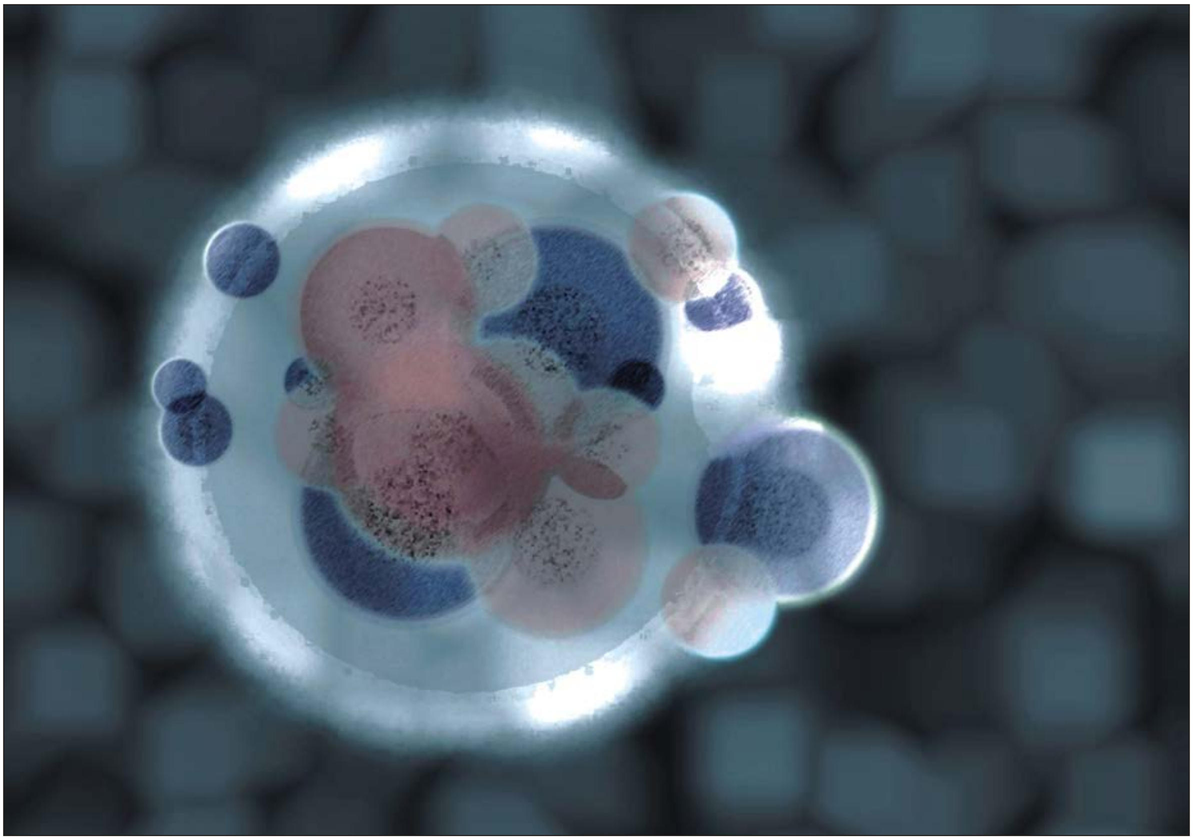

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Influence of Iron and Manganese on the Growth and Contents of Fe, Mn and P in Rice

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Abstract: Rice plants growing on a calcareous soil, supplied with various levels of labeled Fe^{59} and Mn^{54} subjected to two moisture regimes and under flooded(anaerobic) condition, the number of tillers, plant height, dry matter yield and contents of Fe, Mn and P in rice plants increased considerably indicating that soil submergence enhanced the availability of Fe, Mn and P in the growth medium. Mn content in the plant under flooded condition was always higher than that of Fe under similar condition. Unflooded (aerobic) condition showed less growth and nutrient contents in rice plants than the flooded (anaerobic) condition.

Key words: Fe^{57}, Mn^{54}, flooded, unflooded, rice

Introduction

Iron and manganese are needed for chlorophyll synthesis and for the activities of numerous enzymes in plant system (Evans and Sorger,1966). Karim and Alam (1967) have reported that the combined role of Fe and Mn is much more important than their individual role in nutrition of rice plant.

