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INFLUENCE OF SOLUBLE ALUMINIUM ON THE YIELD AND GROWTH CHARACTERS OF THE RICE PLANT

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Aluminium referred as a "ballast element" in plant nutrition by Kanwar (1976) is widely present in plants growing in areas containing soluble and exchangeable aluminium. Under the water-logged conditions in the acid soils of Kerala there is abundant and progressive release of aluminium along with iron and manganese with continuous water-logging and it is absorbed by the rice plant which is mostly grown under these conditions.

Rice plants in such locations may contain as much as 1500 ppm aluminium (Karthikakutty, 1967). Tanaka and Navasero (1966) have studied the aluminium toxicity of the rice plant under water culture conditions and reported that the critical concentration for aluminium in solution for the rice plant was about 25 ppm when the plants receive normal supplies of other nutrients. The symptoms of aluminium toxicity and the effect of aluminium in different concentrations on crops like rye, barley, wheat, beans, potato etc, have been studied and reported by many workers. (Kenneth 1953, Clarkson 1968, Otsuka 1968 and Reid 1971). The general symptoms of aluminium toxicity reported in these studies are reduced yields, with the plants showing stunted roots with stubby tips having little branching and stunted tops with intravenal chlorosis of an orangish yellow colour. The effect of high concentrations of aluminium on the growth characteristics of the rice plant and the symptoms of toxicity have not been systematically studied and reported. The present study was undertaken with a view to obtaining information on the effect of soluble aluminium in presence of other nutrients at concentrations below and above the critical levels as suggested by Tanaka and Navasero (1966) on the growth and yield characters of the rice plant.

Materials and Methods

The experiment was carried out in culture solutions in glazed procelein pots of 2.5 litre recapacity with a medium duration rice variety Sabari. The culture solution was prepared as described by Johnson *et al* (1957). Aluminium was supplied as aluminium chloride to give a concentration in the pot of 0, 10, 20, 30, 40 and 50 ppm aluminium. The initial pH of the culture solution was adjusted to 4.8 using bromocresol green indicator. The solution was renewed weekly once. Fourteen day old seedlings of the rice plant, two each were planted in waxed ratton baskets containing glass marbles to serve as support for the plants. The baskets were placed over the porcelein pots so that 2 cm of the solution remained in contact with the basal portion of the plant. Distilled water was added every day to maintain the level of solution inside the pot.

Results and Discussion

No visible symptoms of aluminium toxicity occurred in the tops in any of the plants during the entire growth period. Normal tillering and other growth characters in the vegetative phase were observed in all the plants.

However, a progressive decrease in root growth was noticed in plants receiving more than 20 ppm aluminium from the 7th day onwards. The root length was considerably reduced and the roots showed a significant and prominent tendency for branching which was more conspicuous in plants grown in 40 and 50 ppm aluminium and gave an appearance similar to the root system of a dicotyledonous plant (plates 1 and 2). Transverse sections of these roots showed three to four vascular traces distributed in the root cortex in addition to the usual single central vascular bundle in a normal root. The air spaces in these roots were also considerably decreased due to over growth of more or less rounded cortical cells (Fig. 1 and 2).

The decrease in size of the root system, however, did not affect any of the yield attributes or the yield of the crop. The length of the tops, the number of tillers and productive earheads, weight of straw and grain etc. did not vary significantly in the differently treated plants (Table 1).

Table 1 Data on growth and yield characters of the differently treated plants (Average of four replications)

Treatments Concentration of aluminium in ppm	Maximum length of shoot cm	Weight of straw g	Maximum length of root cm	Weight of root e	No. of productive tillers	Weight of grain S
0	30.25	39.00	15.75	12.63	24.25	33.10
10	29.25	40.37	12.75	13.94	23.50	32.00
20	28.87	42.12	10.12	9.88	22.00	33.40
30	28.12	41.00	7.63	6.80	22.00	28,15
40	29.87	41.37	7.37	4.58	24.50	28.90
50	30.25	39.63	6.88	4.75	21.50	32.60
CD	—	—	0.976	1.842	—	—

