PHOSPHATE NUTRITION IN RELATION TO THE ABSORPTION OF SOME NUTRITIONAL ELEMENTS BY PLANT

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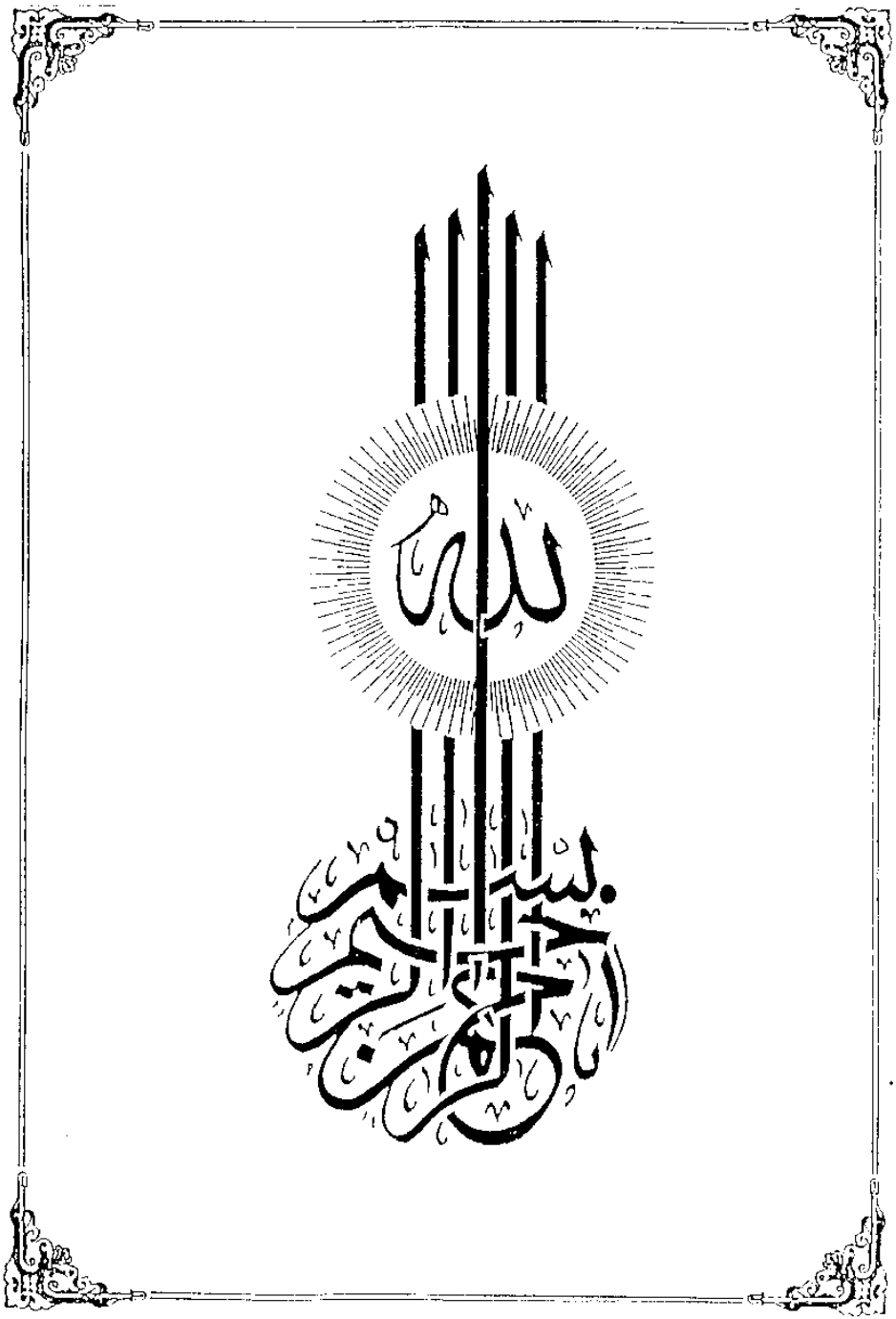

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1- [illegible]

Phosphate has been recognized as an essential element for all plants. It is a fundamental constituent in all living cells. It also plays an important role in a large number of enzymatic reactions particularly what dealing with phosphorylation process which is vital in plant growth and life.

Investigations revealed the presence of certain growth factors interacting with phosphorus nutrition. Such growth factors are mainly dealing with ions such as chloride, sulphate and carbonates of sodium, potassium, calcium and magnesium. All of these ions are usually abundant in relatively great areas of the lands under reclamation within the A.R.E. Sodium salts are characteristic of saline and alkaline regions such as those present in the Northern areas of the Nile Delta; calcium is abundant in the calcareous soils of El Nobaria and gypsum soils of Smallot (Upper Egypt); magnesium largely exists in several areas such as in Shalma of Kafr El-Shaikh Governorate.

