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The Effects of Zinc Application on Physiology and Production of Corn Plants

Nurul Munirah, Mohd Khairi, Mohd Nozulaidi and MdSarwar Jahan

Faculty of Bioresource and Food Industry, Universiti Sultan ZainalAbidin, Besut, Terengganu, 22200 Malaysia

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ABSTRACT

Zn is essential for plant growth and physiological processes, but they become toxic at elevated levels. In this study, effects of zinc (Zn) on corn plants were studied. Different Zn concentrations(0, 0.2, 1.5 and 3 ppm) were externally applied on plant leaves. Plants' height and leaf numbers were not affected by the application of different Zn applications. Relative water content (RWC) increased gradually with increasing Zn concentration followed by decreased at higher level of Zn application. The net photosynthesis rate (Pn) showed similar to RWC results. Chlorophyll (Chl) content increased in Zn-treated plants than Zn-untreated plants but Chl fluorescence increased only at higher Zn concentration condition. Zn application increased yield compared than control but did not differentiate among Zn treatments. Taken together, it seems that Zn at 1.5 ppm as foliar applicationshowed better result in terms of production and physiology of corn plants.

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INTRODUCTION

Corn (*Zea mays* L.) is a world's leading cereal grains along with rice and wheat and used as a food source for both humans and animals. Zn functions as a micronutrient to be essential for plant growth and developments. However, it is also categorized as heavy metal where the prolonged exposure to plant would cause detrimental effects. Nutrients are one of the factors that limit the growth, yield and quality of production of corn. Both macronutrients and micronutrients are essential for corn growth and development. Macronutrients are required a larger quantity while micronutrients are required in smaller quantity. Zinc is one of micronutrients affects corn production. Deficiency (Hafeez *et al*., 2013) and excessive (Weckx and Clijsters, 1997) of Zn might affect plant growth and development, chlorosis and smaller leaves, spikelet sterility (Underwood, 1997 and Railly, 1980). Zinc is one of the most abundant trace elements (Sarwar and Khanif, 2004a) involves in many physiological process but become toxic to plant in excess concentration. Zn also functions as a cofactor of over 300 enzymes and proteins involved in cell division, nucleic acid metabolism and protein synthesis (Marschener, 1995; Cakmak*et al*., 1999). Sharma *et al*. (1994) showed that zinc enhanced the growth of cabbage and increase the chlorophyll content.

Zinc mobility in phloem is relatively high in wheat (Riesen and Feller, 2005) which refers to from leaves to roots, stems and developing grain, and from one root to another (Rengel, 2001). Therefore, external application of Zn on plants tissue might demand for a regulator of Znphloem transport (Pearson *et al*.,1995). In addition Zinc is the only metal functions on enzyme classes (Auld, 2001). The foliar application of Zn may efficient the ability of maintaining high yield in soils with low Zn availability. Under which several mechanisms may underlie Zn efficiency (Rengel, 2001).

To date, no data was found on the effects of Zn on physiology and yield of corn plants. Therefore, the focus of this study was to know the effects Zn on corn production and plant physiology. We showed that Zn induced corn production through improving physiological condition.

2 Methodology:

2.1 Plant material and experimental design:

Plant material used in this study was hybrid corn variety of L41. Two seeds were sowed in a hole on pre-prepared seedbed with the spacing of 25cm X 75cm. Four zinc sulphate (0, 0.2, 1.5 and 3 ppm) treatments with 5 replicates were arranged according to the completely randomize design. Fertilizers and agronomic practices were applied according to previous studies (Jahan *et al*., 2013a;Sarwar and Khanif, 2005b and 2005c).

Corresponding Author: Md. Sarwar Jahan, Faculty of Bioresource and Food Industry, Universiti Sultan ZainalAbidin, Tembila Campus, 22200 Besut, Terengganu, Malaysia.
Tel: ++-6-09-668-8526; Fax: ++-6-09-668-7850; E-mail: sarwarjahan@unisza.edu.my

2.2 Determination of leaf number and plant height:

The number of leaves was counted with visible leaf collars, beginning with the lowermost, short, rounded-tip true leaf and ending with the uppermost leaf with a visible leaf collar (Syuhada*et al.,* 2014;Ritchie *et al*., 1993). The plant height was measured from the soil surface to the longest leaf emerged from the whorl by straighten the plant to the fullest length and measured with a measuring ruler alongside.

2.3 Yield and yield parameters:

Plant height, number of leaves, length and weight of cob were determined after the yield produced(Syuhada*et al.,* 2014). The number of corn cob was counted and weight was taken by using digital measuring instrument for each treatment.

