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EFFECTS OF ZINC, NITROGEN AND TEMPERATURES ON SEEDLING GROWTH OF RICE

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Abstract

A water culture experiment was conducted to examine the effects of Zn ($ZnSO_4$, $7H_2O$ @ 0.0, 2.5 and 5.0 mg/L); N (NH_4SO_4 @ 0.0, 25 and 50 mg/L) and variable temperatures (33^0C and 38^0C) on seedling growth of rice cv. Khushboo. The leaf tip burn and yellowing of green leaves were observed irrespective of zinc and nitrogen treatments and both low and high temperatures. Such deficiency symptoms were prominent at higher temperature and high levels of Zn and N. The shoot and root lengths and fresh and dry weight of shoots increased in the presence of Zn @ 2.5 mg^{-1} + 25 mg^{-1} of N at lower temperature whereas the fresh and dry weights of root decreased in the same treatment. At higher temperature, the root and shoot lengths and their fresh and dry weights decreased more at higher Zn and N treatments. The seedling growth decreased at higher temperature along with higher levels of Zn and N, whereas at lower temperature (33^oC) with Zn @ 2.5 mg^{-1} and N @ 25 mg^{-1}, the growth normally increased.

Introduction

Plants are continuously exposed to natural environmental stresses throughout their life cycle. Seasonal fluctuations in temperature, moisture, salts and nutrients imbalance often to the levels that are sub-optimal generally affect the growth of plant. Plant life exists across the whole range of atmospheric temperatures (Jones, 1992; Nakamoto & Hiyama, 1999). Higher environmental temperature adversely affects plant growth and yield in many areas of the world (Dubey, 1999; Joshi, 1999). Some plants can survive, when the temperature exceeds even 20 ^0C above ambient, whereas in most of the field crops, temperature above 40^0C causes heat injury, severely limits phytosynthesis and alters protein metabolism by causing protein breakdown, protein denaturation and enzyme inactivation (Williams *et al.*, 1999). For instance, if annual precipitation occurs mainly as snow in winter, plants may grow at cooler temperatures than in regions with abundant spring and summer moisture. Climatic temperature is often dominant in determining conditions for the growth of a particular species and thus its distribution worldwide (Jaffree & Jeffree, 1994; Williams & Black, 1993).

High temperature retards the conversion of sucrose to starch in developing grains of rice (Bjorkman *et al.*, 1980). Temperature affects many aspects of plant growth and development and has a primary influence on the distribution of plant species (Harte *et al.*, 1995). During the course of our experiment, rice seedlings were grown in modified Hoagland's nutrient solution at 20, 25, 30, 35, and 40^0C for 10 days using NaCl (0, 8, 14 dS m^{-1}). The shoot and root growth was found to be similar between 20-30 ^0C, whereas it showed inhibition at 35 ^0C and at 40 ^0C the growth was completely inhibited. Continuous use of nitrogenous fertilizer during the last few decades has also caused widespread deficiency of Zn, with the appearance of necrotic spots on expanded leaves of rice plant (Obata *et al.*, 1999).

Table 1. Effect of Zn, N and temperature on growth of rice seedling.

Treatments Zn & N (ppm)	Shoot length (cm)	Root length (cm)	Fresh weight shoot g/pot	Dry weight shoot g/pot	Fresh weight root g/pot	Dry weight root g/pot
(33°C)						
Zn-0 N-0*	15.69±3.71	6.52±2.09	0.238±0.053	0.0545±0.1784	0.0897±0.022	0.3090±0.0154
Zn-0 N-25**	20.40±2.21	6.71±2.89	0.328±0.027	2.1042±0.005	0.0937±0.005	0.0325±0.007
Zn-0 N-50**	15.96±3.38	4.26±1.87	0.223±0.048	0.0895±0.003	0.05502±0.023	0.0178±0.0056
Zn-2.5 N-0	18.92±3.14	5.20±1.17	0.2010±0.005	0.0859±0.020	0.0970±0.016	0.0210±0.0135
Zn-2.5 N-25	25.35±3.70	7.25±1.05	0.2970±0.025	0.0987±0.0713	0.1031±0.021	0.0230±0.0026
Zn-2.5 N-50	14.68±5.53	3.88±1.37	0.1697±0.033	0.0454±0.020	0.0967±0.020	0.019±0.0176
Zn-5 N-0	16.61±1.07	4.88±1.08	0.2137±0.043	0.0557±0.008	0.1247±0.002	0.0166±0.0007
Zn-5 N-25	17.28±4.86	4.82±1.37	0.1583±0.021	0.0537±0.007	0.1417±0.087	0.0109±0.0129
Zn-5 N-50	15.36±2.89	3.77±0.84	0.1391±0.011	0.0537±0.003	0.0852±0.017	0.0100±0.0023
(38°C)						
Zn-0 N-0*	13.200±2.47	7.36±1.44	0.1619±0.002	0.0364±0.005	0.1069±0.023	0.0213±0.0001
Zn-0 N-25**	17.325±5.11	8.56±4.98	0.1414±0.002	0.0260±0.005	0.1244±0.024	0.032±0.0137
Zn-0 N-50**	15.275±5.59	7.60±4.98	0.2025±0.004	0.0575±0.021	0.0765±0.023	0.0220±0.0153
Zn-2.5 N-0	15.200±2.76	6.75±3.79	0.1944±0.007	0.0666±0.006	0.1439±0.012	0.0431±0.169
Zn-2.5 N-25	11.663±3.71	5.75±2.71	0.2927±0.003	0.0467±0.021	0.0690±0.019	0.0148±0.0110
Zn-2.5 N-50	13.938±5.32	2.44±0.077	0.1600±0.001	0.0513±0.002	0.0958±0.038	0.0210±0.011
Zn-5 N-0	12.452±3.98	4.12±2.10	0.1163±0.005	0.0269±0.008	0.0850±0.021	0.0104±0.0007
Zn-5 N-25	14.100±2.35	3.13±1.24	0.1371±0.002	0.0340±0.001	0.069±0.011	0.0137±0.0049
Zn-5 N-50	13.163±6.82	1.81±10.75	0.0943±0.004	0.0108±0.005	0.0816±0.030	0.0145±0.0062

