in tropical and subtropical zones, the occurrence of Zn deficiency has increased [Mengel and Kirkby, 1978]. In conclusion, we can say that Zn is a 'shy' material because the Zn

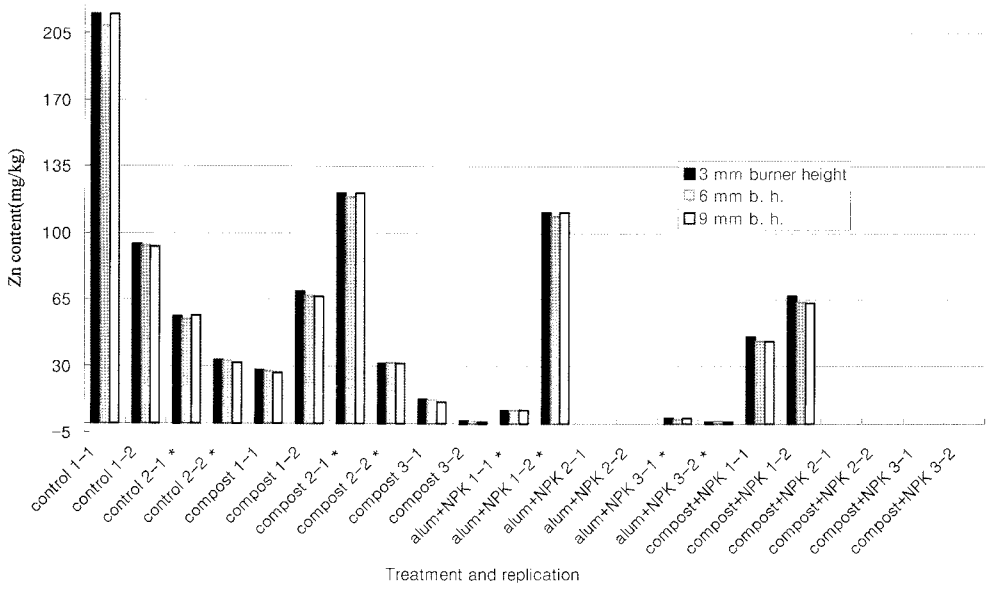


**Fig. 1. The Zn content of sorghum hybrid upon 4 treatments on 3 burner heighs.**

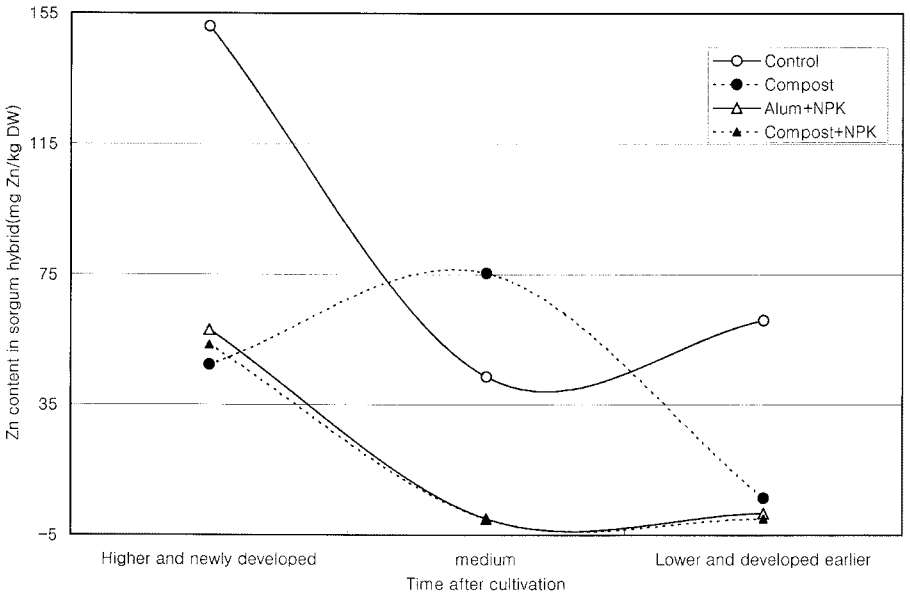


**Fig. 2. Duration time after cultivation and Zn content of sorghum hybrid observed on 6 mm burner height.**

content of the sorghum was lower at early stage in 'sophisticated status' of soil than in soil without NPK fertilizer or soil having later cultivation.

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