2.4 Determination of relative water content:

Weight of fresh leaf (FW) was measured just after detached from the plants then taken turgid weight (TW) after leaf was incubated in distilled water for 24 h to obtain a full turgidity. Dry weight (DW) of leaf was measured after it was dried at 60°C for 24 h in an oven. Relative water content was measured according to the following formula (Chelah *et al*., 2011; Jahan *et al.,* 2013b). Relative Water Content (%) = [(FW-DW) / (TW-DW)] x 100

FW – Sample fresh weight
TW – Sample turgid weight
DW – Sample dry weight

2.5 Measurement of chlorophyll content and chlorophyll fluorescence in leaves of corn plants:

The SPAD-502 portable chlorophyll meter (Minolta, Japan) was used to acquire a rapid estimation of *in situ* leaf chlorophyll content in leaves of corn plants. The second uppermost collared-leaf was selected to determine chlorophyll content. Data were taken from 11 am to 1 pm to avoid the effects of wetness condition on the leaf surface (Jahan *et al*., 2014a; Nozulaidi *et al*., 2015). Five replicates were implemented. A portable Junior-PAM chlorophyll fluorescence monitoring meter (Walz, Germany) was used to quantify *in situ* chlorophyll fluorescence in leaves of corn plants (Jahan *et al*., 2014b; Khairi *et al.,* 2015). The second uppermost collared-leaf was selected for taking the data in between 11 am to 1 pm. The maximum fluorescence levels were recorded.

2.6 Determination of net photosynthesis rate in leaves of corn plants:

Net photosynthesis rate (Pn) was measured using a CI-340 portable photosynthesis meter (CID Biosciences, Inc.) according toSyuhada*et al*. (2014). Data taking procedures were followed according to the manual. These measurements were done in between 11 am to 1 pm. Five replicates were maintained.

2.7 Statistical analysis:

Data were analyzed for differences of mean value among treatments by ANOVA procedure and LSD and T-test using Minitab-16 and MS Excel software according to previous study (Jahan *et al*., 2012; Sarwar*et al*., 2004). Differences at $P < 0.05$ were considered significant.

RESULT AND DISCUSSION

3.1 Effects of Zn on plant height and leaf number:

The plant height and leaf number were presented in the Fig 1a and b. Weekly data showed that the height of corn plant increased with increasing time (Fig. 1a). But no effect of Zn on plant height was observed when compared between Zn-treated and Zn-untreated plants. This result shows that Zn might not affect plant height. Zn is essential plant nutrient which has a vast effect if it is deficient or toxicity in plants. This experiment was conducted at field condition that plant might accumulate somewhat concentration of soil-Zn,therefore the external application of Zn might not affect plant height. This might have other cause, in which, other nutrients may works as a co-factor and increase absorb-ability of Zn by corn plants so that the effects of Zn applications might not observed in terms of plant height.

Application of different Zn concentrations did not affect leaf numbers at different data taking time except 8thweek. In that particular week, Zn-treated plants produced higher leaves compared than that of Zn-untreated plants. This result also suggests that external application of Zn might not affect leaf numbers. Previous study revealed that the effects of zinc application in soil on early corn growth were minimal and had no effect on the dry weight of immature plants (Varsa *et al*., 2005). Taken together, it is suggested that the effect Zn application on plant height and leaf numbers at field condition experiment might not observable due to Zn function in soil.

3.2 Effects of Zn on relative water content and photosynthesis rate in leaves of corn plants:

RWC content significantly increased in leaves of Zn-treated plants compared than that of leaves of Zn-untreated plants (Fig. 2a). Relative water content increased gradually with increasing Zn concentration and reached at highest level when plants were treated with 1.5 ppm Zn. Nevertheless, the RWC declined significantly thereafter when plants were treated with3 ppm Zn compared those other Zn treatments. This result indicates that RWC content may Zn dose dependent. Therefore, RWC increased at steady level then decline thereafter. This indicates something effects about optimum and toxicity level of Zn to be recognized for corn plants. This result also indicates that this may cause of Zn-treated plants may perform their metabolism functions well than that of Zn-untreated plants.

