MANGANESE TOXICITY AQUTIC SYSTEM : AN IMPACT OF EXCESS MANGANESE IN SOLUTION CULTURE ON PLANT GROWTH

Keracunan Mangan di dalam System Akuatik: Pengaruh Kelebihan Mangan dalam Larutan tehadap Pertumbuhan Tanaman

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ABSTRAK

Mn^{2+} sangat larut di dalam system aquatic dimana prinsip kultur larutan adalah sama dengan system akuatik. Dua set eksperimen mengenai pengaruh konsentrasi Mn^{2+} di dalam kultur larutan terhadap pertumbuhan tanaman telah dilakukan di rumah kaca University Putra Malaysia, Serdang, Selangor, Malaysia. Studi ini bertujuan untuk mengetahui konsentrasi toksik Mn^{2+} di dalam kultur larutan pada pertumbuhan tanaman. Sebagai tanaman indicator adalah "vegetable soybean" (Glycine max L.) Pada eksperimen pertama menunjukkan 60 µM Mn berkesan sangat toksik pada pertumbuhan tanaman, sementara pada eksperimen kedua menunjukkan bahwa 7.5 µM adalah optimum. Penurunan berat kering daun, akar dan batang tanaman soybean sangat nyata pada taraf 37.5 µM. Ianya disebabkan oleh pengurangan luas daun dan panjang akar dengan penambahan konsentrasi Mn^{2+} pada kultur larutan.

Keywords : Manganese, solution culture, aquatic system, toxicity and plant growth

INTRODUCTION

It is well documented that Manganese (Mn) is an essential element for the growth of plant and animal (Uzochukwu & Dixon 1986). Manganese can be occurred by the corrosive of parent material, run-away by the rain the comes into the pool of aquatic system (Salcedo *et al*. 1974). The oxidized form (Mn^{3+} and Mn^{4+}) is a predominant in aerobic condition and Mn^{2+} in predominant in unaerobic condition (Lindsey & Jones, 1989). The Mn^{2+} form is considerably more soluble in aquatic system and is easily available to plant compared to the other oxidized forms (Snyder et al. 1990, Schwab & Lindsey, 1983; Patric & Henderson, 1981). In aqueous system, both Mn^{3+} and Mn^{4+} form are quite unstable and are easily reduced to more stable form (Mn^{2+}). The raction is as follows: $MnO^2 + 4\ H^+ = 2e^-\ 4\ Mn^{2+} + 2\ H^+ + H^2O$ (Reddy *et al.* 1991, Smith 1990)

When the excessive Mn^{2+} is present in the solution, plants uptake profuse quantities od Mn^{2+} and accumulates due to inhibitory affects in mitosis and root elongation (Clarksom & Sanderson 1996). The objective of the study was to observe how far the impact of excess Mn in solution culture on plant growth.