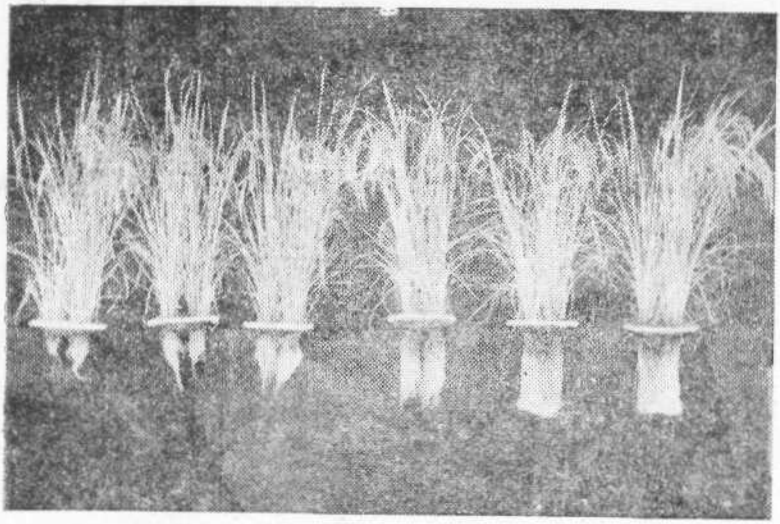

Plate I Rice Plants grown in solution culture with Aluminium left to right (concentration of Aluminium in ppm) 50, 40, 30, 20, 10, 0.

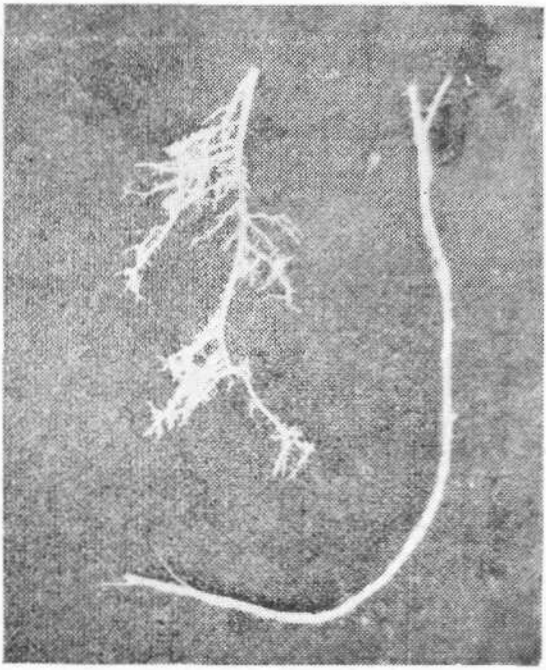

Plate II Root of the rice plant
Left : grown in 50 **ppm** Al
Right : grown in 0 ppm A!

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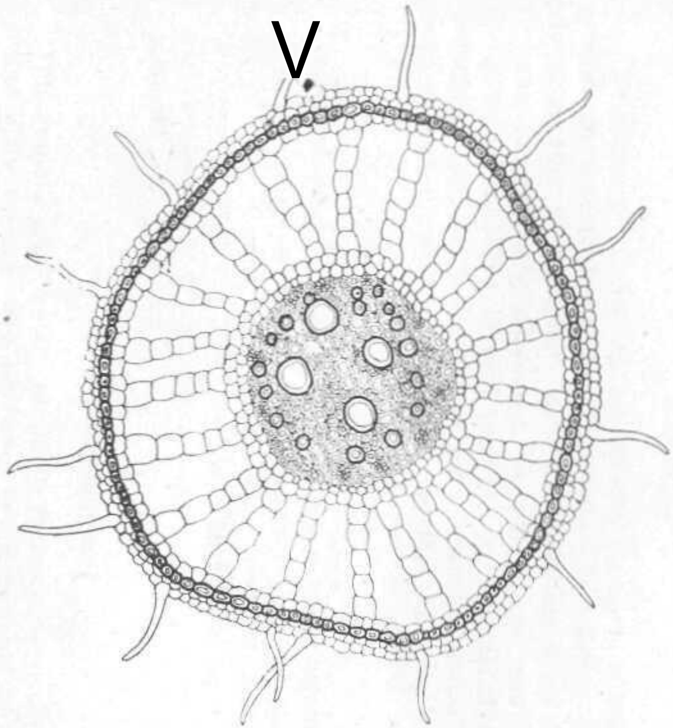