In growth environment, submergence or waterlogging of soil, causes drastic changes in properties of the soils, which affect the nutrition of lowland rice (Patrick and Mahapatra,1968; Tadano and Yoshida, 1978). Under this condition, the plant root zone is changed from aerobic to anaerobic environment as a result of drastic decrease in oxygen supply to soil. Dry matter yield and grain production has been observed higher consistently, when rice plant was grown under waterlogged conditions (Clark *et al*., 1957). The increased availability of some plant nutrients under reduced oxygen conditions brought on by waterlogging, has been observed as one of the primary beneficial effects of soil submergence for production of lowland rice. On flooding, the concentrations of Fe, Mn, Cu, Mg, P and total soluble salts in soil solution were reported to increase (Ansari *et al*., 1994; Ponnamperuma, 1972, Seng *et al*., 1999). Alam (1983), observed that behaviour of phosphate in flooded paddy soil is quite different from its behaviour in upland condition. Under waterlogged condition, the plants absorb more phosphate than under upland soil moisture condition. The reason may be, solubility of fertilizer phosphorus and its availability to plant, as the flooding helps in reduction of phosphate associated with ferric iron to more soluble ferrous phosphate.

Calcareous soils are of wide occurrence in most arid and semi -arid regions of the world. Excessive amounts of $CaCO_3$ and other soluble salts decrease the availability of iron and manganese to plants and it is often necessary to supply additional iron and manganese to the soil (Dahiya and Singh, 1976). The effects of labeled iron and manganese under flooded and unflooded conditions on the growth and contents of Fe, Mn and P in rice plant, were estimated.

Materials and Methods

A bulk soil sample from the surface horizon was collected, air-dried, powdered, screened through a 2 mm sieve and then mixed thoroughly. Some of the Physical and chemical properties of soil are given in Table 1.To uniformly mixed and weighed soil (1.5 kg/pot), were given basic doses of N, P and K fertilizers were given at the rate of 100 kg N/ha as ammonium sulphate, 50 kg P_2O_5/ha in the form of potassium dihydrogen phosphate and 30 kg K_2O/ha as sulphate of potash. The radioisotopes microcurie of Fe and Mn were obtained from Radiochemical Centre, Amersham, England. Four treatments of iron and manganese were applied each at the rate of 0,10,20 and 40 ppm using labeled Fe^{59} and Mn^{54} in ordinary $FeCl_3$ and $MnCl_2$, respectively.

Table 1: Physical and chemical properties of soil

Characteristics	
Sand (%)	39.01
Silt (%)	34.54
Clay (%)	26.54
Textural class	Silt loam
Nitrogen (%)	0.054
Organic matter (%)	1.226
Extractable Fe (ppm)	7.15
Extrastable Mn (ppm)	4.45
Calcium (%)	0.074%
Phosphorus (ppm)	4.95
pH	7.1

The activity of Fe^{59} and Mn^{54} added to each pot was 10 (uc). The iron and manganese solutions and basic fertilizers were thoroughly mixed with the soil in a Patterson-Kelly liquid-solid mixer operated electrically. All the nutrients were supplied in reagent grade chemicals in the form of solution to the soil, at the time of transplanting and placed in tin pots internally painted with asphalt.

Four weeks old rice seedlings were transplanted three seedlings per pot. The pots were kept flooded and unflooded after 10 days of transplantation. The water in the pots receiving continuous flooding were maintained at a height of about 5 cm above the surface of the soil and in case of unflooded soil, sufficient water was added to pots as and when needed to keep the soil enough moist throughout experimental period. The experiment was arranged in Randomized Complete Block Design. All the plant samples were washed and dried for 48 hours, cooled and finally weighed out. The content of radioactive Fe and Mn were determined with the help of Multi-Channel Analyzer. The active samples of iron and manganese were analyzed by putting the dry matter in a glass tube through the lid of the counter. The optimum working voltage was fixed at 950V. Standard counts of labeled Fe and Mn solutions were taken together from an aliquot of the original active solutions.