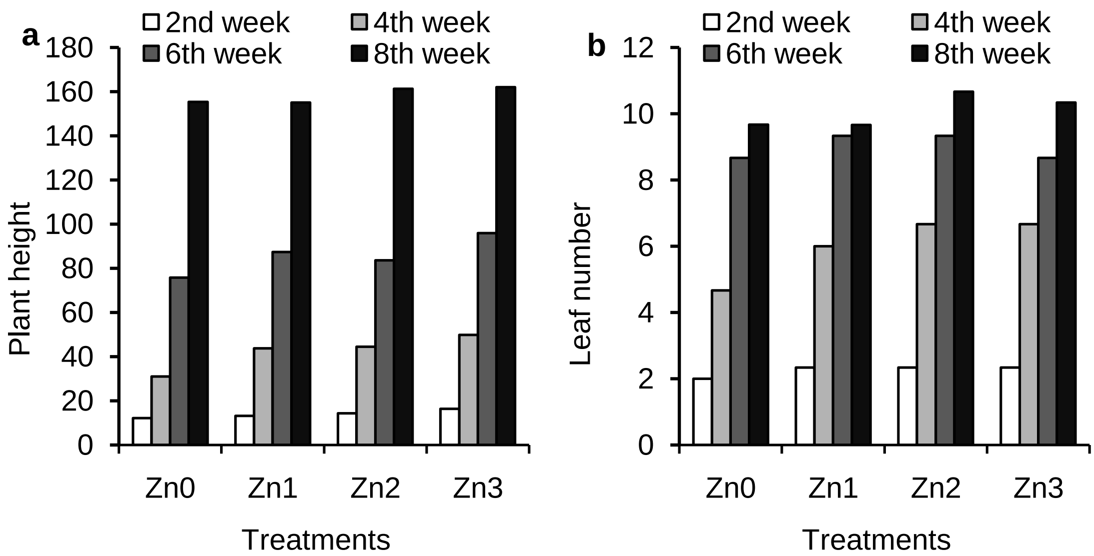

Fig. 1: Effects of different concentrations of Zn on plant height (a) and lean numbers (b).

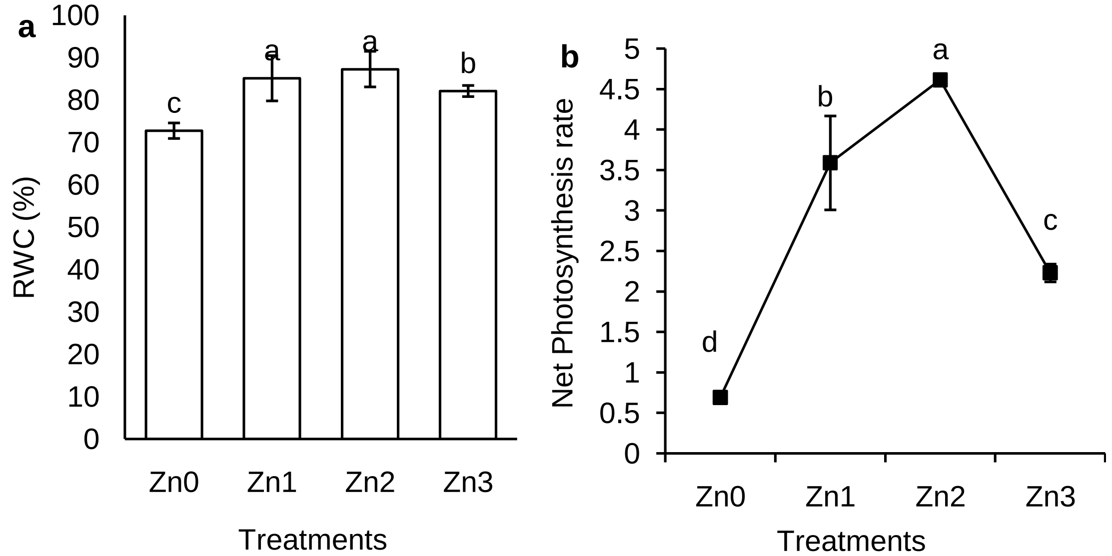

Fig. 2: Effects of different concentrations of Zn on RWC (a) and photosynthesis rate (b).

We also determined the Pn rate in leaves of corn plants under different Zn conditions (Fig. 2b). We found that Zn treatment gradually increased Pn rate at a steady level than declined thereafter in concern with higher Zn concentration (Fig. 2b). That is, higher concentration of Zn at 3 ppm reduced Pn rate while 1.5 ppm or less shows better results in terms of increasing Pn rate. These results were consistent with previous results (Monnet *et al.*, 2001).

3.3 Effects of Zn on chlorophyll content and chlorophyll florescence:

Whether Zn application affected chlorophyll (Chl) content, Chl content in leaves was determined at different growing stages are 15, 25 and 35 days after planting (DAP). There was no effect of Zn on Chl content was observed in leaves of Zn-untreated plants at different timing of observation. But Zn-treated plants showed different Chl accumulations in leaves under different observation times (Fig. 3a). In addition, Chl content was significantly higher in

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leaves of Zn-treated plants than that of leaves of Zn-untreated plants in all observation times. These results suggest that Zn application might increase Chl accumulation in leaves of corn plants. On the other hand, chlorophyll fluorescence data showed dissimilar results to chlorophyll content where Chl fluorescence increased in leaves treated with 3 ppmofZn but other Zn treatments did not show any difference compared than that in leaves of Zn-untreated plants (Fig. 3b). These results support that Zn might affect Chl content and Chl fluorescence differently but the cause in this phenomenon is still unknown.