* 0 = Control;
** 25 and 50 indicates levels in ppm.

Ozanne (1955) reported severe deficiency of Zn in subterranean clover with increased N supply. Dev & Shukla (1980) reported a beneficial effect of N supply of up to 400 mg N/L on shoot, Zn concentration and an antagonistic effect on roots of corn. Application of Zn along with gypsum had an additive effect on the N content (Khan *et al.*, 1992). Experiments were therefore carried out for evaluating the effects of Zn, N and temperatures on rice seedling growth under laboratory conditions. For proper utilization of vast areas of semi-arid lands for growing rice of the country, the use of Zn and N are necessary under variable temperatures that prevails in the country. Against, this background, the present study was undertaken to evaluate the effects of Zn, N and temperatures on the seedling growth of rice plants in nutrient solution culture.

Materials and Methods

A water culture experiment was carried out to determine the effects of Zn, N and temperature on the growth of rice seedling. Zinc levels of 0.0, 2.5 and 5.0 mg/L and N levels of 0.0, 25 and 50 mg/L were added separately or in combination. The sources of Zn and N were $ZnSO_4.7H_2O$ and $(NH_4)_2SO_4$, respectively. Three seven day old rice seedlings of uniform size were transplanted in each pot containing 250 ml Hoagland's nutrient solution and grown for two weeks in two incubators at temperatures of 33^0C and 38^0C, separately with a photo-period of 16 h. The pH of nutrient solution was maintained at 6.5. The solution was changed every week and its level was adjusted with distilled water. The solution was aerated regularly. The visual observations on the growth of rice plants were recorded daily. The plants were harvested after two weeks of growth. The length of shoot and root and their fresh and dry weights were recorded. The data were analyzed statistically to assess the treatment effects.

Results and Discussion

Burning of the leaf tips and yellowish green leaves of rice were observed at both the temperatures irrespective of treatments. Such symptoms were prominent at higher temperature with the higher Zn and N levels. The shoot and root lengths and fresh and dry weights of shoot increased @ 2.5 mg/L Zn alongwith 25 mg/L of N at lower temperature whereas, the fresh and dry weight of root decreased at the similar treatments and temperature. At higher temperature and at higher Zn and N treatments, the root and shoot length and their fresh and dry weight decreased (Table 1). This harmful effect of Zn could be explained by the serious deficiency of N, which possibly be due to formation of insoluble reaction products of Zn and N compounds. Zn - induced chlorosis occurred in vegetable crops when high levels of Zn were supplied with nitrate alone at pH 6.0 (Osawa & Ikeda, 1985). Severe deficiency symptoms have been reported in crop plants with Zn and increasing levels of N in the growth of pear millet (Kumar *et al.*, 1985) and subterranean clover (Ozanne ,1955).

Temperature is also an important environmental variable, which not only affects the rate of photosynthesis, but also all the cellular processes and as a result it has a pronounced influence on the rate of plant growth. Perhaps, temperature was also exerting unfavourable effects on the growth of rice under the present experimental condition. It has been reported that formation of colouring matter is slowed down when air temperature exceeds the optimum temperature and higher temperature is invariably detrimental to the growth of most crop plants (Williams *et al.*, 1999). Factors such as toxins, water and nutrient availability may also interact with temperature to determine growth productivity of different crops. The present study describes the interactive effects of Zn and N of on rice plants which at high levels, severely effects plant growth specially at higher temperature. Zn @ 2.5 mg/L alongwith N @ 25 mg/L at low temperature seem to be adequate levels in nutrient solution for the growth of rice crop.

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