The dry plant material was ground in the Wiley mill and a known weight from the respective treatment was taken in a conical flask and digested in a tri-acid mixture containing, nitric, perchloric and sulphuric acids in the ratio of 10:4:1, respectively. From the digested sample, total Fe, Mn and P were analyzed colorimetrically (Jackson, 1958).

Results and Discussion

Table 2 revealed that with the increasing levels of Fe and Mn, there was an increase in number of tillers, plant height and dry matter yield significantly under flooded soil condition. It

Table 2: Effect of labeled iron (Fe^{59}) and Manganese (Mn^{54}) on the growth parameters content of P, Fe, Mn and % utilization of Fe and Mn by rice plants grown under flooded condition

Treatments Labeled Fe & Mn (ppm)	Plant height (cm)	No. of tillers/ pot	Dry matter Yield g/pot	Fe content (ppm)	Mn content (ppm)	P content (ppm)	% utilization of added Fe	% utilization of added Mn
0,0	77.5±2.08 (0.00)	13.5±1.29 (0.00)	5.498±0.013 (0.00)	221.78±4.58 (0.00)	576.82±10.46 (0.00)	1418.5±15.55 (0.00)	-	-
10,10	82.75±2.21 (+6.77)*	15.25±0.96 (+12.96)	5.528±0.018 (+0.545)	238.71±6.43 (+7.63)	1800.82±12.95 (+212.19)	1931.0±25.92 (+36.13)	20.55±0.595	8.97±0.082
20,20	83.25±3.09 (+7.42)	17.5±1.29 (+29.62)	5.598±0.024 (+1.819)	252.29±7.30 (+13.75)	1048.00±27.76 (+81.69)	1767.5±29.07 (+24.60)	13.71±0.495	40.385±0.921
40,40	85.75±2.63 (+10.64)	19.75±0.96 (+46.29)	5.815±0.012 (+5.76)	284.58±8.15 (+28.31)	1185.17±17.78 (+105.46)	2026.25±13.55 (+42.83)	10.592±0.0839	63.600±1.995

*Figures in the parentheses indicate percent increase (+) or decrease (-) over control

Table 3: Effect of labeled iron (Fe^{59}) on the growth parameters content of P, Fe, Mn and % utilization of Fe and Mn by rice plants grown under unflooded conditions

Treatments Labeled Fe & Mn (ppm)	Plant height (cm) pot	No. of tillers/	Dry matter Yield g/pot	Fe content (ppm)	Mn content (ppm)	P content (ppm)	% utilization of added Fe	% utilization of added Mn
0,0	76.25±2.22 (0.00)	13.5±1.29 (0.00)	3.78±0.015 (0.00)	211.77±4.42 (0.00)	419.25±9.18 (0.00)	1157.5±36.62 (0.00)	-	-
10,10	71.50±1.29 (-6.23)*	11.25±2.63 (-16.66)	3.886±0.012 (+2.80)	216.47±5.18 (+2.22)	979.6.±6.52 (133.65)	1062±16.14 (-5.31)	17.87±0.121	24.895±1.532
20,20	74.75±1.78 (-1.96)	12.25±1.71 (-9.62)	3.845±0.032 (+1.72)	221.11±5.20 (+4.41)	914.0±11.16 (+118.00)	1053±17.5 (-9.02)	14.29±0.507	50.992±1.137
40,40	69.75±1.71 (-8.52)	12.25±1.71 (-9.26)	3.872±0.014 (+2.43)	185.48±3.88 (-21.85)	948.0±10.31 (+126.12)	906.5±11.21 (-21.68)	15.70±0.133	79.30±0.696

*Figures in the parentheses indicate percent increase (+) or decrease (-) over control

has generally been observed that under flooded condition, some important plant nutrients are reduced to soluble forms available to plants resulting in better plant growth. Clark *et al*. (1957) and Ponnamperuma (1972) have revealed that plant growth parameters, are consistently higher, when rice plant was grown in submerged soil in comparison with well drained condition. Contrary to this, insignificant differences were observed in growth of tillers, plant height and dry matter under unflooded soil condition (Table 3). Literature revealed that in such condition most of the plant nutrients generally remain in oxidized state and exist in unavailable forms and are not sufficiently utilized by plant roots, this may lead to reduced plants growth than the lowland soil condition.