Therefore, present work has been conducted in order to investigate the [illegible] in relation to presence of [illegible]

[illegible] particularly in relation to [illegible] and metabolism of phosphorus within barley plants. Techniques of Neubauer pots were followed to be tried later under the field conditions.

2. REVIEW OF LITERATURE

The literature dealing with the effect of salts on the uptake of phosphate nutrition by plants were investigated by many workers. Due to the complexities of this study and for the sake of clarity, the literature concerning this subject will be reviewed under the following headings.

2.1. Sodium salts :

Sodium is not usually regarded as an essential element for plants; its beneficial effects, however, have been reviewed recently by Evans and Sorger (1966). Regarding chloride salts, Reifenberg (1947) grew barley seedlings in cultures supplied with 25, 350, 1750 and 3000 ppm of chloride; nutrients were added in the form of KNO_3 and KH_2PO_4. The obtained results showed that chloride did not impede the intake of phosphate; but phosphate did impede the intake of chloride. It was suggested therefore that it could be possible that fertilizing with phosphorus and potassium might reduce the toxic action of sodium chloride in irrigation water. Conclusion drawn from analysis of the barley seedling showed that it was not salt accumulation as such, but the one-sided predominance of certain ions that may cause crop damage under neutral conditions. In other experiments carried out by the same investigator, barley plants

were grown in a single salt solution of sodium chloride, potassium chloride, ammonium chloride, calcium nitrate or potassium sulphate. Results showed that more cation than anion was absorbed from potassium sulphate and ammonium chloride, and more anion than cation from calcium nitrate. At a concentration below 0.05 N, anions and cations were equally absorbed from sodium chloride and potassium chloride; but at higher concentrations more anion than cation was absorbed. Whenever intake of an anion exceeded that of cation, electrostatic equilibrium was maintained by respiratory activity of the plant which gave up bicarbonate ions to the solution. It was suggested that the formation of bicarbonate by plants might be a cause of the alkalinization of saline soils. Dijkshoorn (1955) reported that replacement of sulphate ions by increasing amounts of chloride in nutrient solutions resulted in an increase for the chloride content in the dry matter of the perennial rye-grass; the increase was amounting to more than twice the decrease in sulphate content. Results also revealed that the uptake of chloride was high from chloride solutions applied to a sandy soil of low initial chloride status. At relatively high chloride application rates, anion uptake was greately increased and phosphorus as well as sulphate contents of grown grass were slightly decreased. Lockard and McWalter (1956), using rice plants grown in sand cultures, found

that phosphorus uptake was decreased with increasing the concentration of sodium in growing medium from 400 to 800 ppm. Shimose (1957), in a study on the distribution of ^{32}P within rice plants grown in excess-chloride solution, stated that ^{32}P accumulated in both roots and leaves; with excess chloride, ions mainly accumulated in the roots. Dijkshoorn (1959), using both pot-and solution culture experiments, indicated that the rate of uptake by perennial rye-grass decreased in the order of chloride > phosphorus > sulfur. Hemingway (1960) reported that application of sodium chloride did not increase the phosphorus utilization by the crop of kal. Turnip plants, however, were improved in their phosphorus uptake; in spite of that, a negative interaction was observed between sodium chloride and super in respect of both yield and phosphorus content of the roots.

With respect to sulphate salts, Takahashi et al. (1955) indicated that the high phosphorus absorption, occurred in the presence of sulphate ions, could be attributed to an effect of the sulphate ions in promoting the metabolic activity of the root. Leggett and Epstein(1956) studied the kinetics of sulphate absorption by barley excised roots. Results showed that the absorption rates of sulphate were highest at pH 4 and varied in response to

the external sulphate concentration, in a manner consistent within the view that the absorption of sulphate involves the attachment of the ions to specific sites of carriers. Goss and Romney (1959) showed a slight reduction of ^{32}P content in beans cultured in nutrient solution created with 10 meq/litre sodium sulphate. Morani and Fortini (1962) reported that application of the sodium sulphate salt solution having a concentration of 200 ppm to a sandy soil, poor in sodium and potassium, increased the phosphorus level in plants of Avena sativa. This was confirmed by Baroccio (1962) who concluded that sodium increased the phosphorus absorption by plants.