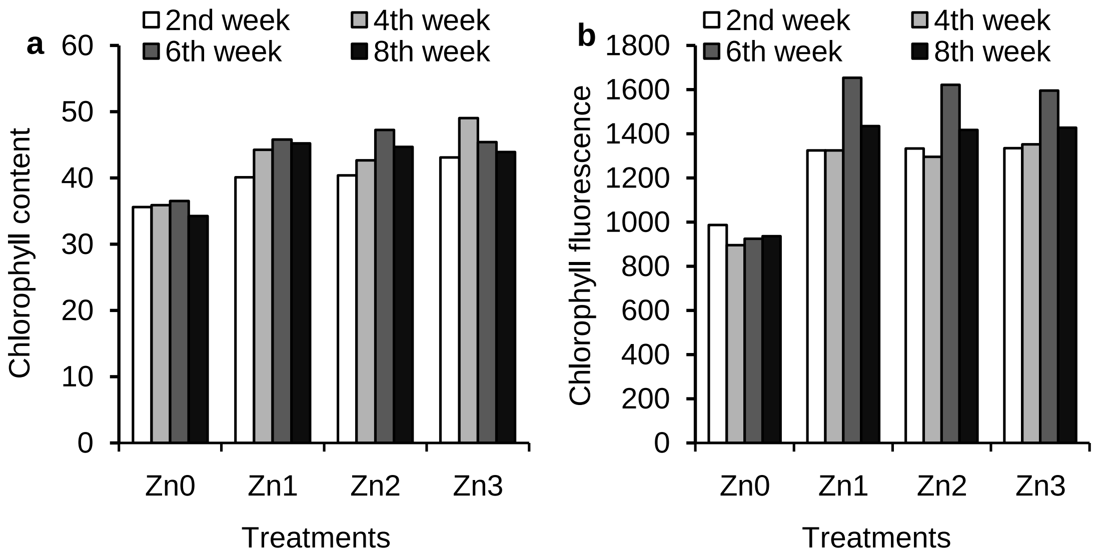

Fig. 3: Effects of different concentrations of Zn on Chl content (a) and Chl florescence (b).

3.4 Effects of Zn concentrations on corn yield:

The yield and yield parameters were determined based on the weight and length of corn fruit which was shown in figure 4a and 4b. The yield gradually increased with increasing Zn concentration (Fig. 4a). While Zn3 showed best performance in terms of yield production. In case of length of corn fruit, Zn-treated plants (Fig. 4b) showed larger size than that of Zn-untreated plants. The length of fruit gradually increased with increasing Zn concentration.

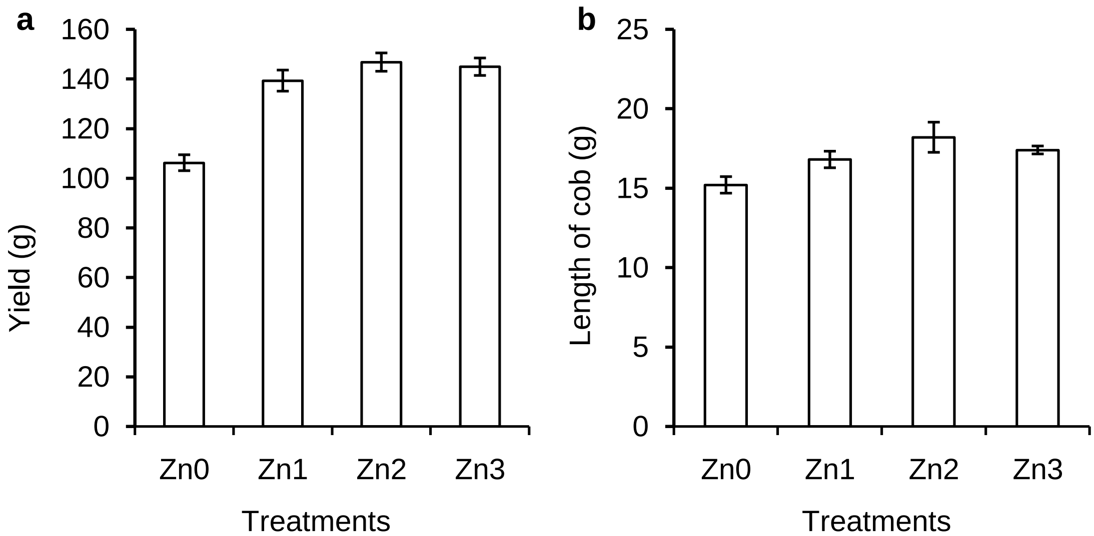

Fig. 4: Effects of different concentrations of Zn on corn yield.

In conclusion, this study confirms that Zn application enhanced physiological parameters, e.g. RWC, Pn rate at the level under which corn plants showed higher yield. The higher dose of Zn application did not increase yield but decreased RWC and Pn. Therefore, Zn at 1.5 ppm might an optimal dose as foliar application for corn plants at field condition.

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