Under unflooded condition, uptake of Fe was low with increased supply of Fe and Mn (Table 3). High Fe content in rice plant may be due to greater solubility of Fe in flooding soil (Senewiratne and Mikkelsen, 1961). Reduction of ferric iron is important in providing adequate bivalent iron for the nutritional requirement of the rice plant. Under flooded and unflooded conditions, the percentage utilization of iron with the increased levels of Fe and Mn was decreased regularly and significantly, and the utilization of Fe under these conditions were more or less similar.

Manganese content significantly increased with increasing levels of Fe and Mn application under flooded conditions. Flooding reduced Mn in soil, releasing more of it, and therefore increasing the concentration of soluble Mn in the soil. (Ponnamperuma, 1972). The Mn content in controlled plants grown under unflooded condition was significantly lower than the other treatments, while the differences between the treatments (10-40 ppm) remained mostly constant. Utilization of Mn increased regularly and progressively with the increased doses of iron and manganese.

Phosphorus increased significantly with increasing levels of Fe, and Mn under flooded condition (Table 2). While, significantly decreased at the highest levels of Fe and Mn under unflooded condition. The higher P content in rice crops of lowland may be due to reduction of ferric phosphate and changes in pH during flooding (Ponnamperuma, 1972). The above results indicated that Fe, Mn and P solubility in the soil and their uptake by rice plants were enhanced due to flooding the soil.

References

Alam, S.M., 1983. Effects of flooded and unflooded soil conditions, Fe and Mn application on growth and nutrient content by rice plants. J. Sci. Technol., 7: 1-2.

Ansari, R.A., N. Khanzada and S.S.M. Naqvi, 1994. Studies on Salt Tolerance in Rice. In: Current Development in Salinity and Drought Tolerance of Plants, Naqvi, S.S.M., R. Ansari, T.J. Flower and A.R. Azmi (Eds.). Atomic Energy Agricultural Research Center (AEARC), TandoJam, Pakistan, pp: 207-239.

Clark, F., D.C. Nearpass and A.W. Specht, 1957. Influence of organic additions and flooding on iron and manganese uptake by rice. Agron. J., 49: 586-589.

Dahiya, S.S. and M. Singh, 1976. Effect of salinity, alkalinity and iron application on the availability of iron, manganese, phosphorus and sodium in pea (*Pisum sativum* L.) crop. Plant Soil, 44: 697-702.

Evans, H.J. and G.J. Sorger, 1966. Role of mineral elements with emphasis on the univalent cations. Annu. Rev. Plant Physiol., 17: 47-76.

Jackson, M.L., 1958. Soil Chemical Analysis. Prentice-Hall, Englewood Cliffs, NJ., USA.

Karim, A.Q.M.B. and S.M. Alam, 1967. Use of radioisotopes in the study of interaction between iron and manganese and their effects on the uptake of phosphorus by rice plants. Pak. J. Soil Sci., 3: 44-51.

Patrick, Jr. W.H. and I.C. Mahapatra, 1968. Transformation and availability to rice of nitrogen and phosphorus in waterlogged soils. Adv. Agron., 20: 323-359.

Ponnamperuma, F.N., 1972. The chemistry of submerged soils. Adv. Agron., 24: 29-96.

Senewiratne, S.T. and D.S. Mikkelsen, 1961. Physiological factors limiting growth and yield of *Oryza sativa* under unflooded conditions. Plant Soil, 14: 127-146.

Seng, V., R.W. Bell, I.R. Willet and H.J. Nesbitt, 1999. Phosphorus nutrition of rice in relation to flooding and temporary loss of soil-water saturation in two lowland soils of Cambodia. Plant Soil, 207: 121-132.

Tadano, T. and S. Yoshida, 1978. Chemical Changes in Submerged Soil and their Effect on Rice Growth. IRRI, Los Banos, Manila, Philippines, pp: 378-415.