MATERIALS AND METHODS

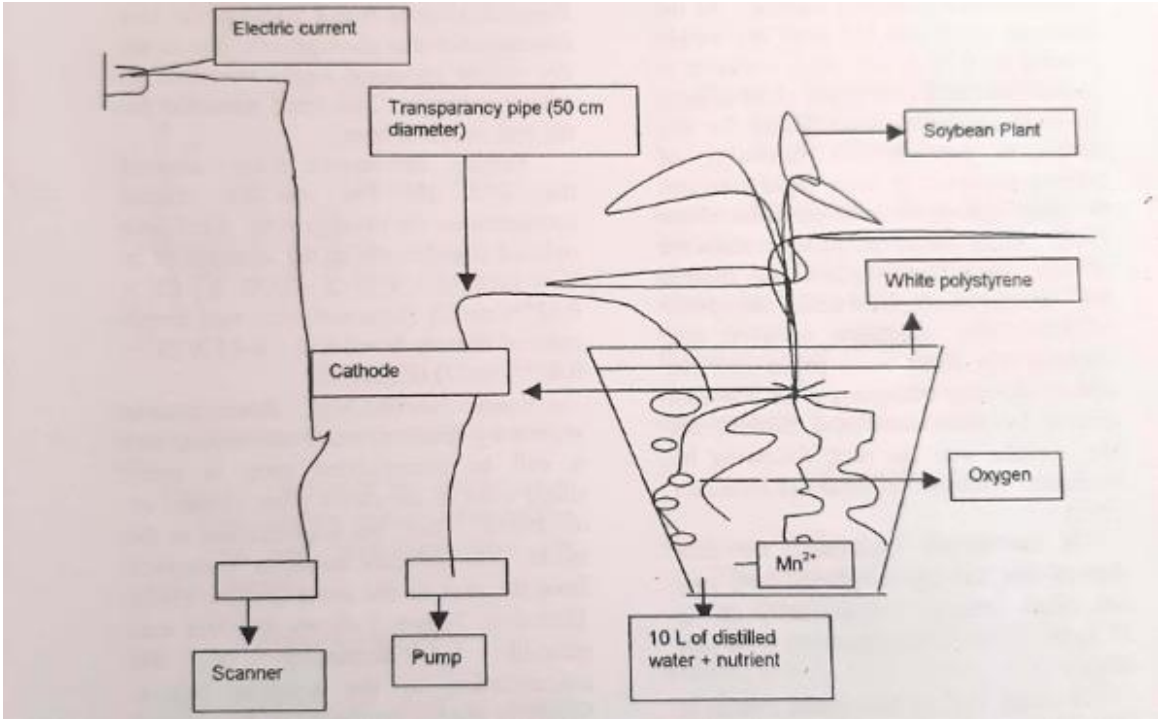
Preparing of Solution Culture

Ten-liter of distilled water was placed into platic container cover with 2 cm thick of white polystyrene. The water was aerated twice per hour for 15 minutes. Time scanner was connecting to the pump oxygen. The oxygen moved to the electric cathode in solution culture through transparency pipe 0.50 cm in diameter. In duration of each 15 minutes the electric pump was not working and the canthode stopped to enter the oxygen in solution immediately. Actually the

solution culture must be fresh in every day and must be changed every 24 hours. Twenty-seven plastic containers (three replication of 9 treatments) were arranged in Randomized Completely Block design at the glass house Faculty of Agriculture, Univesiti Putra Malaysia. The schematic of solution culture was shown in the picture 1.

Plating and Treatment

Three seedlings of soybean plant (*Glycine max* L) were placed for each container and supported by foam. Then, nine levels of Mn concentration (0, 60, 120, 180, 240, 300, 260, 480 µM) for the first experiment were prepared into the solution. For the second experiment, the levels of Mn concentration were (0. 7.5, 15, 22.5, 30, 37.5, 45, 52.5 and 60 µM). The Mn was diluted together with other macro-micro nutrient according to modified Heenan & Campbell (1983) (Appendix 1).



Picture 1. Model of solution culture as an aquatic system

Harvesting and data Collection

Plant were harvested at the 30th days after treatment with Mn in solution culture. All samples of plant were collected at harvest time. The data of dry-weight were analysed using ANOVA ($P \leq 0.05$) and honestly significantly Different (HSD) for means comparison (SAS Institute 1979). Leaf area and root length were analyzed using response curve by regression method.

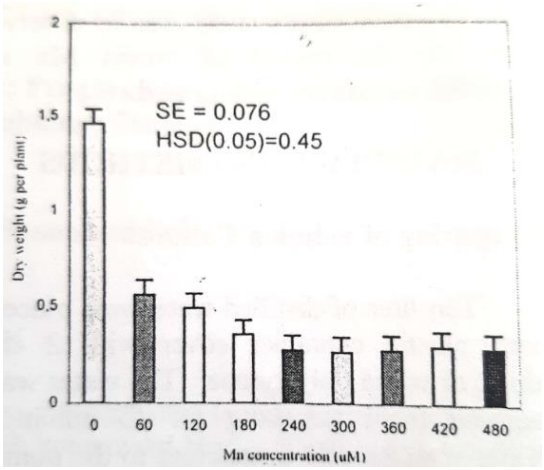
RESULT AND DISCUSSION

Reduction of Dry-weight

Impact of Mn toxicity in the solution culture system is significant on the reduction of plant dry weight. First experiment showed that the reduction of plant dry weight was significant at ($P<0.05$) by high level of Mn concentration in solution culture. At the treatment of 60 µM Mn plant compare to control treatment 1.46 g per plant (Figure 1).

Since the water is so diluted for any instant of nutrient transport is more rapid compare to other system in solution (Marchhner 1986). Root length of plant, availability of Mn^{2+} and root exudated of soluble of Mn^{2+} around rhizosphere affect the uptake of Mn. The processes involved are; realising Mn from solid phase into the aquatic system, transporting to the root surface by mass flow and further, the Mn2+ uptake into root, following by Michalelis Mentein Kinetics (Reisenauer 1998).

In the second experiment the data showed that the dry weight of leaf, root and stem reduced significantly at $\geq$ 37.5 µM ($P \leq 0.05$) compare to $\leq$ 30 µM (Figure 2).



Values followed by different letters are significantly different according to HSD test (P ≤ 0.05)

Figure 1. Effect of Mn concentration in solution culture on plant dry weight

Its means Mn2+ in the aquatic system is still capable as ionic transfer for plant growth even in small concentration. Figure 2 showed that 7.5 µM is the best concentration for plant growth, due to the dry weight increased highly compared to other treatment. This trend remained for the leaf, root and stem.

Further, the aquatic system showed that 37.5µM is the best concentration for plant growth. Leaf area reduced significantly in the response of In Y = 1868.70 = 9.17 X – 0.72 X^2 (R2 = 0.82**; n=27) (Figure 3) and root length reduced linearly Y = 57.76 – 0,41 X (R^2 = 0,82**, n = 27) (Figure 4).