Several investigations were carried out dealing with comparison between the chloride and sulphate salts of sodium. Scharrer and Schreiber (1947) carried out experiments using phosphorus, sulphate and chloride at rates far exceeding those of farming practice. Phosphorus uptake of seedling 9 and 18 days-old, grown in both light and medium textured soils, was much depressed by applications of sulphate as sodium sulphate and especially of chloride as sodium chloride. Shimose (1958) observed that sodium chloride increased phosphorus content in rice plants. Chloride concentrationsin plants of the sodium chloride series were about twice as high as sulphur concentrations in plants of

the sodium sulphate ones. Stanković and Ranović (1958), working on bean seedlings grown in sand, noted that sodium, copper and boron stimulated the phosphorus absorption by plants. Shimose (1963) grew rice plants in sand supplied with a nutrient solution 0.5 atm in osmotic preasure; sodium chloride or sodium sulphate was added to increase the total osmotic preasure up to 1.5, 2.5 or 3.5 atm respectively. Results showed that the total phosphorus content in both the leaves and stems was increased. Palfia (1963) grew rice plants using nutrient solutions containing both ammonium sulphate and potassium mono-phosphate and supplied with various ammounts of either sodium sulphate or sodium chloride. His results showed that investigated plants took up less nitrogen and phosphorus from a solution containing 0.5 gm / litre sodium sulphate and 0.25 gm sodium chloride than from a solution containing a fifth of these amounts. Sulphate and chloride ions were suggested to be antagonistic to phosphorus uptake. Ferguson and Hedlin (1963) showed that response of wheat to phosphate fertilizer was much higher on moderately saline soils than on non saline ones, the difference being not dependent on the amount of $NaHCO_3$ - soluble phosphorus in soil. Greenhouse experiments with artificially salinized soil showed that phosphorus uptake by barley plants was related to salt concentration in soil.

[illegible] increasing the level of applied salt whether this salt was sodium chloride, sodium sulphate or magnesium sulphate; a maximum response was obtained at a saturation soil extract measuring about 6 millimos , then declined with further increases in the salt concentration; the increase in phosphorus uptake was much greater when fertilizer phosphorus was given. A similar relationship between salt concentration and phosphorus absorption was obtained with replacing the soil media with water culture. Maximum phosphorus absorption by barley plants occured when the solution contained 0.05-0.10 M sodium chloride. Montasir et al. (1966) carried out certain water culture experiments using the partial substitution of sodium and potassium. Results indicated that a gradual decrease in the sodium content of severl plant species was accompanied by a decrease in the sodium concentration of the culture media. The addition of extra sodium to the basic culture medium caused an increase in the sodium content of plants. A maximum phosphorus content of any plant species was observed at 20 ppm potassium in presence of 150 ppm sodium in the growth media. When the concentration of potassium was restored to 170 ppm level in absence of sodium, the phosphorus content of plants showed a marked decrease as compared with the phosphorus content of plants grown in the former media.

(1949) indicated that phosphorus content in soybean plants had no significant differences regarding their response to carbonates of Na, Ca or Mg applied, at a level of 3 meq/litre, to a soil of fine sandy loam texture. Goss and Romney (1959) grew bean and barley plants in nutrient solutions treated with 10 meq/litre of sodium bicarbonate. The content of ^{32}P in the shoots was determined at eight-hour period after treatment. They showed that the presence of added bicarbonate very significantly reduced the contents of ^{32}P; this reduction was more severe in bean plants. Barley plant appeared to be more tolerant for the bicarbonate anion than was the bean plant. Agarwala et al. (1964) used salts of Na_2CO_3, $NaHCO_3$ or Na_2SO_4 in a series of experiments. Results indicated that increasing both carbonate and sulphate ions in soil increased the tissue phosphorus of plants grown in both paddy and barley plants.

Regarding the metabolic activities of plant, several investigations revealed a clear close relationship between presence of sodium salts and synthesis of most organic substrates in various tissues. Valsyuk et al.(1955) carried out some pot experiments in which bean, lupin, sugar-beet and clover were grown on sod-podzolized soil supplied

with NPK; radioactive C was applied as Na_2CO_3. Results revealed that ^{14}C was taken up by all plants but only at conditions of neutral or alkaline reaction. Carbon of soil carbonates was found to be directly participated in the synthesis of sugars; therefore, assimilation of soil C by plants was suggested to confirm the importance of organo - mineral fertilizers. These results were confirmed later by Vlasyuk et al. (1956) who repoted that the C of soil carbonates could be taken up by plant roots only when the medium had an alkaline reaction. Bhardwaj and Rao (1962) showed that seedlings treated with 0.2 % Na_2CO_3 for a period of 96 hour contained more reducing sugar and protein N than did seedlings receiving distilled water. Karmarkar and Joshi (1969), using Bryophyllum pinnatum grown in sand cultures, concluded that although plant growth was reduced, presence of Cl tended to produce thicker, larger and heavier leaves; the weight increase was suggested to be due to an increase in the organic matter and not to the enhancement of water absorption. Regarding the metabolic activities within the tested plants, 0.04 M NaCl stimulated organic-acid metabolism and increased the titratable acid number in the leaves but above this level organic acid metabolism was increasingly inhibited. Rajova et al. (1969) studied the effects of iso-osmotic concentrations of Na_2SO_4 and NaCl supplied