Fig. I Transverse section of rice root grown in culture solution. Without Aluminium

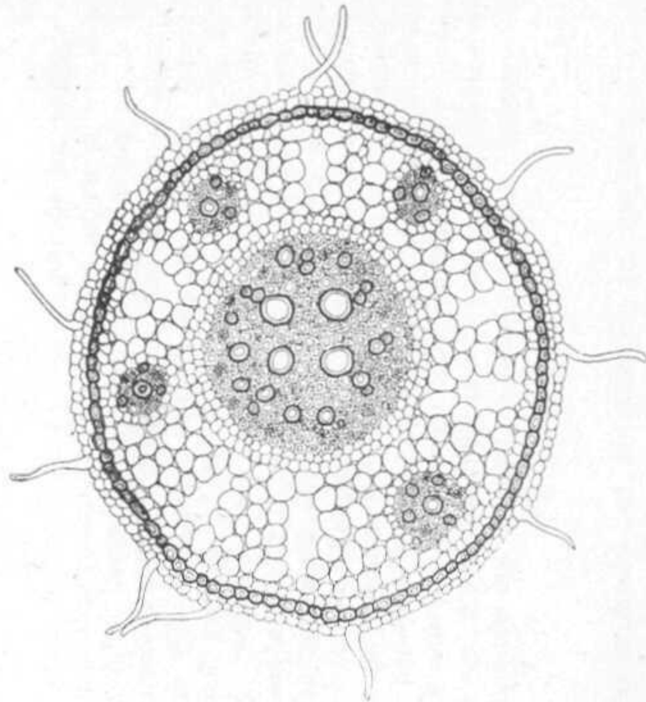

Fig. II Transverse section of rice root grown in culture solution. With 50 ppm Aluminium (showing reduced air spaces and additional vascular traces)

Though aluminium was included in the nutrient solution at different levels mentioned and the pH was adjusted at 4.8, the possible interaction of aluminium ions in solution with phosphates and the hydrolytic precipitation as aluminium hydroxide cannot be completely excluded. This, possibly would have resulted in a lower effective concentration of aluminium in the solution. It is very much possible that this reduced effective concentration of aluminium might not have been sufficient to register symptoms of toxicity in the tops. The results show that the roots appear to be more sensitive with respect to aluminium toxicity in rice plant rather than the tops. Toxicity of aluminium appears to trigger the physiological process of root branching and increasing the number of root vascular bundles. The branching of roots which provides an increase in surface area for nutrient absorption and the additional vascular traces which enhance the translocation together might have compensated for the decrease in length and weight of the root system which would have otherwise affected the absorption and translocation of nutrient elements in these plants.

Summary

The effect of 0, 10, 20, 30, 40 and 50 ppm aluminium on the yield and growth characters of the rice plant grown in solution culture was studied. Toxicity symptoms of aluminium were not manifested on the tops while root growth was progressively decreased in 20, 30, 40 and 50 ppm aluminium containing pots. Decrease in root growth was associated with a tendency for root branching and the formation of mere vascular traces in the root cortex. The reduced root growth did not suppress the yield.

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(maല്യമിനിയത്തിന് നെൽച്ചെടിയുടെ വളർച്ചയിൽ വരുത്താവുന്ന വ്യതിയാനങ്ങളെപ്പററി പഠിക്കാനായി നടത്തിയ ഒരു പരീക്ഷണത്തിൽനിന്നും, നെൽച്ചെടി വളരുന്ന സാഹചര്യത്തിൽ 20 fljwfflil 50 ppm വരെ അല്യമിനിയം ഉണ്ടെങ്കിൽ അത് ചെടിയുടെ വേരിന്റെ വളർച്ചയെ വളരെയധികം ദോഷമായി ബാധിക്കുന്നു എന്നു കണ്ടു. എന്നാൽ വേരുകളുടെ വളർച്ചക്കുറവ് ചെടിയുടെ പൊതുവായ വളർച്ചയേയും വിളവിനെയും ഒട്ടുംതന്നെ ബാധിച്ചിട്ടില്ല എന്നതാണ് ഇതിന്റെ ഒരു പ്രത്യേകത.

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