Root absorbs Mn^{2+} from aquatic system by gradient water movement, and it will be accumulated soon in every single cells in the entire plant (Daniel *et. al,* 1992). Thus, the accumulation in the xylem cells inhibits nutrients movement from the root to the shoot (Miflin 1980). Therefore, Figure 3. Shows that leaf area reduced by increasing of Mn concentration in the solution culture. Similarly the accumulation in the root cell disorders the metabolism system in the cell and it affects on the enlargement of root expansion (Plaut *et al*. 2000), as shown at figure 4.

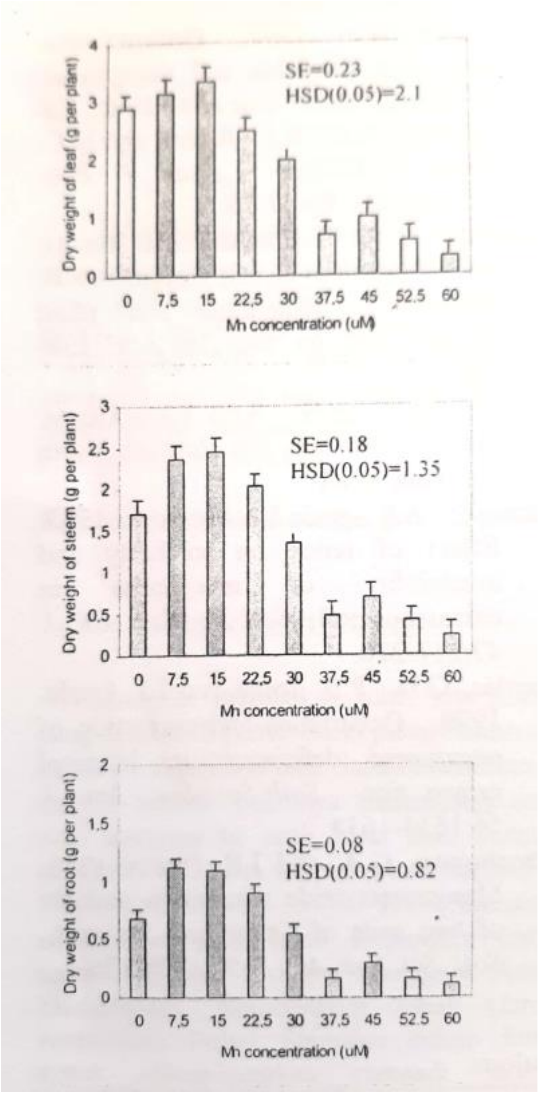


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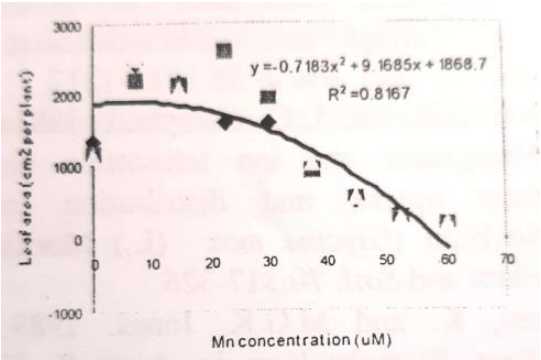
Figure 2. Effect of Mn concentration in solution culture on reduction of leaf, root and stem dry weight



Figgure 3. Effect of Mn concentration in the solution culture on leaf area

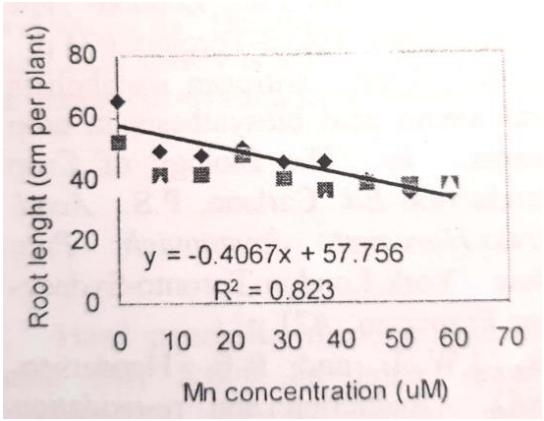


Figure 4. Effect of Mn concentration the solution culture on root length of plant

CONCLUSION

The capability of plant to absorb Mn2+ was really strong in the aquatic system. In solution culture, 7.5 µM Mn was the best concentration for plant growth, and 37.5 µM was crucial where the dry weight of leaf, root and stem was reduced significantly. Especially leaf area and root length decreased by increasing of Mn concentration in solution culture.

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Appendix 1 : Macro and micro nutrient in solution culture

Nutrients	Concentration (µM)
$MgSo_4$ $7H_2O$	100
$CaCl_2$ $2H_2O$	700
K_2SO_4	200
NH_4NO_3	500
$NH_4H_2PO_4$	500
K_2H PO_4	10
Fe EDTA	5
$CuSO_4$ $5H_2O$	0.40
$ZnSO_4$ $7H_2O$	0.30
$(NH_4)MO_7O_{24}$ $4H_2O$	0.10
$Co(NO_3)_2$ $6H_2O$	0.0080

(Source: Heenan & Campbell 1983).